Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

National Spherical Torus Experiment (NSTX) Upgrade Project

May 2012

EXECUTIVE SUMMARY

A Department of Energy Office of Science (DOE/SC) review of the National Spherical Tokomak Experiment (NSTX) Upgrade project was conducted at Princeton Plasma Physics Laboratory (PPPL) on May 2-3, 2012. The review was conducted by the Office of Project Assessment (OPA) at the request of Dr. Edmund Synakowski, Associate Director of Science for the Office of Fusion Energy Sciences (FES). Stephen Meador, OPA, chaired the review. The purpose of the review was to evaluate the overall status of the project with emphasis on construction progress.

The Committee found good progress in executing the central stack (CS) upgrade; the neutral beam (NB) refurbishment; and design and development of ancillary systems. The work control center is functioning well and, overall, the project has adequate resources and the necessary skill mix to successfully complete the project. Safety performance on the NSTX Upgrade project is good. However, potential funding shortfalls in FY 2013 and out-years add significant risk to completing the project on cost and schedule.

Technical

While the NB work is going well, the project should ensure appropriate attention is given to cutting the vacuum vessel to accept the new NB port, NB port fabrication, and NB port installation. These items should be added to the risk registry. Add remaining major procurements for CS components and the risk associated with testing and using Aquapour in CS fabrication to the risk register. The project was advised to pay attention to mundane, low technical components and systems to ensure these activities do not unnecessarily cause project delays.

Cost and Schedule

Overall the project is 40 percent complete. Current cost and schedule performance is good; and remaining cost and schedule contingency is adequate. The critical path continues to run through conductor delivery, CS fabrication, and CS installation. An updated risk identification/assessment and scope contingency plan to help address funding uncertainties is critical. PPPL implemented the corrective actions necessary to satisfy the intent of the Corrective Action Requests (CARs 1-4) and the Continuous Improvement Opportunities (CIOs 1-6) developed during certification of the PPPL Earned Value Management System (EVMS) last year.

Management

The project management team has been stable since baseline approval and authorization to begin construction. Procurements are proceeding well and critical vendors are delivering mostly to plan. The project is performing well with respect to fabrication of major components and readiness for installation. A serious safety incident at the laboratory (not on the NSTX Upgrade project) has focused renewed attention on safety in all aspects of the project.

The President's 2013 budget request jeopardizes the project's accelerated schedule. There may be significant impacts to the project resulting from possible funding reductions at PPPL. Preliminary out-year funding projections for the project indicate negative impacts to the baseline early finish date, budget at completion, cost contingency, and risk. While the impacts have not been fully evaluated, they appear unacceptable to the Committee. There is currently no comprehensive strategy agreed to by PPPL, the DOE/Princeton Site Office (DOE/PSO) and FES to address funding uncertainty. FES, the project, and DOE/PSO must carefully evaluate all impacts to the project baseline from potential changes to funding profiles once the available funding is better understood; and, together, develop a strategy to address impacts from potential changes to the funding profile.

CONTENTS

Appendices

1. INTRODUCTION

The mission of the National Spherical Torus Experiment (NSTX) program is to explore the properties of compact and high normalized pressure 'spherical torus' (ST) magnetic fusion plasmas. The compact and accessible ST configuration is potentially advantageous for the development of fusion energy and also broadens and improves the scientific understanding of plasma confinement at the ITER project. The plasma confinement capability, and the achievable plasma temperature, scale strongly with plasma current in the tokamak and ST. Plasma current in the range of 1 MA (million amperes or 1 mega ampere or MA) is required to access plasma temperatures needed to understand ST physics under fusion-relevant conditions. The only existing Department of Energy (DOE) facility capable of producing MA-class ST plasmas is the NSTX facility.

