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Recommendation #	Recommendation/Disposition Plan
II-1	*PVR panel report:* An important scientific frontier area is understanding the behavior of magnetized plasmas in 3 dimensional configurations. We find that the NCSX experiment will act as a focus and driver for the intellectual development of this important area of plasma physics in the U. S. plasma community. We recommend this scientific leadership role should be more clearly built into the description and execution of the NCSX program mission. *Plan:* The NCSX project will more clearly emphasize its benefits to 3D plasma physics in describing its mission in presentations and project documents in the future. The project will work with the Theory community in identifying research objectives in 3D plasma physics that complement as well as support NCSX, and that provide links to the broader magnetic confinement program. A draft letter to the Theory community identifying R&D issues in 3D plasma physics, based on project needs, is attached. Will update status at next configuration design update (Sept., 2001). *Primary Project Responsibility*: Hutch Neilson Status (June, 2001): Recent presentations have been modified to provide more visibility to benefits of 3D plasma physics. In addition, the project has encouraged and cooperated with Don Batchelor, who is organizing a workshop on "Future Directions in Theory of 3D Magnetic Confinement Systems" for later this fall. The Project provided a mailing list and has offered to present needs at the workshop. Status (September, 2001): In the stellarator community presentations to FESAC on August 1, the role of 3D Theory in the stellarator PoP program and its connection to other 3D plasma physics problems is more clearly explained. The benefits of compact stellarator research to 3D problems in basic plasma physics and toroidal confinement research are presented. Additionally, the Project is continuing to work with Don Batchelor in developing the agenda for the workshop on "Future Directions in Theory of 3D Magnetic Confinement Systems" planned for January, 2002. continued…

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Recommendation #	Recommendation/Disposition Plan
II-1 (cont'd)	Status (December, 2001). The role of the NCSX PAC has been broadened to also encompass stellarator theory and experimental physics research activities, including collaborations. This was a focus of the November PAC meeting, resulting in much valuable advice and strong PAC support for the upcoming workshop, "Future Directions in Theory of 3D Magnetic Confinement Systems," now scheduled for January 7-9, 2002. Several NCSX scientists will participate, both as organizers and presenters. That workshop will produce an assessment document identifying the needs and opportunities for theory and modeling of 3D fusion systems and what could be done to address those issues. Status (January, 2002) and proposed CDR position: The NCSX project has taken specific steps to promote 3D plasma physics research and incorporate advancement of 3D plasma physics into the NCSX mission description. This is now a programmatic issue which will receive our continued attention, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**

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Recommendation #	Recommendation/Disposition Plan
II-2	*PVR panel report:* There is concern that the present pre-conceptual design point may be "too small." This view is due to the marginal parameters in NCSX across a broad spectrum of experimental design factors such as: high energetic NBI ion losses, low base heating power, confinement assumptions needed to reach design beta, very small plasma/pfc distances for some equilibria, and neutral penetration concerns. We recommend that as the Project prepares for a Conceptual Design, the size of the design be carefully considered and well justified at the time of the CDR to allay concerns that critical parameters are being fit within a predefined budget envelope. *Project Response:* It is the case that performance margins have been kept small in order to minimize cost. However, the chosen design parameters (size, magnetic field, heating power pulse length) were carefully analyzed for the PVR and found to meet physics requirements. The proposed design provides the capabilities needed for the first year or more of physics research as well as possibilities for future enhancements depending on results and priorities at the time. The project will review its chosen design point, including an improved understanding of the range of adequacy, taking into account the points raised here, in the course of updating the configuration design for the CDR. Goals are to ensure adequacy of the design for the physics program while avoiding cost growth. *Plan:* After a careful review, the design point choice, including proposed changes if any will be documented to support the updated configuration design. (Sept., 2001). *Primary Project Responsibility*: John Schmidt Status (December, 2001). The project summarized its position on the choice of major radius and baseline heating configuration in the September progress report to DOE and in a presentation at the November, 2001, meeting of the NCSX Program Advisory Committee as follows: The requirements can be satisfied and physics goals can be accomplished at the PVR design point. There would physics benefit in increasing the size or power, but it would raise the cost and delay the program. Margins have been increased more cost-effectively through design improvements. No change is needed. Status (January, 2002) and proposed CDR position: The project decided to keep the PVR design point as the baseline, as documented in the September progress report and the November PAC presentations. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
II-3	*PVR panel report:* An attractive vision of a CS based fusion power system has not yet clearly articulated by the Project and a comprehensive fusion reactor design study has not yet been carried out. This situation makes it more difficult to build community enthusiasm for the CS concept and to justify the design requirements in key physics parameters for the PoP program. We recommend the Project devote some effort to developing this reactor vision and also to strongly support the initiation of a comprehensive fusion reactor design study of the CS concept. *Project Response:* Comprehensive reactor design studies are an element of the proposed compact stellarator proof-of-principle program. Up to now, limited compact stellarator reactor extrapolation studies have carried out by the project; those were documented in the PVR documentation. Future reactor studies will be led by the ARIES team and should be based on a CS magnetic configuration that is optimized as a reactor, which needs to be developed as a first step, before a comprehensive study is undertaken. The ARIES team has already indicated they are very interested in carrying out such a study. *Plan:* The project will continue to work closely with the ARIES team in planning and carrying out reactor studies. Will update status at next configuration design update (Sept., 2001). *Primary Project Responsibility*: Jim Lyon Status (December, 2001). Jim Lyon has discussions with the ARIES team on a continuing basis regarding their input needs and schedule requirements. These discussion have produced a preliminary understanding of the approximate cost and possible schedules for an ARIES CS reactor study, and the preparatory work that both the ARIES and stellarator teams would need to do. The ARIES program is supporting some preparatory physics studies in FY-2002 as a first step toward developing a candidate coil configuration for a reactor study. The timetable for completing the preparatory work and carrying out a full study is still under discussion. Status (January, 2002) and proposed CDR position: NCSX project leaders and PPPL management are working with the ARIES team to develop a plan for preparatory work and a CS reactor study. This is a programmatic issue which will receive our continued attention, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**

