NCSX Program Planning Update

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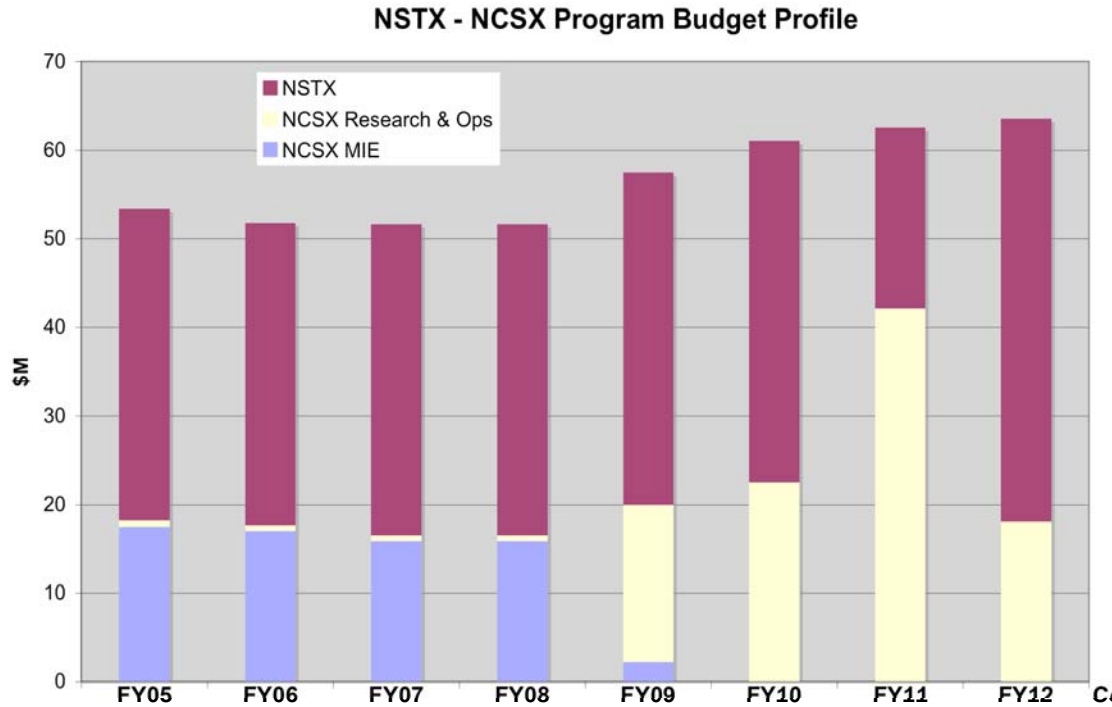
Briefing for Princeton Site Office
Princeton, NJ
September 19, 2006

Planning Context: SC's Five-Year Plan (FY07-11)

NCSX National Compact Stellarator Experiment



NSTX-NCSX budgets presented to OFES in March, 2005 as input to 5–Year Plan

									Comment
Run Weeks									
NCSX					6		24		Alternating,
NSTX	17	11	12	12	12	17		24	per 5-Year Plan
Budgets ($M)									
NCSX MIE	17.5	17.0	15.9	15.9	2.3				Approved baseline & 5YP
NCSX Research & Ops	0.7	0.7	0.7	0.7	17.7	22.5	45.2	21.1	FWP & PPPL plan
NCSX Total	18.2	17.7	16.6	16.6	20.0	22.5	45.2	21.1	Thru FY-08: FWP
NSTX	35.2	34.1	35.1	35.1	37.5	38.6	20.4	45.5	From FY09: PPPL plan
NSTX+NCSX	53.4	51.8	51.7	51.7	57.5	61.1	65.6	66.6	
OFES Non-ITER	261.5	271.8	282.0	277.5	285.5	292.5	303.2		5-Year Plan
NSTX + NCSX Fraction	20%	19%	18%	19%	20%	21%	22%		

NCSX - NSTX Alternation Plan Maintains Portfolio Breadth and Maximizes Scientific Productivity within Essentially Flat Budgets

Agenda: Response to PSO Letter of 7/13/06

1. **NCSX MIE Project, FY07-09– H. Neilson**
   - Q1. Cost control
   - Q2. ETC update
   - Q3. Risk / Contingency Update
2. **NCSX non-MIE Activities, FY09-11– M. Zarnstorff**
   - Q4. Equipment Needed for Research Program

Cost Performance Has Improved in Recent Months

NCSX National Compact Stellarator Experiment

Metric #1: Monthly incremental cost variance.