The ST shares many features in common with the conventional tokamak, but several important differences have also been identified—for example the scaling of turbulent energy transport with the frequency of inter-particle collisions. Understanding the causes of these differences is important not only to ST research, but also for developing a predictive capability for magnetic confinement generally. The new Center Stack (CS) would double the NSTX toroidal magnetic field to (TF) 1 Tesla and enable a doubling of the maximum plasma current to 2 MA for the first time in STs.The Center Stack Upgrade (CSU) combined with the installation of a second Neutral Beam Injection (NBI) will enable operation at higher magnetic field, current, and plasma temperature, thereby reducing the plasma collisionality to values substantially closer to those projected for next-step ST facilities and for ITER. Access to reduced collisionality will extend the plasma physics understanding of the ST and aid in the development of predictive capability for plasma confinement. Further, controllable fully-non-inductive current-sustainment is predicted to be provided by the second NBI, and would enable tests of the potential for steady-state.

The ST operation will contribute to assessing the ST as a cost-effective path to fusion energy. The ST is particularly well suited to provide a cost effective test-bed to bridge several gaps from successful ITER operations to a demonstration fusion power plant (demo) as identified in the Fusion Energy Sciences Advisory Committee (FESAC) report issued October 2007 and entitled: "Priorities, Gaps and Opportunities: Towards A Long-Range Strategic Plan for Magnetic Fusion Energy". More recently, in November 2008, the "Report of the FESAC Toroidal Alternates Panel" also found that the ST offers the potential for an attractive test facility for developing fusion components.Upgrading the NSTX facility could significantly narrow or close capability gaps identified above. In support of these upgrades, the NSTX collaborative research team developed its Five Year Program Plan for 2009-2013, which was favorably peer

reviewed and strongly endorsed in DOE/Office of Fusion Energy Science (FES) reviews conducted on July 28-31, 2008. The review panel specifically endorsed NSTX Upgrade plans, which form the central elements of the NSTX Five-Year Program Plan.

2. TECHNICAL STATUS

2.1 Findings

The Committee reviewed the documentation submitted by the Princeton Plasma Physics Laboratory (PPPL) for this review and identified a few key findings.

The construction efforts are being executed safely. There have been no reportable accidents on the NSTX Upgrade project.

A safety incident with serious injury at PPPL is being thoroughly investigated by the laboratory and lessons learned are being transferred to the NSTX Upgrade project.

A fully resource-loaded schedule for both the baseline and six-month "accelerated" schedule has been prepared. Management reviews analyses of all resource needs by skill type. The project appears to have adequate resources and the necessary skill mix to execute both the baseline and the 6-month accelerated schedule. Potential conflicts with other laboratory projects for analysts have been resolved and the project has addressed a predicted need for additional welders.

The project management is well structured to deliver the scope within budget and schedule. Risks are being actively managed and updated monthly by the Control Account Managers (CAM).

The project responded satisfactorily to all of the technical recommendations of the October 2011 DOE/SC review and earlier reviews. There are no significant outstanding technical issues that need to be resolved. Recommendations that have been adopted include:

- A plan has been developed to measure halo currents and vertical velocity displacements. Implementation is well underway with parts on-hand or delivery expected well before the need date.
- Evaluation of spare key fabrication tools (e.g. induction welder or Vacuum Pressure Impregnation (VPI) oven heaters) was performed. It was determined that expected vendor repair times and readily available spare parts eliminated the need to purchase spare units.
- CAMAC hardware on the NB LCC is being replaced by more modern National Instruments hardware using LABVIEW.
- A large scale test of the Aquapour removal in the CS is scheduled for this summer.

The NBI project is technically sound and is progressing well. The task is under cost and ahead of the accelerated schedule. This task is not on the critical path.

Developments of the friction stir welding procedure and Non-Destructive Testing have been completed with four conductors delivered. Excellent progress has been made on the technique for soldering the cooling tube into the TF conductor and the first conductor has been soldered.

The Digital Coil Protection System (DCPS) algorithm has been significantly simplified and the software Final Design Review (FDR) is scheduled for July 2012. Analyses of all 96 disruption cases have qualified the TF torsional shear.

