Chapter 13 -- Project Plans and Management

13.1. Project Schedule

13.1.1 Current Status

The NCSX project efforts leading up to this review have produced the physics basis for the NCSX proof-of-principle experiment. The scientific mission has been identified and physics requirements consistent with that mission have been developed. Pre-conceptual engineering design efforts, which have complemented the physics efforts during this phase, have produced a reference pre-conceptual design illustrating the existence of a practical machine concept that satisfies physics requirements and can be used in predicting cost and schedule ranges. The design has not been fully analyzed nor has it been optimized; these tasks will be accomplished in the next phase, conceptual design. At this stage, a significant portion of the engineering effort is devoted to the study of alternative design solutions aimed at identifying ways to reduce the cost or risk, or to improve the schedule.

13.1.2 Completing the Design, R&D, and Construction

Following this review, the review findings and recommendations will be incorporated into the project's plans for developing the design and research program. The next step will be to update the reference NCSX design, incorporating improvements identified from completed and ongoing trade studies. That update, scheduled for September, 2001, will be the basis on which the conceptual design will be developed. A conceptual design review (CDR) is currently planned for April, 2002. It is expected that the CDR will formally establish the baseline design, cost, and schedule for NCSX, with changes thereafter being subject to more rigorous control. Approval to construct NCSX would depend on a successful outcome of the CDR.

R&D and physics activities will be important to support the design development. The R&D activities will range from small-scale tests to establish design criteria to large-scale prototypes to establish manufacturing approaches and costs. Manufacturability input from industry will continue to be a feature of the design process. Physics analyses (e.g., coil-set design and flexibility, operating scenarios, boundary physics) will continue in support of the design process. Although the project's activities will become more engineering-oriented, it is expected that a stellarator theory and experimental collaboration program will continue outside the project.

Detailed engineering design is proposed to begin in FY 2003 with fabrication activities starting in FY 2004. After completing machine assembly and pre-operational testing, first plasma will be achieved, marking the completion of the project. For planning purposes, a target of the end of FY 2006 has been established.

13.2 Project Cost

Cost has been a prime consideration in establishing the design parameters for NCSX. The machine size (1.4 m) and maximum toroidal field (approximately 2 T) were established to keep the project cost at the target value of $55M (in FY 1999 dollars) while meeting the mission objectives. This project has been categorized by DOE as a Major Item of Equipment (MIE) activity and the project cost defined accordingly.

The first step in developing the estimate was to determine and document the scope of work. A Work Breakdown Structure (WBS) was established to facilitate definition of the scope of work and tabulate cost. The criteria for determining the scope of work in the Project Cost were as follows:

- The device must be fully capable of supporting initial experimental objectives.
- The device must be fully capable of accommodating required upgrades.

The subsystem managers developed the cost estimate for their subsystems based on their scope of work. A series of internal reviews were held, first to assure a clear understanding of the scope of work, and second to assure the estimates were of a quality and accuracy consistent with this phase of the design process. Where appropriate the subsystems designers solicited input from industrial fabricators to improve the quality of the design and the estimate. Some ancillary systems benefited from recent experience with NSTX and its actual cost data. These factors provided a measure of confidence that the estimate is as complete and as free of duplication and unnecessary scope as possible within the limits of current understanding.

Guidelines were established for estimating contingency. Technical, schedule, and cost risk factors were considered for each WBS element. The technical risk factor was based on the current state and level of the design. The schedule risk factor was based on criticality to the overall schedule. The cost risk factor was based on the estimating methodology used. The overall contingency added up to ~27% of the total without contingency.

The cost estimate was based on a four-year period from the start of Preliminary Design (Title I) until first plasma. R&D activities prior to the start of Preliminary Design were also included in the cost estimate. A summary of the Project Cost by WBS element is provided in Table 13-1. The overall cost is $55.0M (FY99$) including contingency. When inflated to the expected years of expenditure this cost becomes approximately $65M.

Table 13-1. Cost summary by WBS element

WBS		Description	FY1999K$
1		**Fusion Core Systems**	**$18,032.9K**
	11	Plasma Facing Components	$1,492.6K
	12	Vacuum Vessel	$2,512.2K
	13	TF Coils	$1,388.1K
	14	PF Coils	$955.7K
	15	Cryostat	$529.5K
	16	Machine Support Structure	$1,234.1K
	17	Modular Coils	$8,947.6K
	18	Trim Coils	$973.0K
2		**Auxiliary Systems**	**$2,225.5K**
	21	Fueling Systems	$114.9K
	22	Vacuum Pumping Systems	$229.9K
	23	Wall Conditioning Systems	$142.2K
	24	RF Heating Systems	$0.0K
	25	Neutral Beam Heating	$1,738.5K
3		**Diagnostic Systems**	**$2,529.7K**
4		**Power Systems**	**$4,828.5K**
5		**Central I&C & Data Acquisition Systems**	**$3,346.4K**
6		**Site & Facilities**	**$3,764.8K**
	61	Facility Modifications & Test Cell Preparations	$1,766.7K
	62	Heating & Cooling Systems	$880.7K
	63	Cryogenic Systems	$1,067.3K
	64	Utility Systems	$50.1K
7		**Machine Assembly**	**$3,791.2K**
8		**Project Oversight & Support**	**$4,002.0K**
9		**Preparations for Operations**	**$443.0K**
		Subtotal Without Contingency	**$43,293.9K**
		Contingency (~27%)	**$11,706.1K**
		TOTAL	**$55,000.0K**

