Closeout Report for Recommendations from the Preliminary Design Review of the NCSX Project

May 10, 2004

The NCSX site preliminary design review (PDR) was held October 7-9, 2003, at PPPL. The final panel report, issued October 24, contained twenty-four recommendations for improving the project design and plans,. There were also numerous comments in the panel report which the project treated as recommendations in developing a response. We also combined similar items where a combined response is appropriate. In all, thirty-four items were identified.

Immediately after the PDR, the project developed a response and a disposition plan for each item. Because of the urgency of establishing the project baseline for CD-2, an effort was made to come to prompt decisions on those items with cost and schedule impact. These are summarized below.

Cost and Schedule Impacts of the PDR Responses on the CD-2 Baseline

Item	Item Summary	CD-2 Cost Impact ($K)	CD-2 Schedule Impact (mos)
7	Additional winding R&D	195	
17	Coil services estimate	130	
12	Vacuum vessel bakeable to 350C	300	
2	Additional time to evaluate winding form prototypes	226	1
19/20	Additional time for component fit-up tests	226	1
9	Winding & potting development	51	
	Miscellaneous items*	284	
	Total	1,412	2

* Allocated to Items 1, 5, 12, 19, and 23; and 3, 4, 10, 11, 20, 24, 25, 26

Modifications to the project plans resulting from the PDR are incorporated in the revised project baseline that was approved at CD-2. The total change between the PDR and CD-2 baseline, from all reviews and revised DOE guidance, was $5.3M in cost and 8 months on the schedule.

The project's responses were documented in the form of a tracking log which the project has used to track each sequentially-numbered item since the PDR. All of the items that required any significant follow-up activity were incorporated into the project's CD-2 schedule and budget. This document provides the status of each item as of the May, 2004 Final Design Review of the Modular Coil Winding Forms and Vacuum Vessel Sub-Assembly. Many have already been fully addressed during final design and are now completed. All issues affecting the design of the MCWF and VVSA are in that category. Those items which require further work to fully complete the plan are closed out by including that work in the baseline work scope, which will be tracked to completion following the project's normal project control processes.

ID	WBS # Responsible Person	PDR Panel Report: Recommendation / Comment	Disposition Plan and Current Update	FDR Status (May, 2004)
1	**WBS 14 Williamson**	**Comment 4 in Section 2**: For Final Design Review significant work remains to be completed on current feed design. Prototyping and testing needs to be performed to assure quality of these elements. If possible, access through the shell at the current feed locations should be available. Care should be exercised to maintain stellarator symmetry in bus systems for conventional coils as well as the modular coil system.	*Project Response/Plan:* Twisted racetrack coil and straight beam test will prototype leads. Access through shell at current feed locations will be investigated. Additional design and analysis will be required. Maintaining stellarator symmetry in TF bus connections will be investigated. This is not possible with PF coils featuring only one bus connection per coil. *FDR Update (May, 2004):* The current feed design development has progressed, commensurate with the need to finalize the MCWF design.	**Closed.** Included in CD-2 baseline.

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2	**WBS 14 Williamson**	**Comment 2 in Section 2**: Concern exists over the short time between prototype delivery and release of production contracts for minor modifications of winding forms. Close interaction with vendors can help accelerate the feedback into the production design. **Comment 3 in Section 2**: For Final Design and fabrication, verification of the prototype coil should be completed and tested as soon as possible.	*Project Response/Plan:* To accommodate this and several other items (1, 3, 4, 5, 7, 11, 12, 17, 24, 25, 26) which impacted pre-FDR tasks, the FDR milestone was delayed one month relative to the schedule presented at the PDR without additional impact on first plasma. It was also decided to issue draft specifications and statements of work in advance of the RFP, but to delay release of the *final* winding form specification until after the FDR and after any design changes that may result from the FDR conclusions have been incorporated. Any changes resulting from the final phase of prototype manufacture will be incorporated during the contract negotiation process. We believe this is the optimum balance of risks at this time. Further postponement of the spec release would further reduce the risk of changes but increase the risk of schedule delay. The delay in final spec release and contract award delays delivery of the first production winding form and First Plasma by one month relative to the schedule presented at the PDR. This allows more time to incorporate lessons learned from the prototype coil fabrication and testing into the tooling and winding process design before winding the first production coil. These changes were incorporated into the CD-2 baseline along with other changes resulting from the Fall, 2003 project reviews. *FDR Update (May, 2004):* To expedite the procurement process, a draft specification and statement of work has been issued to the prospective suppliers even though the prototype manufacture is not yet completed, allowing them to get an early start on their proposal for the production program.	**Closed.** Included in CD-2 baseline.