All ancillary systems are on schedule, with no technical or procurement problems.

2.2 Comments

The safety culture on the NSTX Upgrade project is excellent and a serious concern for safety is evident at all levels of the project team from upper laboratory management to the field technicians. The safety organization, personnel, training, and procedures appear well suited to being able to perform the NSTX Upgrade project with minimum risk to staff.

The safety incident on the skid steer at PPPL is prompting the laboratory to review many of its procedures and practices. In that spirit, the Committee suggested that they consider expanding their stationary power tool training and qualification program to other more portable, but also potentially dangerous tools, e.g., portable power tools and hand-held hydraulic tools (punch, crimpers).

Continue to examine equipment tooling needs for critical path fabrication and assembly tasks and consider purchasing sufficient in-house spare to minimize down-time.

Although the NB project is progressing smoothly and most technical issues are resolved, significant attention needs to be maintained on the vacuum vessel cutting, port fabrication by the vendor, and port installation. The Committee suggested that this be added to the risk registry.

While there appears to be sufficient time between the large scale Aquapour test this summer and the actual need date to resolve any technical issues that might arise from the test, the Committee judged that the uncertainty of the test should be on the registry.

Given the critical nature of the entire CS fabrication task, the Committee believed that the risk registry should recognize specific risks, especially schedule risks associated with the remaining major procurements (OH conductor, Inconel casing, OH mold), tooling, machines, and fabrication techniques (VPI, inductor brazing). In addition, discussion of near-critical path items and mitigation plans should be presented or provided as supplemental material in the next status review.

The project should consider building five TF quadrants and selecting the best four for final assembly. Evaluate the cost, schedule, and risk impact. Is there a significant reduction in schedule impact if the fifth quadrant is planned rather than performed after a possible failure?

It is our observation that project delays are often the result of problems with more mundane, low-tech systems such as power supplies and water systems. For NSTX Upgrade, the new Poloidal Field (PF) coils, reused cables, and fibers might also fall into this category. The Committee encouraged the project team to pay adequate attention to these items, as well as the more complex R&D issues.

Continue to track the full Thomson scattering system task including any in-vessel calibration on the project schedule even though only the vacuum part is in the project scope.

2.3 Recommendation

1. Review and update the risk registry to more completely reflect items (mentioned in comments) that are on the critical path or near-critical paths.

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3. COST and SCHEDULE

3.1 Findings

The project is 40 percent complete overall, and cost and schedule performance is good. Cost contingency is reported as $15.1 million, or 32 percent of cost to go, which is slightly higher than the 30 percent cost contingency at CD-3.

Table 3-1. PROJECT STATUS (as of March 31, 2012)

Project Type	MIE	
CD-1	Planned: January 2010	Actual: April 2010
CD-2	Planned: October 2010	Actual: December 2010
CD-3	Planned: January 2012	Actual: December 2011
CD-4	Planned: September 2015	Actual:
TPC Percent Complete	Planned: 36.8%	Actual: 40%
TPC Cost to Date	$31.4 M	
TPC Committed to Date	$33.6 M	
TPC	$94.3 M	
TEC	$83.5 M	
Contingency Cost (w/Mgmt Reserve)	$15.7 M	33% to go
Contingency Schedule on CD-4	12 months	41%
CPI Cumulative	1.01	
SPI Cumulative	1.09	

The project risk registry has matured since CD-3. A total of 40 risks are retired, and 45 active risks remain, which account for approximately $4.7 million of cost contingency. Unused cost contingency remaining at the end of the project is planned to be returned to fund laboratory operations. As a consequence, few scope enhancements have been identified, and a viable deductive scope contingency plan is not coordinated.

The project critical path continues to go through conductor delivery, CS fabrication, and CS installation. The standing army cost is approximately $250 K per month.

An accelerated schedule was made possible by the TF coil failure and early shutdown of NSTX. A comparison of the project funding profile approved at CD-2 and the accelerated schedule funding profile is shown in Table 3-2.