In conceptual design, a bottoms up schedule will be developed. The cost will be re-estimated consistent with that schedule and any design changes that occur during the course of conceptual design.

13.3 Management and Organization

13.3.1 Institutional Arrangements

The NCSX is jointly proposed by Princeton Plasma Physics Laboratory and Oak Ridge National Laboratory in partnership. These two national laboratories are collaborating in the design, construction, operation, possible enhancements, and physics research for the NCSX project. PPPL has the lead responsibility for project execution. A management organization for the Project (Figure 13-1) is established within the PPPL organization, reporting to the Department of Energy through the PPPL Director. ORNL provides major support, including leadership in key physics and engineering areas.

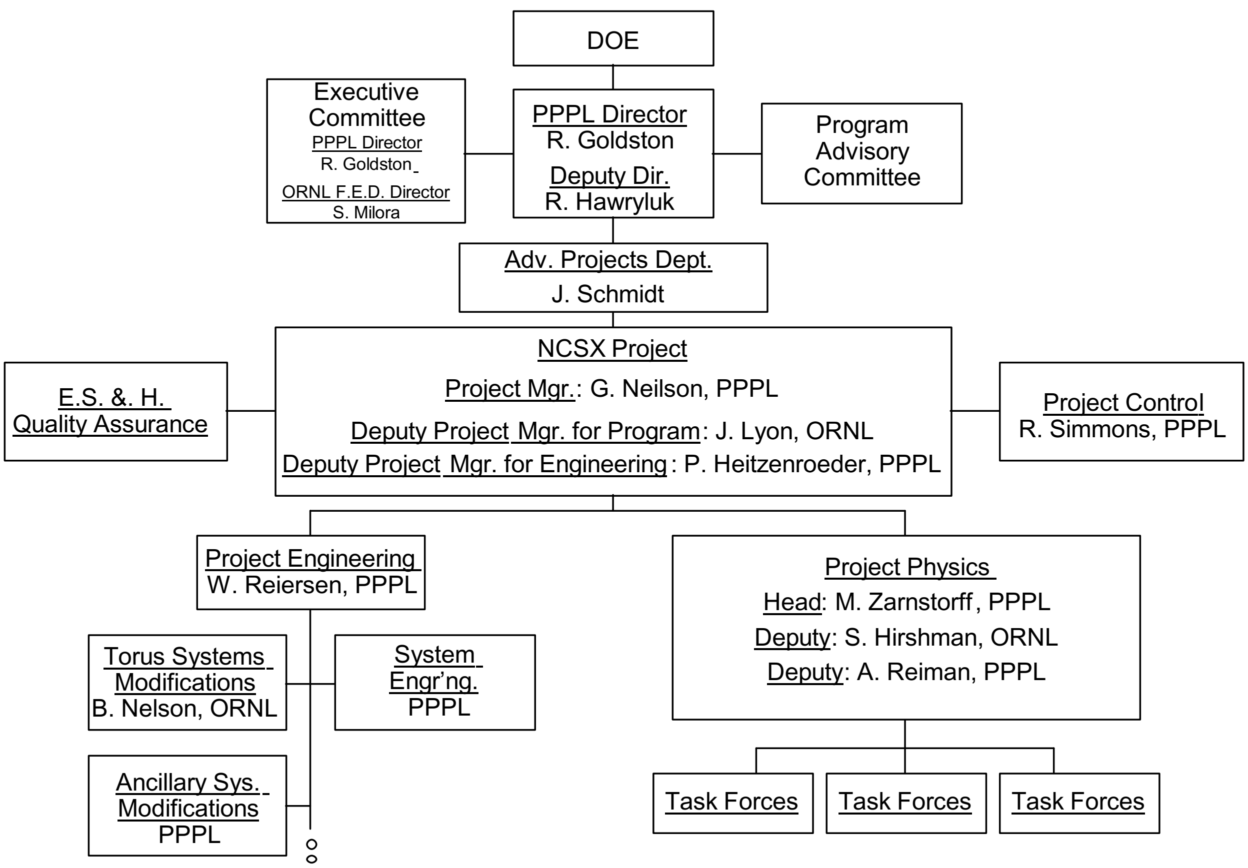

Figure 13-1. NCSX Project Organization

The physics and concept development phase of the NCSX project has been carried out by an integrated national team, led by PPPL and ORNL, with participants from several universities (to date, the University of Texas at Austin, Columbia University, University of California at San Diego, Massachusetts Institute of Technology, Auburn University, University of Montana, University of Wisconsin) and two other laboratories (Lawrence Livermore National Laboratory and Sandia National Laboratories–Albuquerque). The work has benefited from strong collaborations with foreign stellarator researchers (in Germany, Australia, Switzerland, Japan, and Russia) and has been guided by an advisory committee of distinguished U.S. and foreign scientists. This national team approach has facilitated cost-effective knowledge transfer and resource sharing within the DOE system of laboratories and been effective in broadening national participation in the program. Good communication is maintained cost-effectively through frequent teleconference meetings and web-based data sharing, with little need for travel. The success of this approach is best measured by the products it has delivered, namely a scientific knowledge base for compact stellarators and pre-conceptual designs for both the NCSX proof-of-principle experiment and the complementary QOS concept exploration experiment proposed by ORNL (currently under separate review). These constitute the scientific and technical foundations for the proof-of-principle program.

The national team model will be continued as the project moves forward. In carrying out the design and construction phases of the NCSX, PPPL will lead the project management team and be responsible for all procurement, fabrication, installation, testing, and commissioning. ORNL has the lead responsibility for designing the stellarator core (the coils, support structure, vacuum vessel, and cryostat) and will provide on-site engineering support at PPPL for the installation and relevant testing of those systems. Following the integrated team model, PPPL will support ORNL-led activities and vice versa. Both laboratories will continue to be supported in their efforts by other collaborators based on project needs.