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3	**WBS 16, 19 Williamson, Cole**	**Comment 5 in Section 2**: Coil services, such as liquid nitrogen distribution systems need to be laid out with respect to the overall structure. **Comment 1 in Section 5**: No details were presented on how the LN2 was to be supplied to the coils. What types of tubing and electrical breaks are being used? How do the feed and exhaust lines run to the various coils? How is the LN2 controlled? Is it planned to purge the coils of LN2 before running current through the coils? These issues were not reviewed; however, informal talks with the engineer in charge indicated that these systems are being given serious consideration.	*Project Response/Plan:* Agree. These details will be developed in Final Design. Teflon tubing is envisioned for the connections to the coils. Layouts of the Modular Coil cooling lines and electrical leads, and the Vacuum Vessel He lines, are scheduled to be completed before the FDR of the modular coil windings and assembly. (WBS 19) *FDR Update (May, 2004):* The decisions affecting the MCWF and VVSA design have been finalized, namely the location of the electrical leads and LN2 cooling feeds on the modular coils, and the space envelope for heating and cooling lines and manifolds on the vacuum vessel. The routing of helium lines for the vacuum vessel were shown at the PDR. Although work still remains on the layout of electrical leads and LN2 lines inside the cryostat, the critical clearances with components near their connections to the modular coils have been checked and found to be adequate. Even though the details of cooling line routing in the cryostat and electrical breaks are still under development, the design has been developed in sufficient detail to demonstrate that it meets modular coil cooldown requirements. Since the temperature of the coiling lines never gets high enough to vaporize the LN2, there is no reason why the LN2 cannot be allowed to flow continuously, even during the pulse. See the WBS 14 design documentation and associated analysis reports.	**Closed.** Included in CD-2 baseline. Current state of development is sufficient to release MCWF and VVSA for fabrication.

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4	**WBS 14 Williamson**	**Comment 6 in Section 2**: The tolerance budget should be re-examined with regard to assembly to guarantee stellarator symmetry.	*Project Response/Plan:* Agree. The twisted racetrack coil should provide a better understanding of what we can achieve during the winding process. As our understanding of deflections, positioning, and measurements become clearer during Final Design, the tolerance budget will be re-examined. *FDR Update (May, 2004)*: This position was re-affirmed in a peer review of the winding pack configuration on March 12. The MCWF tolerances will be kept the same. So far there are no indications of problems meeting those tolerances from the MCWF suppliers, although the machining phase of their studies is still in progress. Field error analyses showing that tolerances can be relaxed in some regions of the coil, and the planned shim-as-you-go winding approach provide fallbacks in the event the cost of meeting the MCWF tolerances is prohibitive. Winding pack tolerances will be reviewed after completion of the twisted racetrack coil in the fourth quarter of FY-04.	**Closed.** Included in CD-2 baseline. Current state of development is sufficient to release MCWF and VVSA for fabrication.
5	**WBS 14 Williamson**	**Comment 7 in Section 2**: It should be confirmed that the cable is compacted without any lubricant which would degrade the epoxy/copper bonding and lower the shear strength.	*Project Response/Plan:* We agree that processes that could affect the adhesion of the epoxy to the copper (and thereby effect the mechanical properties of the conductor) need to be identified and controlled. The NCSX project will undertake a test program to determine whether to specify the normal process used in cable fabrication or to introduce a cleaning step to "de-grease" the conductor. *FDR Update (May 2004):* Tests to date on cable that has been rigorously cleaned as well as cable subjected to normal manufacturing processes show little or no difference in behavior.	**Closed.** Included in CD-2 baseline.

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6	**WBS 14 Williamson**	**Comment 8 in Section 2**: As prototyping and R&D continue, efforts should continue to identify areas where the schedule contingencies could be increased.	*Project Response/Plan:* Agree. During final design, we have looked for opportunities in all critical systems, not just the modular coils. *FDR Update (May, 2004):* Decisions taken during final design: • A decision was made to allow delivery of each vacuum vessel sector as it is fabricated rather than requiring complete assembly by the supplier. This gives the supplier more flexibility to optimize his process for minimum cost and will allow the project to start field period assembly earlier, improving schedule flexibility. • A decision was made to change to a mechanical attachment scheme for the vacuum vessel heating and cooling tubing, eliminating the need for grouting or welding. This reduces cost and installation time and provides more options for installation. • A decision was made to add a second modular coil winding station, which will provide additional schedule flexibility as well as improve the quality of the oversight coverage. • The winding form suppliers were given advanced models of all three coil designs and authorized to analyze them for any special casting and machining issues that do not appear in the Type C prototype. The original plan was not to examine the Type A and B shapes in detail until the production phase, but this will provide an earlier opportunity to identify potential problems and reduce cost and schedule risks. Schedule improvement opportunities will continue to be sought as part of the project's approach to risk management.	**Closed.**