Table 3-2. Comparison of CD-2 and Accelerated NSTX Upgrade Funding Profiles

	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	Total ($M)
BA (CD-2 baseline)	$5.1	$8.3	$9.6	$14.6	$25.3	$27.5	$3.8	$94.3
BA (accelerated)	$5.1	$8.3	$9.7	$21.6	$25.3	$24.3	$0.0	$94.3

3.2 Comments

The current project cost and schedule projections are consistent with the approved baseline cost and schedule at CD-2, as modified by Engineering Change Proposals (ECP) 001 through 029. ECP-004 accelerates the project schedule and increases schedule contingency from 12 to 18 months. The remaining contingency is adequate for the risk that remains.

The project has a risk registry; however, the registry only lists $4.7 million of cost contingency. As a consequence, approximately $11.0 million of available contingency is not linked to the risk registry. The risk registry and assessment should be updated to include risks such as funding reduction, unknown-unknowns, and risks identified elsewhere in this report.

While the aggressiveness of the project team in accelerating the schedule is admirable, contingency funding is a concern because it is back-end loaded in FY 2014, therefore no contingency funding is planned to be available in FY 2012 and 2013. If risks are realized, the project has a general strategy to delay non-critical path activities and redirect funding to mitigate the problem. However, the project team continues to need a more comprehensive and detailed contingency plan to be ready for potential funding reductions or cost overruns. A prioritized list of activities to slow down is needed. The project needs to understand the timing, amount of funds available, collateral impacts and schedule contingency for the delayed activities. A deductive scope contingency plan would also help to manage risk in the event of a funding shortfall.

3.3 Recommendation

2. Review the risk registry/assessment and scope contingency plan to ensure they are complete and up-to-date.

4. MANAGEMENT

4.1 Findings and Comments

The key management personnel required to deliver the baseline are still in place within the project organization. This includes DOE Federal Project Director, senior laboratory and contractor leadership. For the most part, these personnel have been closely associated with the project since its inception. More importantly, these personnel are highly experienced with the NSTX facility. Every major scope element for this project has been successfully performed by this project team in the past as part of operations or prior facility upgrades. The project organization has remained stable since CD-2.

The project is performing exceptionally well and is still forecasting a six-month accelerated early finish relative to the CD-2 approved baseline early finish. Procurements are proceeding well and so far, the critical vendors are delivering mostly to plan. Fabrication of major technical components (CS, neutral beam, ancillary systems) is making excellent progress with no major technical complications or significant risks on the horizon. Installation and construction is proceeding very well with “disassembly” nearly complete and labor costs lower than estimated.

There were no project related recordable injuries or significant radiological incidents since CD-3. There is renewed emphasis on safety at PPPL in general, and on the project, resulting from an injury at PPPL in March. Overall, safety appeared to be appropriately emphasized and ES&H performance was adequate.

The University’s Advisory Committee visited PPPL in late April and reviewed the project along with other programs at the laboratory. There were no project sponsored peer reviews since CD-3. This level of review appeared adequate given the excellent performance and absence of major technical issues needing resolution. However, the project should continue to consider peer review assistance especially if major issues or directed funding changes require major changes to the baseline.

The President’s requested budget for 2013 jeopardizes the accelerated schedule plan but keeps the project on track with the CD-2 approved baseline. Moreover, the President’s request, plus projected out-year funding projections, negatively impacts the baseline early finish date, budget at completion, cost contingency and risks. In addition, there may be significant impacts to the project resulting from possible funding reductions in other operations at the laboratory in

2013 and beyond. A careful, bottoms-up analysis of the impacts from this funding profile has not been completed. A top-down first estimate of these impacts indicates the project would finish six months later than the baseline early finish with a cost increase of approximately $5 million. That would leave six months of schedule contingency and 18 percent contingency on a $52 million cost to complete. This would also backload the contingency mostly into the last year of construction, reducing flexibility and possibly creating significant additional schedule risks. The Committee found these impacts unacceptable using parameters for approving a baseline at CD-2 as the benchmark. However, this estimate, while appropriate at this time and level of uncertainty, is not reliable as a tool to base important decisions. A more careful, peer assisted, analysis might find opportunities to create a plan that could be acceptable but might also find even more cost growth and risk.