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Recommendation #	Recommendation/Disposition Plan
II-4	*PVR panel report:* Plasma flow in a QAS stellarator has been identified by the NCSX Project as a key physics issue which also connects CS and tokamak confinement physics. The Project should more seriously investigate expected flow drive and damping mechanisms in 3-D plasmas in planning the experimental program on NCSX. ***Project response:*** The critical quantity for the stellarator design is the toroidal flow damping rate, since it could set the upper bound on acceptable ripple. Neutral beams and mode-conversion RF (as an upgrade) will provide a source of flow. The project will use existing tools to estimate flow rates expected in NCSX, however because of the low effective ripple (0.01%) in the core, we do not expect 3D effects to dominate in that region. The project will work with the Theory community to encourage research on flow drive and damping mechanisms. *Plan:* The project will evaluate flow damping using analytic calculations and report results at the CDR. (April, 2002). *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). Initial estimates of flow damping and and rotation driven by ambipolar radial E-field were presented at the PAC-5 meeting (Nov., 2001). Anticipated completion date remains the CDR (April 2002). Status (January, 2002) and proposed CDR position: Analyses sufficient for design purposes will presented at the CDR. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
II-5	*PVR panel report:* The link between primary experimental physics objectives and the critical diagnostics needed to achieve these objectives is not yet well defined. Careful definition of this important part of the science mission and experimental program of NCSX is essential and should be completed as part of the conceptual design. ***Project response:*** Agree. *Plan:* Will develop an experimental strategy as a basis for defining diagnostic requirements and document for the CDR. (April, 2002). *Primary Project Responsibility*: Dave Johnson Status (December, 2001). The Project is continuing to develop the logic linking diagnostics to physics program and priorities as indicated in the diagnostic implementation plan. Developing a matrix relating physics issues to plasma parameters measured to diagnostic requirements. Planning to include in this matrix a summary of the geometrical access requirements for diagnostics in the plan. Providing more detail on plans for measurements of flow and turbulence. A phased NCSX experimental program plan was presented at the PAC-5 meeting (Nov., 2001). Research topics were listed for each phase and measurements needs to address those topics were identified. For the CDR, a diagnostic plan to meet the time-phased measurement needs will be developed. Status (January, 2002) and proposed CDR position: An experimental plan at a level detail sufficient for design purposes will presented at the CDR. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
II-6	*PVR panel report:* The review lacked a full discussion of the status of QAS vis-à-vis the large range of stellarator possibilities. While the advantages of QAS were made clear, there was essentially no discussion of its limitations. The presentation of these comparisons would likely increase the desirability of diverse stellarator experiments and enhance understanding of the role of the CS in the portfolio of toroidal magnetic configurations by the broad fusion science community. ***Project response:*** The limitations of the QAS concept depend on its physics (equilibrium and stability limits, transport and its dependence on quasi-symmetry, edge characteristics, etc.). Our current understanding of these limits was documented for the PVR (e.g., Chapters 4, 5, 6, 8, and 11), as was the relationship of NCSX to other stellarator experiments (Chapter 1). The proposed physics research on NCSX will improve the physics understanding, and is needed to assess attractiveness relative to other concepts. *Plan:* The role of NCSX in the context of the U.S. program and its relationship to the world program will be explained at the CDR. *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). Recent NCSX presentations have more carefully explained both benefits and costs and the relationship of NCSX to other stellarators. This work will be done as part of the preparation of the physics documentation to support the CDR. Expected to be completed in the second quarter of FY-2002. Status (January, 2002) and proposed CDR position: As recommended by its Program Advisory Committee in Nov., 2001, the NCSX team will concisely state the mission of the device, including its relationship to the U.S. and world fusion program, at the CDR. There are no issues as far as NCSX design and fabrication are concerned. **Will be presented in the context of the mission.**