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7	**WBS 14 Williamson**	**Comment 1 in Section 2**: Thermal and electromagnetic load cycles may lead to de-lamination of the copper-epoxy composite due to low shear strength. The conduction cooling of the coil could then be adversely effected. Efforts should be undertaken to examine the expected fatigue properties of the modular coil system. **Recommendation 2-1**: Develop and implement a plan to evaluate shear stress quality of the composite used and fatigue properties of the modular coil system.	*Project Response/Plan:* Agree. A supplementary test plan has been generated for completion in Final Design. Additional tests include: • Shear strength in the axial direction. • Fatigue properties. • Tests to follow up on open issues from the first round of testing. *FDR Update (May, 2004):* Test results have been taken into account in the MCWF design.	**Closed.** Included in CD-2 baseline. Current status of the implemented program is sufficient to release MCWF and VVSA for fabrication.
8	**WBS 14 Williamson**	**Recommendation 2-2**: Determine motions from machining in the "tee" section and investigate potential processes to minimize this motion. Significant motion could have a large impact on cost and delivery time. The sample twisted casting could be useful in this regard.	*Project Response/Plan:* Agree. This is already part of the MCWF R&D scope. *FDR Update (May, 2004):* Machining of the twisted racetrack coil have not shown any particular problems due to deflection.	**Closed** Current status is sufficient to release MCWF for fabrication.
9	**WBS 14 Williamson**	**Recommendation 2-3**: Continue winding and potting coil sections with multiple curvatures to gain experience in conductor placement and clamping and epoxy flow in complex geometries.	*Project Response/Plan:* Agree. The winding program has been improved by adding a 3D winding trial on a closed twisted tee, and improving the twisted racetrack coil design to provide a more prototypical test. *FDR Update (May, 2004):* The closed twisted tee winding trials are in progress and have been beneficial for tooling design, staff training, conductor handling, and other aspects of the winding process.	**Closed.** Included in CD-2 baseline.

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10	**WBS 12 Goranson**	**Recommendation 3-1**: *Port Extensions*. Transition to stainless steel as soon as possible in the port extensions. If possible this should be done at the short stub weld location. The current design, which extends Inconel to the primary flange location on these ports, introduces added machining and preparation costs on these large vacuum seal surfaces. The selection of vacuum vessel and port material may benefit from a graded approach to technical requirements. Inconel 625 is clearly appropriate for the vacuum vessel due to its high strength, low electrical conductivity and low magnetic permeability, although its cost and difficulty of fabrication are high. As distance from the plasma increases, Inconel's properties are less important. Review of cost and fabrication issues may support the selection of stainless steel for ports and the neutral beam port box. Inconel flanges should be avoided if possible. The panel also recommends that the vessel weld joint be changed on these parts to provide a final internal vacuum integrity pass. The external weld should be a skip weld providing only the area required to react to mechanical loads. After the port openings are cut, an internal weld pass should be made to assure vacuum integrity.	*Project Response/Plan:* Agreed. The port flanges and everything beyond will be stainless steel. The location of the Inconel to stainless steel transition will be optimized in Final Design. The use of an external skip weld will also be investigated during Final Design. *FDR Update (May, 2004):* In the FDR design, each port has a first flange just outside the modular coil shell, in order to maximize future flexibility for diagnostic adapters beyond the first flange. The port extension from the vacuum vessel shell to the first flange is inconel. Everything beyond the first flange is stainless steel. Full penetration welds have been retained in the design. They are needed for strength and they avoid the requirement for another internal weld to assure vacuum integrity.	**Closed**

