NCSX Management, Cost, and Schedule Overview

Management Plans and Procedures for Carrying Out the NCSX Project
Adequacy of the Cost, Schedule and Contingency Estimates

Charge #3: With regard to the cost, schedule and management aspects of the project, comment on the cost and schedule estimates for the project, including (a) adequacy of the contingency estimates considering the current stage of project definition, and (b) the management plans and procedures identified for carrying out the project.

The NCSX Project is following a proven project management approach that has been successfully applied in previous PPPL-managed projects, most recently the NSTX fabrication project and the TFTR Decontamination and Decommissioning (D&D) project. The NCSX project has adapted its management approach to take into account recent developments in DOE project management guidelines. In addition, as part of the Princeton Plasma Physics Laboratory, the project resides within an organization that has decades of experience with fusion projects comparable to NCSX. The Laboratory's organizational structure, management systems, DOE-approved plans and procedures (e.g., for project control, integrated safety management, quality assurance, procurement), and experience are well matched to the needs of NCSX. Details are documented in the NCSX Preliminary Project Execution Plan.

Acquisition planning for NCSX has progressed commensurate with the needs of the design process. The project has passed physics reviews and has been endorsed by the Fusion Energy Sciences Advisory Committee. The Office of Fusion Energy Sciences has a funding plan for the Major Item of Equipment design and fabrication in FY-2003 through FY-2007, and has requested the first year's funds in its FY-2003 Congressional budget submission. The project has developed a conceptual design, cost and schedule estimates, and plans, using input from industrial suppliers for the the critical components. Risks have been identified and measures have been taken to mitigate them. The cost and schedule estimates were developed from the bottom up and include appropriate contingencies based on risk assessment. The plans and estimates now in place are appropriately developed and implemented for the current stage of the project and constitute a sound basis for proceeding.

1. Project Organization

The NCSX project is led by the Princeton Plasma Physics Laboratory (PPPL), with Oak Ridge National Laboratory (ORNL) providing major leadership and support as a partner. The project organization is established within PPPL and reports to DOE through the PPPL Director. ORNL has management and design responsibility for the stellarator core.

The Integrated Project Team (IPT) is composed of the DOE NCSX Project Manager (DOE-Princeton Area Office), the NCSX Program Manager (DOE-Office of Fusion Energy Sciences), the contractor project manager (PPPL), the deputy project manager (ORNL), and other personnel as needed. The IPT holds teleconference meetings at least monthly and has been functioning since mid-2000, conducting major project reviews (physics validation review, conceptual design review) and preparing documentation for CD-0 and CD-1. The contractor project organization has been in place and functioning well since 1998 in managing the project through the physics definition, pre-conceptual design, and conceptual design phases. The project is supported in the areas of quality assurance; environment, safety, and health (ES&H); and procurement by the respective PPPL organizations. The project organization chart appears in Fig. 1.