The NCSX Project is well supported by the PPPL management and appears in the Laboratory’s institutional plan as a major initiative. The NCSX is the largest activity in the Advanced Projects Department, which leads the project, and also receives strong support from the Theory, Experiment, and Engineering Departments. Project status and issues are reviewed with the Laboratory Director and Deputy Director on a weekly basis. The PPPL and ORNL Directors have jointly written to the Department of Energy to express their strong support for NCSX and the compact stellarator program.

13.3.2 Project Organization

The lead laboratories, PPPL and ORNL, have assembled a leadership team of senior physicists and engineers for the NCSX project. Collectively they have extensive experience in stellarators and in other fusion projects of NCSX scale and larger. The key personnel and their responsibilities are:

Management

- Hutch Neilson, PPPL (Project Manager): overall project execution.
- Jim Lyon, ORNL (Deputy Project Manager for Program): project management support, emphasizing programmatic issues.
- Phil Heitzenroeder, PPPL (Deputy Project Manager for Engineering): project management support, emphasizing engineering issues.
- John Schmidt, PPPL (Advanced Projects Dept. Head): project management guidance.

Physics

- Mike Zarnstorff, PPPL (Physics Head): physics design and research
- Allan Reiman, PPPL (Deputy Physics Head): stellarator theory, plasma configurations.
- Steve Hirshman, ORNL (Deputy Physics Head): stellarator theory, coils.
- Ed Lazarus, ORNL: experimental physics, scenarios.
- Peter Mioduszewski, ORNL: power and particle handling.

Engineering

- Wayne Reiersen, PPPL (Engineering Head): overall engineering design and construction.
- Brad Nelson, ORNL (Stellarator Core Manager): stellarator core design.
- Charles Neumeyer, PPPL (Power Systems Manager): power systems design.

The project is guided by an informal Program Advisory Committee, reporting to the PPPL Director, which provides advice on technical matters. The Committee, which is composed of senior U.S. and foreign fusion researchers with broad expertise, has met four times since 1998. It has played an important role in developing the physics basis and design requirements for the NCSX. Members who have served on the committee to date are:

Prof. David T. Anderson, *University of Wisconsin*
Prof. Ira B. Bernstein, *Yale University*
Prof. Allen H. Boozer (chair), *Columbia University*
Dr. Paul R. Garabedian, *New York University*
Prof. Jeffrey H. Harris, *The Australian National University, Australia*
Prof. Richard D. Hazeltine, *University of Texas at Austin*
Prof. Chris C. Hegna, *University of Wisconsin*
Prof. Stephen F. Knowlton, *Auburn University*
Dr. James F. Lyon, *Oak Ridge National Laboratory*
Dr. Earl S. Marmar, *Massachusetts Institute of Technology*
Prof. K. Matsuoka, *National Institute for Fusion Science, Japan*

Dr. William M. Nevins, *Lawrence Livermore National Laboratory*
Dr. Peter A. Politzer, *General Atomics*
Dr. David W. Ross, *University of Texas at Austin*
Dr. Edmund Synakowski, *Princeton Plasma Physics Laboratory*
Prof. Friedrich Wagner, *Max Planck Institute for Plasma Physics, Germany*
Prof. Harold Weitzner, *New York University*