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11	**WBS 12 Goranson**	**Recommendation 3-2**: *Vessel Welds*. Evaluate feasibility of automating the final vessel assembly welds at the three spool insert locations. The flanges on these welds should provide a convenient means of tracking the weld joint and supporting a fixture for the weld head. This would eliminate the need for manual welding operations in this restricted area during assembly and should produce more reliable root and fill pass weld joints. The project should also evaluate use of Penetration Enhancing Compounds (PEC) to increase root pass penetration depth and reduce the number of fill passes on all vessel welds. This could significantly reduce weld distortion and residual stress. On the ITER project, PEC's were used to increase root pass depth from 2 to 6-mm in an extensive length of 1000 psi water channel close-out welds on a large SS-316 structure without any weld quality, vacuum integrity, or magnetic permeability side effects.	*Project Response/Plan:* An evaluation of the viability of manual welding will be done during the VV R&D program. If it reveals problems, ORNL will assess the feasibility of automated welding using automated welding tools already developed as part of the ITER project. *FDR Update (May, 2004):* The VV weld joint R&D program has begun. Results of small-sample tests may be available by the time of the FDR, A full-scale sample is being procured for tests later this FY. The results of the weld joint R&D will influence plans for final assembly but are not expected to impact the VVSA manufacture. Following up on this recommendation, we discussed the use of PECs with our suppliers. They advised that it would not be appropriate in this application since it is typically used only in the "downhand" position..	**Closed** Current state of development is sufficient to release MCWF and VVSA for fabrication.

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12	**WBS 12 Goranson**	**Recommendation 3-3**: *Bakeout Temperature*. Assess viability of increasing the vessel bakeout temperature to 350C. This temperature is presently used on the D-III device and it enables conditioning to be accomplished in a few hours. More importantly, it would also eliminate the need for installation of a separate in-vessel PFC heating loop during future upgrades. The PFCs could instead be passively mounted to the wall with simple electrical isolation breaks. This would eliminate costs associated with the 200 psi in-vessel helium system and potential leaks that could develop in this system during operation. **Recommendation 9-1**: If graphite is to be used it would be much preferred to bake the vessel and the PFCs to 350 C and eliminate the complications of invessel helium lines, shields, and complicated support structure. On the other hand, using hi-Z PFCs and no carbon should also be considered.	*Project Response/Plan:* In response to this recommendation, the project conducted a conceptual design study to address the feasibility issues and costs of making such a change at this time. The conclusion was a decision to implement the capability to bake the vacuum vessel to 350C. The substantial reduction in cost and risk of future plasma-facing components justifies the additional cost (included in the CD-2 baseline) of building a vessel that can be heated to higher temperatures. A 150C bakeout is the requirement for initial operation because there will be little or no carbon inside the vacuum vessel initially. Bakeout at 350C will be fully implemented when carbon PFCs are installed. The GRD requires that alternate material be accommodated as future upgrades, including lithium, tungsten, and molybdenum. *FDR Update (May, 2004):* The VVSA design presented at the FDR satisfies the new 350□C requirement.	**Closed.** Included in CD-2 baseline and in the FDR design of the vacuum vessel.
13	**WBS 84 Zarnstorff**	**Recommendation 9-2**: Bakeout on C-Mod requires 5 to 10 days at 130C. This long bake period is primarily the result of water evolution from cabling and conduits. DIII-D at 350 C bakes for 10 hours or so. So this tradeoff should also be considered.	*Project Response/Plan:* The transport of water out of carbon PFCs drops dramatically below about 300□C, so there is not an acceptable tradeoff of time for temperature if carbon is contemplated. The experience on TFTR was that operating efficiency suffered because of the inability to bake to 350C. Experience with high-temperature bakeout on NSTX has been favorable. The requirement for 350C bakeout is retained.	**Closed**

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14	**WBS 12 Goranson**	**Recommendation 3-4**. *Insulation.* Alternatives should be assessed to the proposed use of Microtherm blankets for the vessel insulation. While efficient, this insulator will be difficult to conform to the compound curvatures associated with the NCSX vessel. On Wendelstein 7, this insulator needed to be made in 10x10-cm tiles that were stitched together to form a blanket. Newer high-performance, flexible insulating blankets are available using silica aerogel technology that should be applicable to the NCSX environments. Aerogel materials are ultra low conductivity, low density insulations that offer market-leading thermal insulation, acoustic protection, and infrared suppression performance.	*Project Response/Plan:* Agree. We will investigate alternatives to the Microtherm blanket, including a flexible Aerogel blanket. *FDR Update (May, 2004):* Aerogel samples were obtained and the material was evaluated and rejected due to high cost (100k$), dust problems, and lack of resilience. It was also not as flexible as hoped and showed little if any advantages over Microtherm.	**Closed**