The Committee was not presented with an overall strategy to address the funding uncertainties. The overall strategic goal should be to optimize project performance, but it should also focus on broader impacts to the Laboratory. Such a strategy might include the timing for key decisions, required input for key decisions, parameters for rebaseline, etc. These are just suggestions though; the strategy must be designed by the management team. As a minimum it is strongly suggested that the strategy represent general agreement among the parties, PPPL, NTSX, DOE/FES and DOE/PSO on the path forward.

In summary, the management team remains in place, functioning well with adequate systems and resources to deliver the baseline. The project has performed very well since CD-3 as measured by Earned Value Management System (EVMS) data. The project appears on track to successful early completion based on performance to date, remaining cost and schedule contingencies, and risk analysis. Installation and construction appear very well planned and executed so far. Safety performance is adequate. Funding uncertainties lie ahead and need to be addressed strategically.

Update on Earned Value Management System

The Committee determined that PPPL has implemented the corrective actions necessary to satisfy the intent of Corrective Action Requests (CAR) #1-4 and Continuous Improvement Opportunities (CIO) #1-6. CIO #7 was corrected during the October 2011 EVMS Certification Review.

CAR-01 was addressed by implementation of Engineering Change Proposal #004 and the project is continuing to evaluate the need for changes to the Performance Measurement Baseline.

The EVM System Description was updated to address the preparation of Variance Analysis Reports (CAR-02) and the current Control Account Manager (CAM) Training Program satisfies the recommendation that PPPL develop a training procedure. Although the project revised the variance analysis thresholds in response to CAR-02, the OPA and PPPL will evaluate the need to change the variance thresholds in the Project Execution Plan in response to the project's performance over the previous six months. The project schedule has been thoroughly reviewed and updated in response to CAR-03 and the number of constrained activities has been reduced significantly to approximately five percent. Each of the project work packages was reviewed in response to CAR-04 to ensure the correct identification and application of level-of-effort versus discrete effort and inconsistencies have been corrected, as necessary. PPPL has implemented corrective actions in response to all CIOs. The project has improved Estimate at Completion preparation, documentation, and tracking; the PPPL Chief Financial Officer now validates the monthly actual costs; additional EVMS training has been provided; and Work Authorization Forms have been updated to include the EV technique for each control account. Based on discussions with the Committee, it appears the CAMs have taken a proactive role in the EVMS and baseline management process in keeping with EVM best practices. The Committee encouraged PPPL to continue their diligent implementation of EVM processes.

4.2 Recommendation

3. The Program, Project, Laboratory and Site Office develop a strategy to address impacts from potential changes in the funding profile.

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APPENDIX A

CHARGE MEMORANDUM

Department of Energy
Washington, DC 20585

February 23, 2012

MEMORANDUM FOR: DANIEL R. LEHMAN
DIRECTOR
OFFICE OF PROJECT ASSESSMENT
OFFICE OF SCIENCE

FROM: EDMUND J. SYNAKOWSKI
ASSOCIATE DIRECTOR OF THE OFFICE OF SCIENCE
FOR THE OFFICE OF FUSION ENERGY SCIENCES

SUBJECT: OFFICE OF SCIENCE PROJECT REVIEW FOR THE NATIONAL SPHERICAL TORUS EXPERIMENT (NSTX) UPGRADE PROJECT

I request that your office organize and lead an Office of Science (SC) project review of the NSTX Upgrade Project at PPPL on May 2-3, 2012. The purpose of this review will be to assess the current status of the Project's performance.