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Recommendation #	Recommendation/Disposition Plan
III-1	*PVR panel report:* Examine island formation, destruction of flux surfaces, and maintenance of QA symmetry, using *finite model* coil configurations close to the final design. ***Project response:*** Agree, already underway *Plan:* Will document for the CDR. (April, 2002). *Primary Project Responsibility*: Wayne Reiersen, Mike Zarnstorff Status (December, 2001). Preliminary results did not show significant differences between PIES and VMEC solutions. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**
III-2	*PVR panel report:* Study the effects of coil construction errors, and other field perturbations, on flux surfaces in particular, and equilibrium and stability in general. ***Project response:*** Agree. This is needed to set tolerances. *Plan:* Will document for the CDR. (April, 2002). *Primary Project Responsibility*: Wayne Reiersen, Mike Zarnstorff Status (December, 2001). A work plan for perturbation studies, and some results, were presented at the PAC-5 meeting (Nov., 2001). This study will be completed prior to the CDR to establish tolerance requirements. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
III-3	*PVR panel report:* Carry out, where appropriate, calculations of island formation and destruction of surfaces in the full torus, dealing with perturbations that break the 3-fold symmetry. ***Project response:*** The effects of symmetry-breaking field errors will be analyzed to set tolerances and correction coil requirements. Various approaches, including full-torus calculations, are under way. *Plan:* Will document for the CDR. (April, 2002). *Primary Project Responsibility*: Wayne Reiersen Status (December, 2001). A work plan and some results were presented at the PAC-5 meeting (Nov., 2001). This study will be completed prior to the CDR to establish tolerance requirements. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
III-4	*PVR panel report:* Develop additional self-consistent startup evolutions, using the final coil set, with realistic, time-dependent collisionalities, especially in the evaluation of the bootstrap current. ***Project response:*** An improved transport model will be incorporated into the startup modeling to refine coil current and volt-second requirements. *Plan:* Will document by CDR (April 2002). *Primary Project Responsibility*: Mike Zarnstorff Status (January, 2002). Inclusion of the improved transport model and updating the scenario analysis with the new (M45) coil design is part of the FY-2002 work plan. Status (January, 2002) and proposed CDR position: Report status at the CDR. **CDR Issue (Charge #1a).**
III-5	*PVR panel report:* Use these self-consistent start-up scenarios in PIES and other codes to examine flux surface quality and stability properties at a number of points along the evolution path. ***Project response:*** Agree. *Plan:* Will document by CDR (April 2002). *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). PIES convergence was speeded up as a preparatory task in FY-2001. Updated physics analyses of NCSX equilibria are included in FY-2002 work plan. Status (January, 2002) and proposed CDR position: Report status at the CDR. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
III-6 (Rev 1)	*PVR panel report:* Develop real-time reconstruction of the last plasma surface from external magnetic measurement, for purposes of real-time control. ***Project response:*** We agree that real-time plasma control is needed and expect this capability to be developed in stages, starting with simpler approaches than real-time reconstruction. *Plan:* • Develop the full real-time reconstruction capability in stages, e.g.: - Linear flux projection (constant coefficients). - Nonlinear flux projection (plasma parameter-dependent coefficients) - (Possibly) real-time reconstruction. • Develop "3D EFIT" (recommendation III-7a), which is necessary for the development of both flux-projection methods. *Primary Project Responsibility*: Ed Lazarus Status (December, 2001). A proposal to for development of a 3D equilibrium reconstruction code, that encompasses III-6, III-7a, and III-7b, was submitted to OFES. The project's understanding is that it will be funded in FY-2002. Status (January, 2002) and proposed CDR position: In response to this recommendation, a proposal was developed by the community and has been funded by DOE. **Explain in the context of NCSX research preparation (Charge #4).** Note: NCSX design/fabrication issues related to this task are covered in III-7(b).