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15	**WBS 12 Goranson**	**Recommendation 3-5**. *Prototype Sector*. Due to the significant amount of welding used in vessel fabrication, the panel is concerned about possible effects of residual weld stress on the vessel dimensional stability. We therefore recommend that a 400 C thermal stress anneal cycle be performed on one of the prototype vessel sectors to evaluate possible benefits of this added fabrication step on the dimensional stability of the vessel after fabrication. This anneal cycle should be performed before the port extensions are removed so that the extended port structure is in-place to help maintain the wall stub geometry until weld stresses are relieved. In addition, the panel recommends that fabrication of a complete, 120-deg sector of the vessel be initiated as soon as possible once supplier down-select is completed. The contract should allow for staged delivery of the full-scale prototype sectors so that the first one is available early to assess tolerance build-up and dimensional stability of a full sector of the vessel to determine if any Final Design or manufacturing process adjustments are needed prior to exercising the option for the remaining sectors. This will provide incentive for the supplier to achieve first-time quality and full confidence to proceed with the remaining vessel sector fabrication.	*Project Response/Plan:* Dimensional stability under thermal cycling is a fundamental requirement for the production vacuum vessel. This is especially true now that the project has accepted the recommendation ot be able to bake the vessel shell to 350□C, while the ports must be kept at 150□C. Thermally cycling of the vessel to temperatures higher than the nominal highest operating temperature is planned for the production vessel in order to verify that this requirement is met. The project carefully considered the recommendation that this should be verified on the prototype vacuum vessel segment, however it was concluded that with only one small port that step would not be very instructive. Production of the first 120-degree sector is already on a fast track. In response to this recommendation, we have decided to expedite delivery by not requiring factory fit-up of all three sectors. Proper fit-up will be assured through the use of precision fixtures. A complete inspection is planned for the first article to find out if there are any deficiencies that should be corrected in subsequent fabrications. We do not believe that a true prototype - a fourth 120-degree sector – is warranted, nor do we understand that to be the intent in the Panel's recommendation.	**Closed**

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16	**WBS 12** **Goranson**	**Recommendation 3-6**: *Port Bakeout.* The panel recommends that additional measures be taken to assure that the large wall surface areas associated with the neutral beam boxes and other port extensions be raised to above 100 C to assure good wall conditioning prior to operation. This could be done using external heating blankets and insulation blankets where appropriate, but a plan for heating these volumes should be presented at the FDR.	*Project Response/Plan:* Port extensions are already required to be baked to 150C. Neutral beam boxes do not require baking because of the large pumping capacity of the cryopumps inside the beam boxes. The transition ducts between the VV and the neutral beams are treated as port extensions, except the transition flange connecting to the vessel and the transition body will be fabricated from Inconel, due to the close proximity to the vessel shell..	**Closed**
17	**WBS 12, 16** **Goranson, Williamson**	**Recommendation 3-7**: *Auxiliary Utility Lines*. The panel is concerned that costs associated with electrical breaks, single point grounding, and other installation details associated with the auxiliary LN2 and high pressure helium lines that must penetrate the cryostat are not properly accounted for in the PDR cost assessment. Due to the large number of these lines, more typical installation detail is needed prior to the FDR to assure that these costs are properly budgeted for in the estimate.	*Project Response/Plan:* Agree. The budgets for this scope in the Vacuum Vessel (WBS 12) and Coil Services (WBS 16) have been revisited. We do not intend to use any ceramic cryogenic insulators, but will use Teflon tubes as are used by C-Mod. Helium lines will probably require a minimum of 6 ceramic breaks, i.e. a supply and return insulator for each field period.	**Closed.** Included in CD-2 baseline.

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18	**WBS 18 Chrzanowski, Raftopoulos**	**Comment 1 in Section 4**: Although the metrology tools have been identified for measuring locations of critical points, the software for resolving these points into the NCSX coordinate system has not been developed/procured. This is a critical element of the assembly process and should be obtained as early as possible. **Recommendation 4-1**: Obtain metrology software to allow testing and debugging before critical needs arise.	*Project Response/Plan:* Agreed. It was decided to advance the procurement of metrology equipment to FY-04, so that the project team can use it and gain experience during the 3D winding development activities, and to make measurements on the prototype winding forms and vacuum vessel during FY-04. *FDR Update (May, 2004):* We have identified both the metrology hardware and the associated software that will perform the "CADD to part" analysis. The order was placed in April, 2004, following a competitive source selection process, and some hardware has been received. The NCSX coordinate system can be established in this software and/or in our design drafting package (Pro Engineer). The new tools will be first applied to the prototype vacuum vessel sector (already received) and the twisted racetrack coil. Additional metrology procurements (equipment and software) are planned for FY-05.	**Closed.** Included in CD-2 baseline.
19	**WBS 18 Chrzanowski**	**Comment 2 in Section 4**: The surfaces of the modular coil castings will be contour machined only where the coil winding pack will be placed and there is high reliance on CAD models to assure the castings will provide adequate clearance during assembly – although a worst case condition of clearances approaching _ inch is envisioned. Time should be allowed in the schedule to pre-assemble castings for each type of joint: A-A, A-B, B-C, C-C, to assure the planned clearance exists. **Recommendation 4-2**: Plan time in the schedule to pre-assemble each type of modular casting assembly joint to assure adequate clearance exists between mating parts.	*Project Response/Plan:* We will add time in the schedule for pre-assembly, but will try to minimize impact on the winding schedule. This means we may be fitting a winding form with a coil wound on it with a winding form just received from the supplier. Nonetheless, some schedule impact is expected. We will continue to rely on QA and metrology as our primary and "early warning," means for detecting interference problems with out-of-spec parts. We will rely on mockups (based on our CAD models) to assure that there are no interferences embedded in our CAD models.	**Closed.** Included in CD-2 baseline.