The NSTX Upgrade Project received Critical Decision (CD-0) approval in February 2009, CD-1 approval in April 2010, CD-2 approval in December 2010, and CD-3 approval in December 2011. The project is currently in the construction/execution phase, with significant field construction, fabrication and procurement activities underway.

In carrying out its charge, the review committee is requested to consider the following questions:

1. Construction Efforts: Are construction efforts being executed safely? Does the project have adequate resources and the appropriate skills mix to execute the project per the plan?

2. Baseline Cost and Schedule: Are the current project cost and schedule projections consistent with the approved baseline cost and schedule? Is the contingency remaining adequate for the risks that remain?

3. Management: Evaluate the management structure as to its adequacy to deliver the scope within budget and schedule. Are risks being actively managed? Has the project responded satisfactorily to the recommendations from the previous SC project review?

4. Earned Value Management (EVM): Has Princeton University/ PPPL implemented all required actions in the Corrective Action Plan that was developed following the EVM System certification review from October 2011?

Barry Sullivan is the program manager for this project and will serve as the contact person for this review. He can be reached at 301-903-8438. I would appreciate receiving your committee's report within 60 days of the review's conclusion.

cc:

J. Makiel, SC-PSO
A. Indelicato, SC-PSO
B. Sullivan SC-FES
S. Eckstrand, SC-FES
G. Nardella, SC-FES
S. Meador, SC-28
E. Merrill, SC-28
S. Prager, PPPL
A. Cohen, PPPL
M. Zarnstorff, PPPL
M. Williams, PPPL
R. Strykowsky, PPPL
E. Perry, PPPL
M. Ono, PPPL
J. Menard, PPPL

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the
National Spherical Torus Experiment (NSTX) Upgrade Project
May 2-3, 2012

REVIEW COMMITTEE PARTICIPANTS

Department of Energy

Stephen Meador, SC, Chairperson

Review Committee

Subcommittee 1: Technical
*Arnie Kellman, General Atomics
David Lissauer, BNL

Subcommittee 2: Cost and Schedule
*Ray Won, DOE/SC
Tim Maier, DOE/BHSO
Ethan Merrill, DOE/SC

Subcommittee 3: Management
*Frank Crescenzo, DOE/BHSO
Mike Epps, DOE/TJSO

*Lead

Observers

Ed Synakowski, DOE/SC
Barry Sullivan, DOE/SC
Jeff Makiel, DOE/PSO
Maria Dikeakos, DOE/PSO

APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
National Spherical Torus Experiment (NSTX) Upgrade Project
May 2-3, 2012

AGENDA

Wednesday, May 2, 2012—LSB, Room B318

8:00 am	Executive Session	
9:00 am	Laboratory Perspective	Stewart Prager
9:10 am	Project Overview	Ron Strykowsky
9:50 am	NSTX Centerstack Fabrication	Jim Chrzanowski
10:15 am	Break	
10:30 am	Second Neutral Beam on NSTX	Tim Stevenson
10:55 am	NSTX Centerstack Ancillary Systems Progress	Larry Dudek
11:20 am	Machine Installations & Construction Management	Erik Perry
11:50 am	Safety	Jerry Levine
12:00 pm	Lunch	
1:00 pm	Tour NSTXU test cell, TFTR TC, and CS High Bay CS Fab Shop	
2:00 pm	Break-out Sessions	
4:00 pm	Executive Session	
5:30 pm	Adjourn	

Thursday, May 3, 2012

8:00 am	Follow-up and Report Writing
10:30 am	Dry Run
11:15 am	Debrief
11:30 am	Closeout Presentation
12:00 pm	Adjourn

APPENDIX D

COST TABLE

NSTX Upgrade Cost Table

CONTRACT PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN: Thousands of $ | FORM APPROVED OMB No. 0704-0188