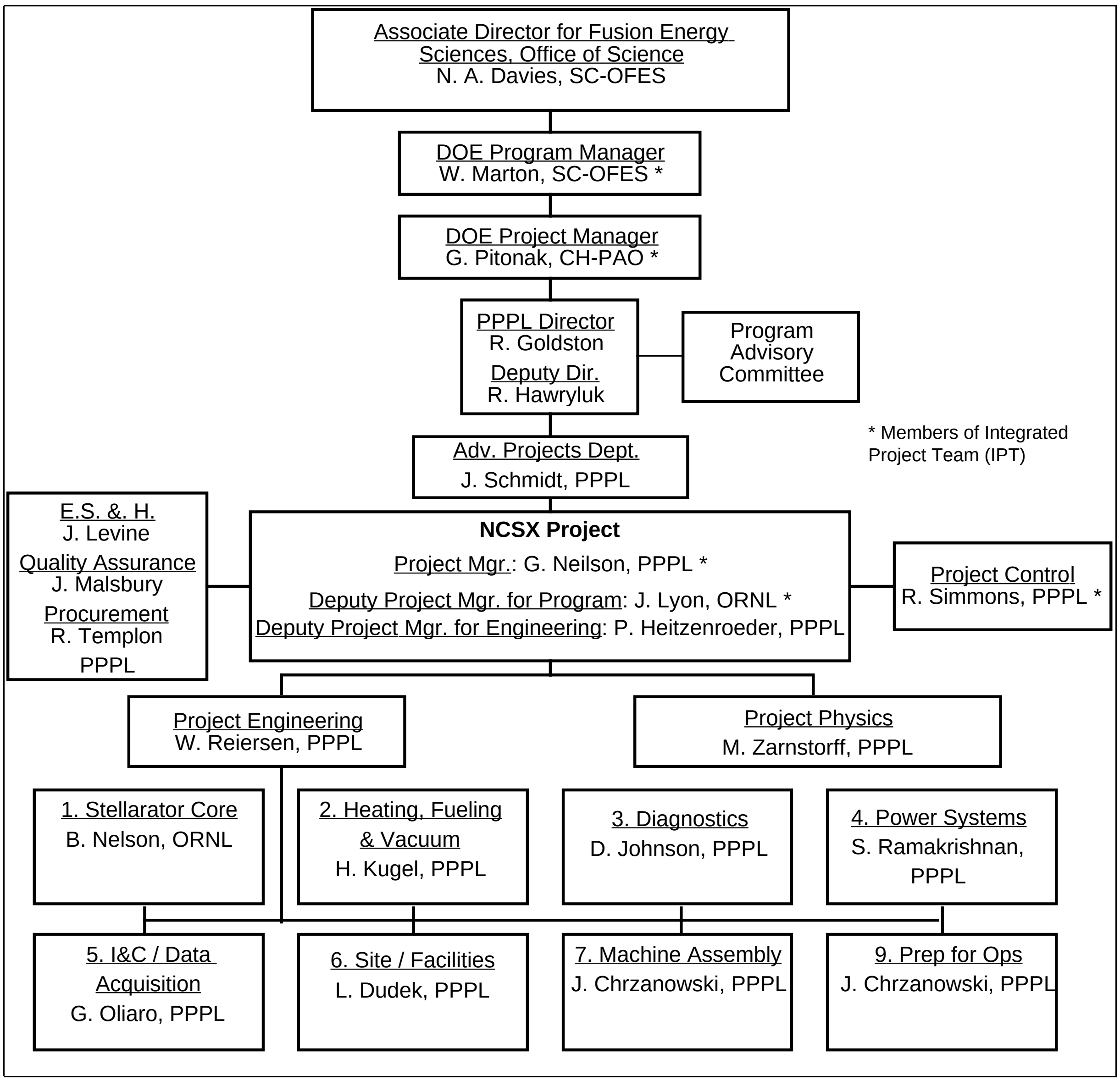

Fig. 1. NCSX Project Organization

The project is advised by a Program Advisory Committee which reports to the PPPL Director and provides broad-based input to the project from the fusion research community. The committee, which is composed of senior U.S. and foreign fusion scientists with broad expertise, has met at least once a year since 1998.

2. Project Control

The NCSX project will manage the execution of project workscope using PPPL's DOE-approved Project Control System (PCS), the same system used on NSTX, TFTR D&D, and previous PPPL-managed projects. The PCS provides a centralized work authorization system for all project work and provides management with cost and schedule performance information that can be used to monitor and control progress.

The configuration baseline will be controlled according to the changing needs of the project. Initially, the functional baseline or top-level system specification is controlled. At final design, the product baseline, or "build-to" specification, will be controlled. The cost and schedule baselines are maintained in a master resource-loaded schedule using a commercial project planning software tool. The process for controlling changes to the baseline uses formal engineering change proposals which will be dispositioned by a change control board chaired by the project manager. Changes to the DOE-approved baseline and changes involving the use of contingency funds must be approved by DOE. Cost and schedule reviews with DOE will be held twice per year. Written progress reports will be submitted quarterly.