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20	**WBS 18 Chrzanowski**	**Comment 4 in Section 4**: The integration of the modular coil pair subassemblies around the vacuum vessel segment is a critical operation. At the earliest possible time, a full-scale mockup should be developed that allows this operation to be practiced. This same mockup, if so constructed, could be used to demonstrate adequate clearance for making all the in board connections between subassemblies at final assembly. Experience could also be gained with the metrology tools and software using the mockup. **Recommendation 4-3**: Develop a full-size mockup to be used to demonstrate the assembly of the modular coil pairs around the vacuum vessel segment.	*Project Response/Plan:* Agree. The budget for procuring the mockup coils and vacuum vessel are already in our plans for developing metrology techniques. The additional activities recommended here will be added.	**Closed.** Included in CD-2 baseline.
21	**WBS 18 Chrzanowski**	**Comment 3 in Section 4**: The alignment of coils utilizing custom shims can become complex. Guidelines should be established to utilize standard shims unless some acceptable threshold misalignment is exceeded. **Recommendation 4-4**: Develop misalignment threshold for installation of customized shims.	*Project Response/Plan:* Standard shims or shim packs will be used. The NCSX project will assess whether the nominal clearance for shims is adequate.	**Closed.**
22	**WBS 12 Goranson**	**Comment 5 in Section 4:** Welding of port extensions may prove to be more challenging than presently envisioned. There is a need to document flange locations and tolerances so a short development effort can be conducted to demonstrate that these requirements can be met during the assembly process.	*Project Response/Plan:* This is covered in the prototype vacuum vessel segment R&D program.	**Closed.**

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23	**WBS 17, 62 Gettelfinger**	**Recommendation 5-1**: More consideration should be given to providing an external vaporizer to provide initial room temperature GN2 pressurization of the cryostat. Initial removal of moisture from the cryostat and machine surfaces should be done without introducing LN2 into the system since control of the low temperature vapor from such a system would be difficult. On the scale of NCSX, this is a minor cost with large benefits for the facility. **Recommendation 5-2**: The addition of humidity sensors inside the cryostat is strongly encouraged. Otherwise it will not be known for certain how well sealed the system is or when introduction of cool gas and liquid into the system should be made.	*Project Response/Plan:* Agreed. An external vaporizer and humidity sensors need to be provided prior to operation at cryogenic temperature, which is now included in the project scope as a result of post-PDR decisions.	**Closed**
24	**WBS 12 Goranson**	**Comment 2 in Section 6**: Vacuum vessel and port welds, particularly field welds that may be made with limited access, may develop leaks anytime throughout the life of the machine. This process of leak locating should be identified during the design of the machine. This may require the permanent installation of helium injection tubes to the area of the weld on the outside of the vessel.	*Project Response/Plan:* Strongly agree. Isolation and repair of vacuum leaks is a fundamental requirement that will be addressed in Final Design. Full penetration welds should minimize the likelihood of leakage, but does not obviate the need for fault isolation and repair. *FDR Update (May, 2004):* Leak check tubes are being incorporated into each of the port extensions so leaks may be isolated and repaired. A similar system will be used at the field joint. All other welds are checked prior to field period assembly using conventional techniques.	**Closed**