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Recommendation #	Recommendation/Disposition Plan
III-7 (a) (Rev 1)	*PVR panel report:* Develop a 3D counterpart to the EFIT code for reconstructing equilibrium profiles from internal and external experimental measurements. ***Project response:*** We agree that this capability is needed and should be developed. Proposals are being prepared to address this. Collaboration with other groups is planned in order to develop this capability, which is also needed for tokamaks and other stellarators, as cost-effectively as possible. *Plan:* Develop full "3D EFIT" in the long term. *Primary Project Responsibility*: Ed Lazarus Status (December, 2001).Addressed in item III-6. Status (January, 2002) and proposed CDR position: In response to this recommendation, a proposal was developed by the community and has been funded by DOE. **Explain in the context of NCSX research preparation (Charge #4).** Note: NCSX design/fabrication issues related to this task are covered in III-7(b).

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Recommendation #	Recommendation/Disposition Plan

III-7 (b) (Rev 1)	*PVR panel report:* Identify the critical measurements necessary to accurately reconstruct the equilibrium so that they can be integrated into the NCSX machine design.
	
	Project response: Critical measurements needs will be identified for the CDR.
	
	Plan:
	• *By the CDR (April, 2002)*
	  • Identify critical measurement needs and diagnostic solutions.
	  • Establish space envelopes and interfaces with the critical machine systems (coils, vacuum vessel, in-vessel hardware), as part of an integrated facility configuration design.
	  • Develop plans for completing the design and construction of the diagnostics within the project's scope.
	
	Primary Project Responsibility: Dave Johnson
	
	Status (December, 2001). Work needed for the CDR is included in FY-2002 work plan. Status of the long-term plan is addressed in item III-6.
	
	Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
III-8	*PVR panel report:* The NCSX Project should promote the development of 3D tearing mode theory and computation. ***Project response:*** Agree. *Plan:* We have been and will continue to work closely with the Theory community to encourage this. *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). The Project suggested M3D development as a topic for the 3D Physics Theory Workshop (see II-1) and it will be addressed there. In addition, M3D effort has received funding for stellarator work via SCIDAC. Status (January, 2002) and proposed CDR position: This is an issue for long-term research, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**

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Recommendation #	Recommendation/Disposition Plan
IV-1	*PVR panel report:* The Panel recommends that the NCSX team plan on using 6 MW of NBI power as the primary heating source. ***Project response:*** Agree, but can be achieved without including all 6 MW in the baseline. *Plan:* Two beams (3 MW) are included in the baseline and will be available for use in the first year. The current plan is to propose the remaining two beams (for a total of 6 MW) as the first heating upgrade. Will document and justify at CDR (April 2002). *Primary Project Responsibility*: John Schmidt Status (December, 2001). The project's position was presented to the PAC at the November, 2001 meeting in connection with the discussion on design point (II-2). See II-2 for details. Status (January, 2002) and proposed CDR position: The project decided to keep the PVR design point as the baseline, as documented in the September progress report and the November PAC presentations. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-2	*PVR panel report:* The present machine design results in significant beam orbit losses. This lowers the absorbed heating power somewhat, and also reduces the room for maneuver in setting up configurations with balanced momentum input or sheared rotation. The Panel recommends that these marginal conditions in the current design, which may limit control of flow shear and optimization of absorbed power, be carefully considered and clear solutions (*e.g.* flexibility in re-orienting the beam lines) be identified prior to the CDR. ***Project response:*** The need for additional capabilities to control flow shear and power absorption will be considered as part of the design-point review described in the response to Recommendation II.2. *Plan:* Minimize neutral beam orbit losses in choosing the reference coil design *Primary Project Responsibility*: Henry Kugel Status (December, 2001). The need for additional capabilities to control flow shear and power absorption will be considered as part of the conceptual design process. An element of this response is the investigation in progress for providing flexibility in the baseline to allow for the possible reorientation of the neutral beamlines. This involves 1) determining implications and costs for providing in the baseline sufficient power cable slack, and flexible water and vacuum lines. Given the ability to install the beamlines so as to facilitate future angle adjustments, it is also necessary to determine 2) how many angular degrees, the NBI aiming be varied before interfering with external constraints (coils and vessel structures), 3) the implications for the transition duct design as this angle is varied, and 4) given the beamline angle change allowed by the exterior constraints, and a willingness to accept reduced injected power for the sake of a particular experiment, what are the power deposition issues in the vessel as the injection angle changes to its maximum allowed +/- values (e.g., far-wall RF antenna's and diagnostics, and the available space for wall armor in the duct and narrowest sections of the vessel. Status and Status (January, 2002) and proposed CDR position: Aiming flexibility, which is tightly limited by the beam and machine dimensions, is not a solution to this issue. In selecting its reference coil design for the CDR, a high-priority goal was reducing the calculated neutral-beam orbit losses, to the extent that additional time and effort was devoted to achieving it. It resulted in coil design improvement which reduced the calculated losses from 1.5 times to 1.1 times the losses in the reference plasma over a two-month period. The physics goals can be accomplished with this design. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-3	*PVR panel report:* The Panel thus recommends that the NCSX team plan to increase the NBI pulse length to 500 ms or more as soon as possible. ***Project response:*** The beams already have this capability at 2/3 of rated power. *Plan:* Higher power at this pulse length is feasible and will be pursued in the course of optimizing beam operation in the operations phase of the program. *Primary Project Responsibility*: Henry Kugel Status (June, 2001): The NB power handling surfaces were engineered by ORNL to operate at a maximum of 500 msec pulses at the full power peak power density of 3 kW/cm^2. Both ORNL and PPPL have previously demonstated to operate with H^0 and D^0 species at this pulse length and power. In addition, experiments at MAST are exploring even longer pulse lengths. Accordingly, NCSX will consider steps to increase the NBI pulse length to 500 msec or longer. In order to achieve this, a plan is being developed to complete work previously initiated, but not completed, and to optimize beam operation in the initial plasma heating and transport phase of the program to upgrade to 500 msec NBI operation. This will require addition of a software and controls engineer as part of the startup team and initial plasma heating and transport phase to ensure that the required additional thermal diagnostics are added, that these new diagnostics are interlocked with operator alarm displays, and a test program that increases the pulse length gradually is implemented. Status (December, 2001). The initial NB injection is for 300 ms. Operations labor money can handle upgrading from 300 to 500msec during the initial plasma heating phase. There may be some small amount of M&S required which cannot be determined until we start bringing up the systems. The schedule for this will be approximately the beginning of the 2nd operating period following first injection. This will allow using the first major maintenance period following the first injection to repair systems and prepare for longer pulse operation. No further work planned at this time. Status (January, 2002) and proposed CDR position: This is an issue for operations, but there are no issues as far as NCSX design and fabrication are concerned. **Part of NCSX research program planning (Charge #4).**