3. Design, Acquisition Planning, and Estimates for NCSX Fabrication

The physics concept and main configuration features of NCSX were developed during the pre-conceptual design phase, including a Physics Validation Review (PVR) in March, 2001. The PVR panel report confirmed the soundness of the NCSX physics design basis and the appropriateness of the pre-conceptual design as the basis for proceeding. The Fusion Energy Sciences Advisory Committee (FESAC) endorsed the NCSX as a proof-of-principle experiment. The DOE Office of Fusion Energy Sciences (OFES) approved mission need (CD-0) and start of conceptual design in June, 2001. During the conceptual design phase, the design has steadily improved in terms of its physics capabilities (e.g., diagnostics access, space for in-vessel hardware) and manufacturability. Also, manufacturing studies of the critical components, performed by industrial suppliers, provided valuable input on the design, cost and schedule, and acquisition planning for these components. As a result, uncertainties have been considerably reduced in the past year.

Acquisition planning for NCSX has progressed commensurate with the needs of the design process and overall project planning. The stellarator core will be assembled from all new components. It will be installed in the C-site test cell at PPPL, making use of the existing fusion energy program equipment and infrastructure that is available there. It will re-use the PBX-M neutral beam systems, TFTR magnet power supplies, and control room facilities adjacent to the test cell.

The most critical components are the modular coils and vacuum vessel. The design process will include manufacturing development and prototyping of these components to reduce production cost and schedule uncertainties and associated risk. In the case of the vacuum vessel and modular coil winding forms, both the development and fabrication will be done in industry because of the special facilities and expertise required to make these large highly shaped structural components. The coils will be wound by PPPL, taking advantage of in-house experience. It was concluded, based on input from the manufacturing studies, that this approach is the most attractive for the project from the standpoint of cost, schedule, and risk. The remaining stellarator core components, the TF and PF coils, support structure, and cryostat, are more straightforward and will most likely be fabricated in industry. The stellarator core components will be assembled and installed by Laboratory staff.

The main components of the magnet power, neutral beam heating, and vacuum pumping systems already exist and were extensively operated in previous projects. The modifications needed to adapt them to NCSX are relatively straightforward and similar to past projects. They will involve a combination of procured components and services and in-house fabrication, assembly, and installation. The same applies to the site preparation and facility modifications work.

The design of the central I&C and data acquisition system will be largely patterned after the recently implemented NSTX system. This computer-based system will be assembled from procured components.

The NCSX baseline diagnostics will be based on proven techniques and detection technologies. The main issues have to do with designing the interface to the stellarator device to provide optimum measurement capability in the complex stellarator geometry. Researchers working with design engineers using CAD models will address this issue. Once these design and interface issues are resolved, implementation will be relatively straightforward and similar to past projects.

The scope of the NCSX Major Item of Equipment (MIE) project includes all equipment needed at the time of First Plasma plus a 3 MW neutral beam injection heating system needed for plasma heating experiments later in the program. The design engineers have developed cost and schedule estimates based on the NCSX conceptual design. They have analyzed fabrication and assembly activities at the task level to estimate labor requirements and durations, and have estimated procurement costs based on actual data from previous projects or supplier quotes where possible. In the case of the modular coils and vacuum vessel, supplier input based on detailed manufacturing studies has been incorporated. In case of the central I&C, data acquisition, magnet power, neutral beam heating, vacuum pumping, and site and utility systems, actual cost data from previous similar projects provides a sound estimating basis. Contingencies have been estimated at the subsystem level, using a methodology based on an evaluation of cost, schedule, and technical risk factors. Subsystem contingencies range from 10% for the Central I&C and Data Acquisition system (a near duplicate of the NSTX system) to 40% for the modular coils and vacuum vessel. The total estimated cost (TEC) of the NCSX Major Item of Equipment is $72M, which includes 28% overall contingency. The breakdown by subsystem is summarized in Table I.