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25	**WBS 16, 19** **Williamson, Cole**	**Comment 3 in Section 6**: Space allocation inside the cryostat is limited. Before the Final Design review, space allocations should be well defined. The following is a short list of equipment to be packaged within this volume: 1. Electric power feeds to all coil systems 2. Turn to turn electrical connection for the TF coils 3. Insulated bake out helium supply and return manifolds, lines and electrical breaks 4. Instrumentation lines 5. Nitrogen supply lines 6. Grounding cables Sufficient design work should be done to assure a reasonable arrangement could be developed within the space allocated.	*Project Response/Plan:* Agree. Space allocations inside the cryostat will be determined in FY04. Layouts of the Modular Coil cooling lines and electrical leads, and the Vacuum Vessel He lines and electrical breaks, are scheduled to be completed before the FDR. Layouts for the conventional coil leads and services will be completed in the last quarter of FY-04. (WBS 19) *FDR Update (May, 2004):* The decisions affecting the MCWF and VVSA design have been finalized, namely the location of the electrical leads and LN2 cooling feeds on the modular coils, and the space envelope for heating and cooling lines and manifolds on the vacuum vessel. The routing of helium lines for the vacuum vessel were shown at the PDR. Although work still remains on the layout of electrical leads and LN2 lines inside the cryostat, the critical clearances with components near their connections to the modular coils have been checked and found to be adequate. Electrical leads and other services to the PF and TF coils and TF coil turn-to-turn transitions will be addressed in the design development of these systems and be completed before their FDRs.	**Closed.** Included in CD-2 baseline. Current state of development is sufficient to release MCWF and VVSA for fabrication.

ID	WBS # Responsible Person	PDR Panel Report: Recommendation / Comment	Disposition Plan and Current Update	FDR Status (May, 2004)
26	**WBS 14 Williamson**	**Comment 1 in Section 6**: The issue of the lack of access for bolt installation and tightening of fasteners between field period assemblies in the inboard area needs to be addressed. These equivalent bolts are accessible during build up of the Field Period Assemblies since the TF coils are installed last into these assemblies. The presence of the wedged TF coils during the machine assembly task forms a barrier to the access required for these bolts. **Recommendation 6-1**: Resolution of the bolting between field period assemblies is required. The preload requirement for this joint is uncertain. Can the bolt requirement be met by additional accessible bolts at the top and bottom or by spacers compressed between the field period assemblies? A cure-in-place shim the full height of the joint might be feasible. This could be made from an inflatable shim bag filled with pressurized epoxy. Would this be beneficial?	*Project Response/Plan:* We agree that access to the bolts is a primary consideration. Bolting of the modular coil flanges will be addressed in modular coil Final Design. *FDR Update (May, 2004):* The bolting arrangement has been modified to accommodate changes to the vacuum vessel port locations, as well as accessibility concerns. A structural analysis model has been developed and has been used to determine the force distribution in the bolts due to various operating scenarios. It has been determined that the bolts in the least accessible areas can be eliminated.	**Closed**
27	**WBS 4 Ramakrishnan**	**Comment 1 in Section 7**: It appears that the deployment of a ground fault monitor to sense the status of the many insulating breaks in the machine structure has not been included in the Project scope. Although the system is not needed during construction, it would save time and reduce risk beginning with the first energization of the magnets. **Recommendation 7-1**: It is recommended that the wiring of these elements to a single point ground, along with a ground fault monitor, be included in the project scope.	*Project Response/Plan:* Wiring of components to a single point ground is already included in the project scope. Now that the baseline includes a significant period of operation as part of the startup program prior to CD-4, we agree that the ground fault monitor would be useful and should be included in the baseline.	**Closed**

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28	**WBS 84 Zarnstorff**	**Recommendation 11-1**: Develop more specific goals for the field mapping experiments following MIE that take into account that NCSX has a highly variable magnetic configuration.	*Project Response/Plan:* Agree. This will be planned as part of research preparation. *FDR Update (May, 2004):* Vacuum magnetic configurations have been designed which exhibit the key resonances with relevant shear. These can be used during field mapping to probe the basic magnetic configuration quality.	**Closed** Included in research prep plans.
29	**WBS 84 Zarnstorff**	**Comment 2 in Section 11**: Diagnostic issues are minor at this stage relative to construction needs. Looking to the future, there is some uncertainty in the plan for field mapping experiments to be carried out following project completion. While field mapping equipment is provided for in the project budget (but will not be used), there is no provision in the budget to check out and hook up the existing power supplies for the trim coils that should be included in the field mapping experiments. Furthermore, the Initial Operation period calls for wall conditioning, but installation of glow discharge cleaning has been postponed until after this period. **Recommendation 11-2**: One can defer purchase of e-beam equipment until completion of project; consider implementing funds for GDC earlier.	*Project Response/Plan:* The e-beam mapping apparatus is needed to meet the new CD-4 criteria that were adopted after the PDR. Therefore it remains in the MIE scope. The in-scope field mapping operations will be used to confirm the existence of scenarios with good magnetic surfaces, sufficient for the start of operation. They will be performed with the cryostat off to facilitate adjustments to coil or lead positions, should they be necessary. Use of the trim coils to improve flux surfaces is part of the research program that will not start until well after first plasma. The power supplies will use available PPPL legacy equipment which has been recently tested and found to be in good condition. It is straight-forward to connect them to the trim coil terminals outside the cryostat when they are needed by the program. The GDC is not needed for First Plasma, since we can bake the vacuum vessel at 150C. However, GDC will be added early in experimental operations.	**Closed**