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME: Princeton University-Plasma Physics Lab	a. NAME: DOE-SC-OFES-NSTX Upgrade	a. NAME: NSTX Upgrade Project	a. FROM (YYYYMMDD): 2012 / 02 / 01
b. LOCATION (Address and ZIP Code): Princeton, New Jersey	b. NUMBER: DE-AC02-09CH11466	b. PHASE: CD-3	b. TO (YYYYMMDD): 2012 / 02 / 29
	c. TYPE: M&O; d. SHARE RATIO	c. EVMS ACCEPTANCE: NO / X YES (YYYYMMDD): 2011 / 12 / 30	

5. CONTRACT DATA

a. QUANTITY	b. NEGOTIATED COST	c. ESTIMATED COST OF AUTHORIZED UNPRICED WORK	d. TARGET PROFIT/FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. ESTIMATED CONTRACT CEILING	i. DATE OF OTB/OTS (YYYYMMDD)
1	78,838	0	0	78,838	0	0	0	

6. ESTIMATED COST AT COMPLETION

	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)
a. BEST CASE	0		
b. WORST CASE	0		
c. MOST LIKELY	0	78,838	78,838

7. AUTHORIZED CONTRACTOR REPRESENTATIVE

a. NAME (Last, First, Middle Initial): Ronald Strykowsky
b. TITLE: Project Manager
c. SIGNATURE
d. DATE SIGNED (YYYYMMDD)

8. PERFORMANCE DATA

WBS ITEM (1)	CURRENT PERIOD: BUDGETED COST WORK SCHEDULED (2)	BUDGETED COST WORK PERFORMED (3)	ACTUAL COST WORK PERFORMED (4)	VARIANCE SCHEDULE (5)	VARIANCE COST (6)	CUMULATIVE TO DATE: BUDGETED COST WORK SCHEDULED (7)	BUDGETED COST WORK PERFORMED (8)	ACTUAL COST WORK PERFORMED (9)	VARIANCE SCHEDULE (10)	VARIANCE COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12a)	SCHEDULE VARIANCE (12b)	BUDGET (13)	AT COMPLETION: BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)
1.1 Torus Systems	745	1,107	1,080	362	27	10,010	9,955	10,665	-55	-711	0	0	0	19,877	20,669	-792
1.2 Plasma Heating and Current D	220	590	425	370	165	5,721	7,352	6,737	1,631	615	0	0	0	23,269	23,095	174
1.3 Auxiliary Systems	0	38	2	38	35	120	162	69	42	93	0	0	0	377	309	68
1.4 Plasma Diagnostics	48	41	42	-7	0	927	935	1,060	8	-125	0	0	0	1,785	2,028	-243
1.5 Power Systems	115	106	220	-9	-114	2,670	2,611	2,555	-59	56	0	0	0	9,360	10,487	-1,127
1.6 Central Instrumentation & Co	1	28	28	28	0	121	192	184	71	8	0	0	0	918	930	-12
1.7 Project Support & Integration	353	213	297	-140	-84	6,913	6,774	6,478	-140	296	0	0	0	14,368	14,936	-568
1.8 Site Preparation and Torus As	218	124	293	-94	-169	1,230	1,642	1,401	412	241	0	0	0	8,884	9,270	-385
b. COST OF MONEY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c. GENERAL AND ADMINISTRATIVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
d. UNDISTRIBUTED BUDGET														0	0	0
e. SUBTOTAL	1,699	2,247	2,388	548	-140	27,711	29,622	29,148	1,910	473	0	0	0	78,838	81,722	-2,884
f. MANAGEMENT RESERVE														0		
g. TOTAL	1,699	2,247	2,388	548	-140	27,711	29,622	29,148	1,910	473	0	0	0	78,838		