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Recommendation #	Recommendation/Disposition Plan
IV-4	*PVR panel report:* The Panel recommends that provision to accommodate suitable antennas on the high-field side of the torus be made in the base machine design, with actual deployment of the antenna system coming after the experiments with NBI are well in hand. ***Project response:*** Agree. *Plan:* The machine is being designed to accommodate high-field-side antennas for mode-conversion heating. The antenna system is planned as an upgrade. (CDR, April, 2002). *Primary Project Responsibility*: Wayne Reiersen Status (December, 2001). Design impacts of accommodating inboard RF have been accommodated. In developing the NCSX conceptual design, the capability to accommodate high-field-side antennas is now considered to be a requirement. Status (January, 2002) and proposed CDR position: Will address the feasibility of meeting this requirement at the CDR. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-5	*PVR panel report:* The Panel therefore recommends that work on HHFW for NCSX be deferred to a later stage in the NCSX program. ***Project response:*** Agree. *Plan:* The machine is being designed to also accommodate HHFW antennas on the outboard side. The antenna system is planned as an upgrade. More data on this scenario will likely be available from NSTX well before decisions on implementation have to be made. *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). Will be revisited later in the Project. No further work planned at this time. Status (January, 2002) and proposed CDR position: **Part of NCSX research program planning (Charge #4).**

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Recommendation #	Recommendation/Disposition Plan
IV-6	*PVR panel report:* The Panel recommends that calculations of the circuit and image current responses be coupled into the development of experimental discharge control scenarios. ***Project response:*** At this time, we do not think this is necessary as part of the conceptual design, as the wall time-constant is much less than the time-scale for anticipated magnetic field changes (by design). *Plan:* This will be done in the long term. It may be needed for operations. *Primary Project Responsibility*: Mike Zarnstorff Status (December, 2001). Not needed for the CDR. This will be developed and investigated during preparation for operations. No further work planned at this time. Status (January, 2002) and proposed CDR position: **Part of NCSX research preparation and program planning (Charge #4).**

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Recommendation #	Recommendation/Disposition Plan
IV-7	*PVR panel report:* The Panel recommends that, now that the general magnetic configuration has stabilized, an intensive investigation of the neutral penetration issue be carried out. This would involve detailed study of the 3-D field structure and application of existing edge physics models in appropriate frames of reference, and comparison with relevant experimental results, especially those from Wendelstein 7AS, which has a similar edge topology. The Panel notes that this project would be an excellent target for expanded collaboration with the US edge physics and stellarator community as well as with overseas stellarator programs. ***Project response:*** The minimum waist full-width was at least 24 cm for all the NCSX configurations presented at the PVR. The W7-AS experiment has a waist that is about 14-17 cm minimum full-width, depending on the configuration, yet W7-AS obtains temperatures up to ~2keV (with peak Te as high as 5keV). The neutral penetration in a stellarator, where the narrow waist regions are localized, is much less than in an axisymmetric device with the same minimum waist width. Neutral penetration calculations, detailed studies of 3D field structures, application of edge physics models, and comparisons with experimental results are planned as part of CDR preparations. The project will work with the international collaboration program leadership to encourage collaboration on this topic. *Plan:* Document analyses and physics requirement for the CDR. (April, 2002). *Primary Project Responsibility*: Peter Mioduszewski continued…