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30	**WBS 3, 19, 84 Johnson, Cole, Majeski, Zarnstorff**	**Comment 3 in Section 11**: Present diagnostic integration studies i.e., how to implement profile diagnostics in 3-D plasma geometry through long port extensions have begun, and have been responsible for improving the port design. Nonetheless, many of the studies appear to be mainly conceptual at this stage, and not yet inclusive of all appropriate diagnostics. **Recommendation 11-3**: Review diagnostic integration studies, and strengthen emphasis on critical diagnostics. After April 2004 (scheduled FDR for the vacuum vessel), it will be too late for further accommodations.	*Project Response/Plan:* Development of VV interfaces (including diagnostic interfaces) is an ongoing task and will be completed well in advance of the vacuum vessel FDR. *FDR Update (May, 2004):* The port configuration was significantly modified since the PDR. The ports were optimized in size, shape, orientation, and number to meet program requirements with adequate clearance to adjacent structures. A series of peer reviews completed in April concluded that an acceptable port configuration has been developed. The FDR designs of the MCWF and VVSA are consistent with the new configuration, which is a significant change in the technical and cost baselines. A draft ECP documenting these changes is part of the FDR documentation package and will be submitted for approval after the FDR.	**Closed.**
31	**WBS 8 Neilson**	**Comment 4 in Section 12**: The Project should document the items removed from the scope baseline between the CDR and the PDR. The rationale for these changes should be included in this documentation. This will provide a documented history for removal of these components and justification for their consideration as upgrades during operations.	*Project Response/Plan:* The NCSX project will document items removed from the scope baseline and their rationale. *FDR Update (May, 2004):* Completed and posted on the CD-2 web page.	**Closed**
32	**WBS 8 Neilson**	**Comment 3 in Section 12**: Project management acknowledged the value of continuing a value engineering activity but was not clear on what form this should take. The Subcommittee strongly urges the Project Management to make and document this decision and implement a continuing value engineering activity for NCSX. **Recommendation 12-1**: The project should clearly identify and document how value engineering will be applied and used during the life of the project.	*Project Response/Plan:* The project's Value Engineering plan after the Preliminary Design phase is to continue to seek lower-cost alternatives for all phases of subsystem implementation and to follow up on open items documented in the VE task force report during Preliminary Design. Implementation will be accomplished via the project's regular work planning and tracking process and the design planning and review process. This is now documented in the Project Execution Plan.	**Closed**

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33	**WBS 8 Neilson**	**Comment 1 in Section 12**: The annual "bottom-up" cost estimate provides a valuable management tool to Project leaders/managers and the Subcommittee strongly recommends that NCSX management commit to this activity. This activity will be a major impact on Project activities and progress each year, therefore, this activity needs to be included in the Project's master schedule, with milestones associated with this continuing activity. **Recommendation 12-2**: The project needs to document the plan to do an annual "bottom-up" estimation of cost to complete. This activity should be included in the project schedule.	*Project Response/Plan:* Agree. This will be done in connection with the expected regular Office of Science project reviews each year at or about the turn of the fiscal year. *FDR Update (May, 2004):* The plan for FY-04 is to perform the bottom-up re-estimate in August/September. By that time the prices for the MCWF and VVSA should be known and WBS managers will be planning their FY-05 jobs in detail.	**Closed.** Incorporated into project execution plans.
34	**WBS 8 Neilson**	**Comment 2 in Section 12:** The Project management stated their intention of keeping the Risk Management Plan current throughout the life of the Project. This is essential and Project Management must commit to this idea. Many of the identified risks will be managed and handled successfully, but as the Project proceeds new risks will be identified and earlier identified risks will indeed become reality and must be dealt with.	*Project Response/Plan:* Agree. *FDR Update (May, 2004):* The Risk Management Plan was revised and approved as a controlled document. A critical-issues tracking list has been adopted as a more flexible tool for day-to-day risk management. Newly recognized risks are classified as Category□I (Critical, but no resolution plan in place) and moved to Category□II (resolution plan being worked) and then Category□III (resolved). The list is reviewed and updated at weekly SIT meetings. A current list is posted on the web. Updated risk assessments will be presented at major project reviews.	**Closed**