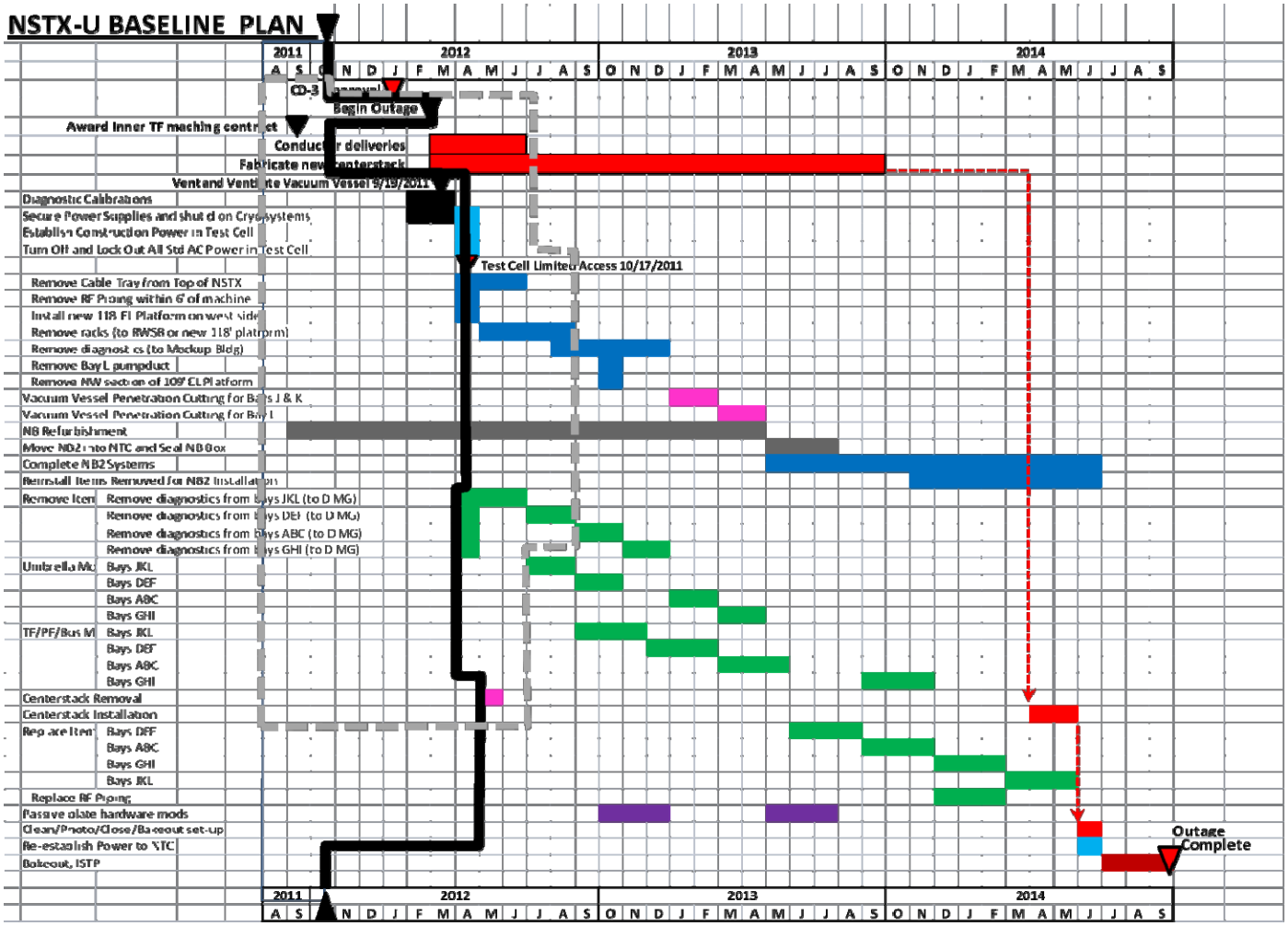
9. RECONCILIATION TO CONTRACT BUDGET BASELINE

a. VARIANCE ADJUSTMENT																
b. TOTAL CONTRACT VARIANCE									1,910	473				78,838	81,722	-2,884

APPENDIX E

SCHEDULE CHART

NSTX Upgrade Schedule



APPENDIX F

MANAGEMENT CHART

NSTX Upgrade Project Team