Table I. NCSX Cost Estimate Summary

Subsystem	Cost ($M)	Contingency
Stellarator Core	28.6	36.4%
Heating, Fueling, & Vacuum	2.2	18.0%
Diagnostics	2.4	28.8%
Power Systems	5.4	17.4%
Central I&C	4.0	9.8%
Site and Utilities	2.5	16.2%
Machine Assembly	4.2	21.4%
Management and Integration	5.7	15.0%
Integrated Testing	0.5	20.0%
PPPL Allocations	0.8	15.0%
Total Base Estimate	56.3	
Contingency	15.7	27.8%
Total	72.0	

The resource-loaded schedule for NCSX has been developed by integrating detailed task estimates (incorporating manufacturer input) and logical linkages provided by the design engineers. The critical path (Fig. 2) runs through the design, manufacturing development, and fabrication of the modular coils, followed by final machine assembly and integrated testing. The plans require delivery of the first of the eighteen structural coil forms a little more than 2 years after project initiation and completion of the order about a year thereafter. Laboratory staff will begin winding the coils onto their forms once they start arriving. Finally, the coils will be assembled onto vacuum vessel segments to produce three field-period subassemblies, which will then be bolted together in the final assembly phase. Integrated systems testing culminating in first plasma completes the project. The schedule analysis indicates that, given project initiation in October, 2002, it will be completed by the end of March, 2007 with about 4 months of schedule contingency.