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Recommendation #	Recommendation/Disposition Plan
IV-7 cont'd.	Status (December, 2001). At the PAC-5 meeting (Nov., 2001), progress in 3D field line analysis, edge transport modeling, and neutrals modeling was presented. The implications for NCSX of recent W7-AS divertor results were assessed. The FY-2002 work plan for boundary physics analysis in preparation for the CDR was presented. The project's plan for a phased approach to eventual implementation of a pumped divertor was endorsed by the PAC. The plasma-facing components are being designed in such a way that recycling occurs at the banana tips and not the midplane. Calculations presented at the PVR and updated for the PAC show that the neutral penetration is drastically reduced in that case. The LLNL theory group has proposed a collaboration with the German stellarator group in the development of a 3D boundary plasma simulation code. Status (January, 2002) and proposed CDR position: The boundary physics program that has been undertaken is responsive to the recommendation and was endorsed by the PAC. A concise update of the PAC presentation and the status of any issues affecting the NCSX design and fabrication project will be presented at the CDR. **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-8	*PVR panel report:* The Panel recommends that prior to the CDR the NCSX team develop a matrix relating the key program physics issues to the diagnostic requirements to investigate them, as well as the geometric access required to perform the measurements. This will facilitate setting priorities, staging, and even port allocation, and will also catalyze the expansion of collaborative relationships with the US and international fusion communities by providing accessible entry points. ***Project response:*** Agree. *Plan:* • Develop an experimental strategy as the basis for defining diagnostic requirements and document programmatic rationale for diagnostic selection, including a matrix relating diagnostics to physics issues, for the CDR. (April, 2002) • Develop diagnostic configuration for the CDR. (April, 2002). *Primary Project Responsibility*: Dave Johnson Status (December, 2001). Partly addressed in II-5. Continuing to develop the logic linking diagnostics to physics program and priorities as indicated in the diagnostic implementation plan. Developing a matrix relating physics issues to plasma parameters measured to diagnostic requirements. Planning to include in this matrix a summary of the geometrical access requirements for diagnostics in the plan. Providing more detail on plans for measurements of flow and turbulence. In addition, working to integrate diagnostic access requirements with the VV and coil design for particular diagnostic systems included in the diagnostic implementation plan with initial assessments of sightlines and fields of view obtainable, and identification of critical issues. In particular, considering whether diagnostic access to symmetry planes can be obtained. Also giving particular attention to diagnosing 3D nature of the plasma. Integration of diagnostics with the stellarator core design is included in the FY-2002 work plans in preparation for the CDR. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-9	*PVR panel report:* Because of the special concerns about flux surface robustness at low aspect ratio, the unique magnetic geometry of NCSX, and the anticipated use of trim coils to fine tune the magnetic configuration in the presence of both predictable and discovered perturbation fields, the Panel recommends the deployment of a system for convenient, rapid electron-beam flux surface measurements as part of the permanent operational equipment of the machine. Such a system should use retractable components so that it can be operated without causing major interruptions to plasma operation. ***Project response:*** This will be carefully evaluated as part of developing the diagnostic configuration for the CDR. *Plan:* Document electron-beam design and rationale for the CDR. (April, 2002). *Primary Project Responsibility*: Dave Johnson Status (December, 2001). The Project plans to complete the conceptual design of the e-beam mapping system and develop a plan for operation in FY-2002. Will assess feasibility of a retractable system deployable without serious impact on plasma operations. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-10	*PVR panel report:* Experience on other toroidal confinement experiments indicates that measurements of the changes in the magnetic field induced by the plasma provide the basis for the reconstruction of equilibria, physics analysis, and ultimately optimal control of plasma performance. The Panel recommends that the development of magnetic diagnostics and analysis be integrated with the configuration and engineering design process. ***Project response:*** We agree. *Plan:* Document magnetic diagnostic design and rationale for the CDR. (April, 2002). *Primary Project Responsibility*: Dave Johnson Status (December, 2001). Complete conceptual design of magnetic diagnostics is required for plasma control, equilibrium reconstruction, and MHD analysis. This design will be integrated with the engineering design of the VV, the PFC system, and the diagnostic access ports. Will begin optimization of sensor number and location in conjunction with the development of the 3D EFIT. Will consider the strategy for installation and maintenance of in-vessel sensors. Work that is required for the CDR is included in FY-2002 work plans. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-11	*PVR panel report:* The QAS configuration was chosen in large part because of its predicted capacity to support sheared flows like those developed in enhanced confinement tokamak plasmas in which turbulent energy transport is greatly reduced. The Panel thus recommends that measurements of turbulence and flow with sufficient spatial resolution to address key physics questions should play a more prominent role in the diagnostics program than appears to be the case at present. ***Project response:*** Measurements of turbulence and flow with sufficient spatial resolution to address key physics questions will be included in the diagnostic configuration development for the CDR. *Plan:* Document turbulence and flow diagnostics design and rationale for the CDR. (April, 2002). *Primary Project Responsibility*: Dave Johnson Status (December, 2001). Addressed in items items II-5 and IV-8. Continuing to develop the logic linking diagnostics to physics program and priorities as indicated in the diagnostic implementation plan. Developing a matrix relating physics issues to plasma parameters measured to diagnostic requirements. Planning to include in this matrix a summary of the geometrical access requirements for diagnostics in the plan. Providing more detail on plans for measurements of flow and turbulence. Included in FY-2002 work plans in preparation for the CDR. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
IV-12	*PVR panel report:* The three-dimensional nature of the stellarator configuration places additional demands on diagnostic development, favoring the use of multi-view and large area imaging systems. The Panel recommends that greater consideration be given to the specifications of such systems in preparation of the detailed experimental program. ***Project response:*** We agree that the stellarator has special features that affect the optimization of the diagnostic configuration. We will take these into account and study the solutions suggested here in the course of developing the diagnostic configuration for the CDR. *Plan:* Document diagnostic configuration design and rationale for the CDR (April, 2002), including a discussion of how issues associated with the stellarator geometry are accommodated. *Primary Project Responsibility*: Dave Johnson Status (December, 2001) Same response as for second part of item IV-8. In addition, working to integrate diagnostic access requirements with the VV and coil design for particular diagnostic systems included in the diagnostic implementation plan with initial assessments of sightlines and fields of view obtainable, and identification of critical issues. In particular, considering whether diagnostic access to symmetry planes can be obtained. Also giving particular attention to diagnosing 3D nature of the plasma. A new 18-coil modular and TF coil design was developed in FY-2001, which has no coils centered on symmetry planes, providing better diagnostic access there. This is responsive to a point that was made at the PVR and was presented to the NCSX PAC at the November, 2001, meeting. Status (January, 2002) and proposed CDR position: **CDR Issue (Charge #1a).**

