Second Report of the Informal National Compact Stellarator Experiment Program Advisory Committee

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The Informal National Compact Stellarator Experiment (NCSX) Program Advisory Committee met on December 2-3, 1998 to advise the director of the Princeton Plasma Physics Laboratory, Robert Goldston, on whether the appropriate: (1) requirements and constraints are being placed on the design of the NCSX for the facility to economically address the central physics issues; (2) plasma, coil concept, and machine implementation options have been identified; and (3) analyses are being performed to evaluate plasma, coil concept, and machine implementation options. In addition to presentations on NCSX, the Committee was given background information on a proposal being developed for a complementary stellarator concept exploration facility based on the concept of quasi-omnigenity. The Committee would like to compliment the team working on the concept exploration proposal, but no specific recommendations were requested or are given on this effort.

The Committee would like to compliment the NCSX team on the quality and forthrightness of the presentations and on the completeness of the answers to the questions that the Committee posed.

The NCSX team suggested a May/June 1999 date for a Physics Validation Review (PVR). The Committee recognizes the need for a timely PVR. Given sufficient time, it is very likely that a quasi-axisymmetric stellarator can be designed that is consistent with the properties sought by the NCSX team. However, a number of serious design issues remain, and there is concern about their resolution before the suggested May/June date for a PVR.

The Committee endorses having a decision between the inside-PBX and the new machine option for the NCSX facility by the end of December 1998. An early decision is critical to meeting the suggested PVR schedule. The NCSX team must develop a clear rationale for this decision, which should not necessarily be on cost alone.

The development of a suitable coil system defines the critical path for achieving a May/June PVR. By the time of the PVR, a buildable coil set must be found that gives plasma configurations, including a start-up path, that are consistent with the goals of NCSX. The absence of a suitable coil system is limiting progress in a number of areas required for the PVR. Whatever resources are required to speed progress in this area should be supplied.

A start-up scenario should be defined using a set of fixed-time equilibria with the final beta value consistent with the project objectives. The profiles of pressure and current can be any profiles that could be obtained with the available heating power, Ohmic transformer, and coil system. Although it is preferable that the final profiles be consistent with the likely bootstrap current of a power plant, this is not essential for the program to achieve its highest priority goals.

The analysis of energy confinement in NCSX should be extended to include the effect of the radial variation of the anomalous transport. This extension may relieve some of the issues of axisymmetric neoclassical transport that are associated with the relatively low poloidal flux content of the present NCSX designs. A better design criterion is required than a global energy confinement time.

The Committee endorses the priority ranking that was presented by the NCSX team. In priority order, these were:

1. Achievement of an average beta greater than 4% in plasmas that do not disrupt.

2. Optimization of the quasi-axisymmetry.

3. Definition of a robust and flexible set of plasmas that could be credibly produced in the NCSX.

4. The achievement of the three higher priorities in plasmas that have current and pressure profiles that are consistent with the likely bootstrap current of a power plant.

Lower priority items, in order of priority, include:

5. Minimization of beam-orbit loss.

6. Maximization of the rotational transform produced externally.

7. Achievement of the collisionality of a power plant grade plasma.

A number of other issues need to be addressed by the NCSX team before the Physics Validation Review. The team should: (1) Give a rationale for the choice of pulse length relative to the project priorities and cost. (2) Examine the error fields produced by eddy currents in support structures such as the thick aluminum shell that was described as part of one of the inside-PBX options. (3) Study the effect of Alfven modes on the confinement of high energy particles. (4) Examine the utility of ion cyclotron heating for reaching NCSX goals. (5) Consider the consistency of the NCSX design with electron cyclotron heating.

Finally, the project should establish closer relations with the major stellarator efforts within the world fusion program. In particular, one or more NCSX team members should spend sufficient time with the W7-AS and the CHS stellarator groups to assess the implications of the data from these stellarators on the NCSX design.