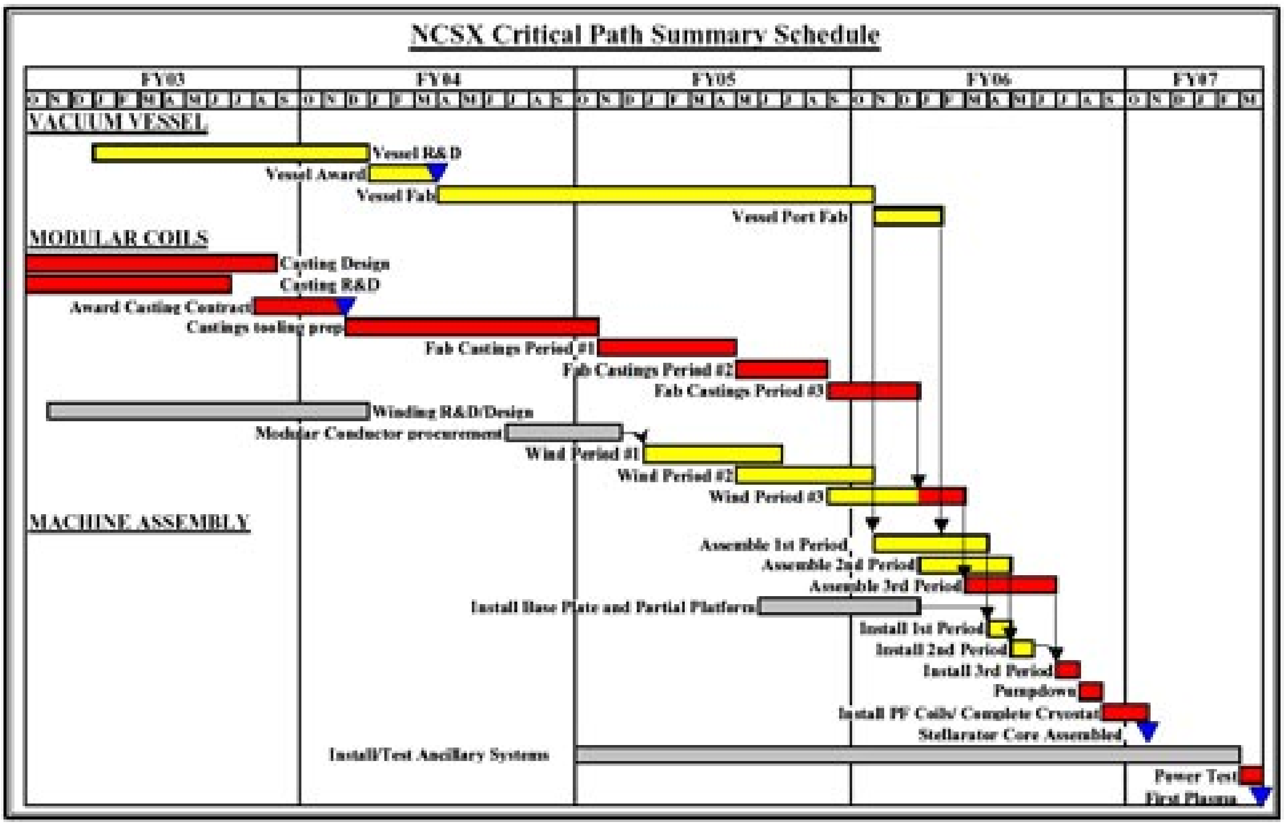

Fig. 2. NCSX Critical Path Summary Schedule

Annual spending (B/O) and funding (B/A) requirements for the NCSX Fabrication project have been determined based on the project schedule and the expected contingency utilization profile. The difference between B/A and B/O is due to procurements that cross fiscal year boundaries. The requirements are summarized in Table II.

Table II. NCSX Fabrication Project Budget Requirements ($M)

Fiscal Year:	2003	2004	2005	2006	2007	Total
Contingency	1.4	2.5	4.5	4.8	2.5	15.7
Spending (B/O)	10.5	14.8	21.9	18.0	6.8	72.0
Required Funding (B/A)	11.0	18.3	19.5	16.4	6.8	72.0

5. Research Preparation Plans

During the NCSX fabrication period (FY2003-07), a parallel research preparation activity will be carried out so that the program will be able to proceed as effectively as possible after First Plasma. The goals are to prepare analytical and hardware tools that will be needed beyond the first plasma and flux-surface mapping phases of the research program, and to maintain an active physics component of the NCSX program during machine fabrication. This is very similar to the approach that was followed on NSTX. Plans are explained in detail in the document, "Mission, Experimental Plans, and Preparations," and costs are explained in "Research Preparation Costs"

Estimated annual funding requirements for research preparation are summarized in Table III. Costs for those hardware upgrades that begin in FY-2006 are shown through FY-2008 for completeness. Operations funding (not yet estimated) is planned to start in FY-2007. None of these costs are included in the fabrication project TEC.

Table III. NCSX Research Preparation Budget Requirements ($M)

	2003	2004	2005	2006	2007	2008
Research & Design	1.0	1.2	1.6	2.1	*	*
Hardware upgrades				2.6	6.7	7.4
Total	1.0	1.2	1.6	4.7	*	*

* Operating budgets start in FY-2007.

6. Department of Energy Funding Plan

The Office of Fusion Energy Sciences (OFES) has provided a funding profile, shown in Table IV, as guidance to the project. The FY-2003 funds listed there have been requested in the Department's Congressional budget submission for FY-2003. This profile was developed by the Office nearly a year ago using preconceptual estimates as input. The design development and manufacturing studies since that time have greatly increased the level of understanding of the required work scope and have correspondingly reduced the uncertainty in its expected cost, although the project performance baseline will not be formally established until the completion of Title I design in mid-FY2003. Research preparation requirements have been more fully developed in the past year. The current estimates shown in Table IV exceed the guidance profiles. The increases are needed in order to complete the fabrication project by the desired date (March, 2007) and to be ready to proceed as effectively as possible with the research program once the machine becomes available. It is expected that the differences between the guidance profiles and the project's annual funding needs as they are now understood (Fig. 3) will be resolved by OFES via the normal budgeting process.

Table IV. DOE Funding Guidance and Current Estimates for NCSX ($M)

Fiscal Year	2003	2004	2005	2006	2007	Total
DOE Guidance						
Fabrication Project	11.0	16.0	17.0	17.0	8.0	69.0
Research Preparation	0.8	0.8	1.2	1.6	*	
NCSX Program Total	11.8	16.8	18.2	18.6	*	
Current Estimate						
Fabrication Project B/A	11.0	18.3	19.5	16.4	6.8	72.0
Research Preparation	1.0	1.2	1.6	4.7	*	*
NCSX Program Total	12.0	19.5	21.1	21.1	*	

* Operations funding will begin in FY-2007.