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Recommendation #	Recommendation/Disposition Plan
V-1	*PVR panel report:* The PPPL/ORNL partnership has been successful in developing the NCSX pre-conceptual design. However, looking forward to the CDR and beyond, we recommend that a more inclusive management approach be adopted to successfully implement the CS PoP program with NCSX playing the primary organizing role. The NCSX management should try to involve all elements of the US and international stellarator activities to form a truly National CS Program with international collaborations. This should include both experimental and theoretical activities. For example, (i) more direct contact and collaboration with existing stellarator experiments is needed to solidify the physics and operational base for the Conceptual Design; (ii) opportunities exist to benchmark the PIES code against similar codes (*e.g.* HINT at NIFS in Japan) and against experimental stellarator results; (iii) serving as a focus for or supporting organizing efforts in the theory community to more effectively address 3D magnetized plasma physics; and (iv) making plans to begin establishing a national experimental research team to carry out experiments on NCSX. *Project response:* The NCSX project management will focus on its responsibility to construct the NCSX facility and, ultimately, to carry out the experimental research on NCSX. At the same time, the project will work to encourage strong programs in 3D theory, 3D diagnostic development, and international collaboration on stellarators. The project will cooperate with the managers of those programs at the various institutions and in DOE in efforts to continuously improve coordination among all elements of the U.S. stellarator program and to optimize its overall effectiveness. *Plan:* As to the specific suggestions made: (i) PPPL is strengthening its stellarator collaboration program and, by involving some of the same people, its coupling to NCSX. Because of the time required for collaborations to be established and bear fruit, the physics benefits to NCSX from such collaborations would be more apparent in the operating phase than in the conceptual design work in the coming year. (ii) PIES-HINT benchmarking efforts are already in progress; benchmarking against experimental results is planned. (iii) The project will strongly encourage and cooperate with Theory program efforts to advance 3D plasma physics. (iv) Provisions for national collaboration will be explicitly included in the planning and budgeting for operating NCSX, which is in the early stages. continued…