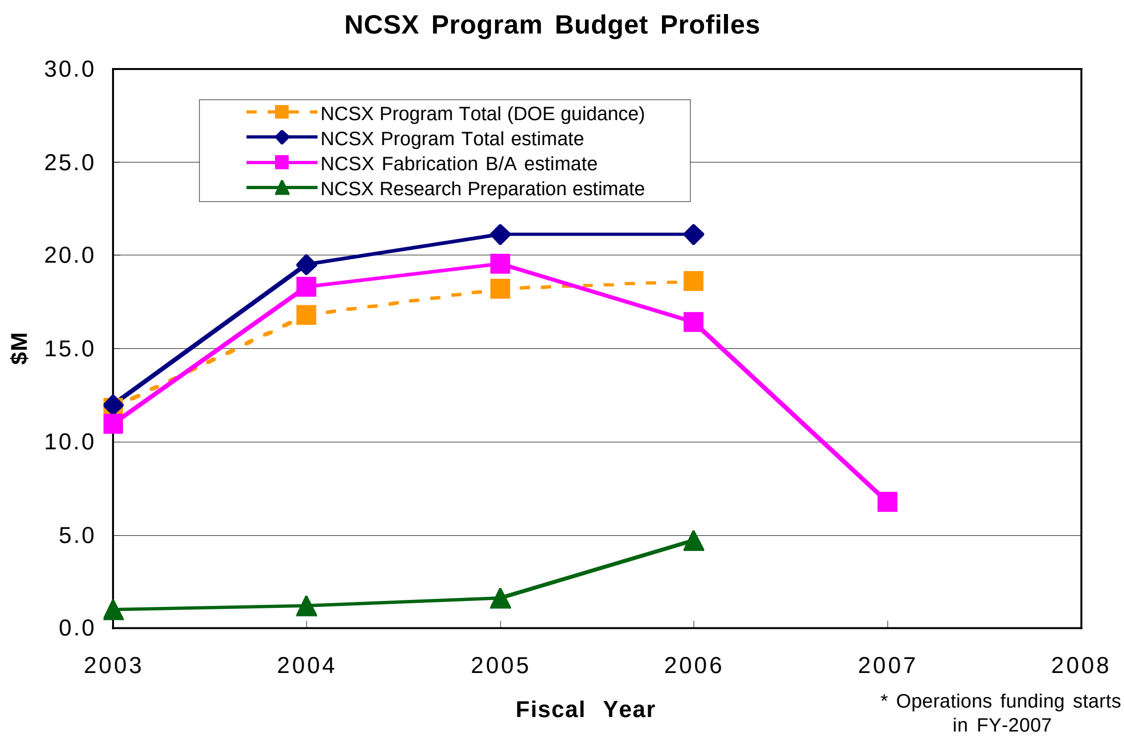

Fig. 3. NCSX Funding Requirements: Estimates and DOE Guidance

Funding mechanisms for project participants that have been well established during the project planning stages will be continued. Project funds are provided to PPPL and ORNL directly by DOE via those institutions' respective financial plans. The division of project funds between PPPL and ORNL is updated each year via the Field Work Proposal process according to the needs of the project. When necessary, fine-tuning adjustments are made by requesting financial plan transfers from one partner to the other. All major hardware procurements will be subcontracted through PPPL. Small subcontracts for consultation or support services may be funded by either PPPL or ORNL. LLNL receives a small amount of direct funding from DOE to support physics participation in the project.

7. Conclusion

The management plans and procedures for carrying out the NCSX project are well defined and appropriately implemented for the current stage of the project. The plans and estimates for NCSX fabrication have also been developed to an appropriate degree. The manufacturing studies by industry, which have provided valuable input on cost, schedule, and acquisition strategy for the most critical components, provide an extra measure of confidence in the project's plans and estimates.