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Recommendation #	Recommendation/Disposition Plan
V-1 cont'd.	The project will cooperate with Laboratory management and the managers of the theory and domestic and international collaboration program in taking steps toward a more inclusive management approach. For example, steps being considered at PPPL: • Work with the domestic diagnostic development community to promote discussion of NCSX diagnostic needs. • Strengthened coordination among NCSX, theory and computation, collaboration, and reactor study efforts. • Broadening the charter of the stellarator program advisory committee (heretofore focussed exclusively on NCSX) to include all elements of PPPL's stellarator program. • Inviting other institutions to participate in PPPL's stellarator PAC process if they so desire. *Primary Project Responsibility*: Hutch Neilson Status (June, 2001): (i) The Project has been working with the International Collaboration leadership at PPPL and ORNL in the planning of collaborations with LHD and W7-AS. The aim of our involvement is to strengthen the coupling of NCSX in the choice of collaboration topics and the involvement of some of the same people in both NCSX and International Collaboration. (ii) PIES-HINT benchmarking is included in the Project's work plans and Don Monticello recently spent several weeks at NIFS working on it. (iii) The Project is working with the Theory Program leadership (Don Batchelor and others in organizing their 3D Physics Theory Workshop (see II-1). (iv) Plans to broaden the scope of PPPL's Stellarator Program Advisory Committee were announced by Rob Goldston at the May FESAC meeting. continued…

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Recommendation #	Recommendation/Disposition Plan
V-1 cont'd.	Status (September, 2001): NCSX physicists Hutch Neilson and Allan Reiman were members of a delegation led by Raffi Nazikian, PPPL International Collaborations Head, which visited NIFS in July, 2001, to plan collaborations with LHD. Physicists who have been involved in the NCSX design work have begun to shift focus to collaborations with LHD and W7-AS. Physics topics include neoclassical transport, anomalous transport, energetic ion physics, and MHD equilibrium and stability. Progress was made in planning collaborative research tasks. Status (December, 2001). The NCSX Program Advisory Committee's charter has been revised, broadening it to encompass other PPPL stellarator activities and to provide the opportunity for stellarator groups outside of PPPL to make presentations if they wish. The PAC-5 meeting in November included presentations and discussion on theory and collaboration. NCSX physicists will participate in the workshop on "Future Directions in Theory of 3D Magnetic Confinement Systems" for January, 2002. The stellarator community is working together in the preparations for the ICC meeting in January, and the Snowmass meeting on burning plasmas in July. Status (January, 2002) and proposed CDR position: Specific steps have been taken to adopt a more inclusive management focus. This will receive continued attention, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**

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Recommendation #	Recommendation/Disposition Plan
V-2	*PVR panel report:* The FESAC Program & Balance Report set out a 10-year goal to "Determine attractiveness of a Compact Stellarator by assessing resistance to disruption at high beta without instability feedback control or significant current drive, assessing confinement at high temperature, and investigating 3-D divertor operation." We find that the CS PoP program plan presented to us by the Project is aimed at meeting this goal, and that NCSX is the central element in that plan. However, we note that other supporting elements are called out including theory and modeling support, and CE level experimental programs (some of which are already funded projects by DOE). In addition to these elements listed by the NCSX Project, we recommend that a comprehensive CS fusion reactor design study be included in the PoP plan as an important element in achieving this FESAC 10-year goal to determine the attractiveness of the CS concept. *Project Response:* See response to Recommendation II.3. Will update status at configuration design update (Sept., 2001). *Primary Project Responsibility*: Jim Lyon Status (December, 2001). Addressed in item II-3. Status (January, 2002) and proposed CDR position: NCSX project leaders and PPPL management are working with the ARIES team to develop a plan for preparatory work and a CS reactor study. This is a programmatic issue which will receive our continued attention, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**

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Recommendation #	Recommendation/Disposition Plan
V-3	*PVR panel report:* We note that the PoP Panel endorsed classification of the CS as a PoP program. We recognize that construction of NCSX would be a relatively costly investment over many years by the Fusion Energy Sciences Program. Therefore, we recommend the OFES and FESAC address the larger programmatic issues to determine whether or not to proceed with construction of NCSX and, if so, on what time scale. These include the issue of program balance within available fusion program budgets, needs of present elements in the program, and opportunities for other new starts and collaborations. *Plan:* The project will support the OFES and FESAC decision process. *Primary Project Responsibility*: Hutch Neilson Status (December, 2001). The stellarator community presentations to FESAC in May and August explained the program goals, the purpose of each element of the program and their interrelationships, the costs, and the program's expected benefits to fusion science and energy. Status (January, 2002) and proposed CDR position: The project will continue to support decision processes, but there are no issues as far as NCSX design and fabrication are concerned. **Not a CDR issue.**