Target: > -$150k/month (Jan-Apr. average was < -$300k/month)

	May	June	July	August	
Monthly CV ($k)	+43	-224	-208	+2	Avg.: -97

Metric #2: Monthly incremental cost performance index

Target: > 0.90 (Jan-Apr. average was 0.82)

	May	June	July	August	
Monthly CPI	1.03	0.86	0.87	1.00	Avg.: 0.94

Improved Cost Performance in Component Procurements is Sustainable

NCSX National Compact Stellarator Experiment

Manufacturing R&D and Prototypes: Completed in FY-05.

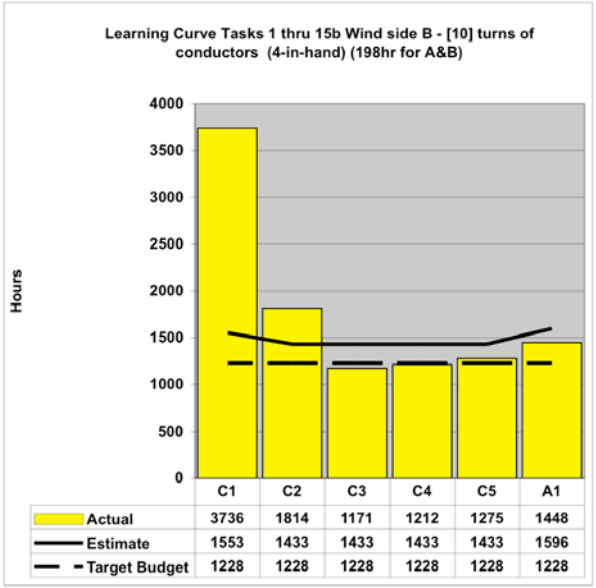
Production Contracts Have Minimal Financial Risk

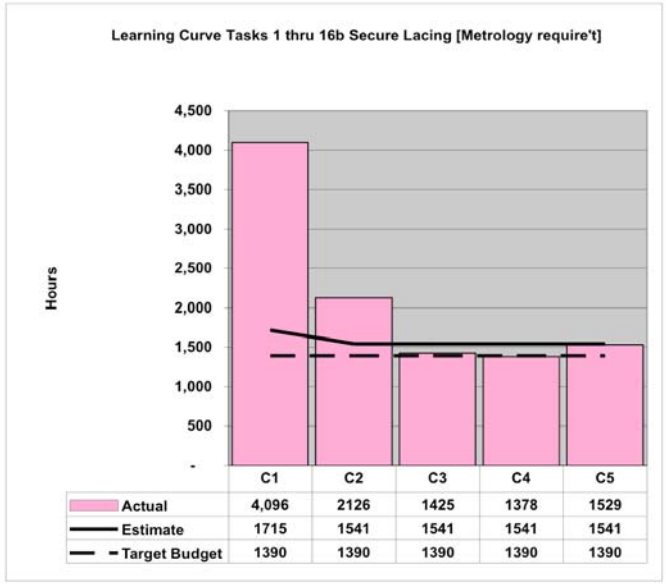
- VVSA: Complete this month.
- MCWF: Producing reliably.
- TF: Off to a good start, and technically much less challenging.

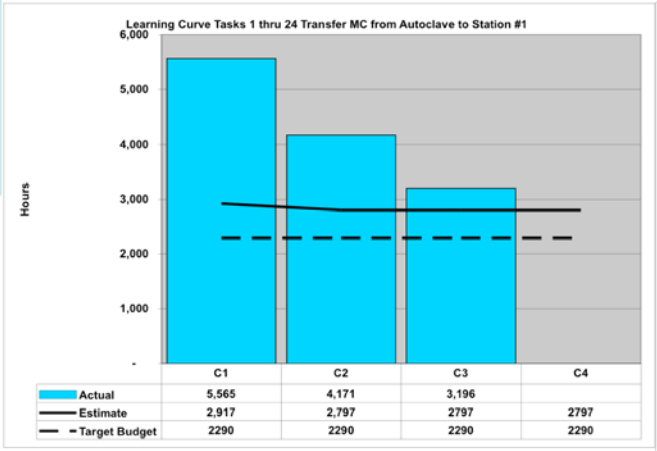
Modular Coil Winding Cost Trends Are Favorable

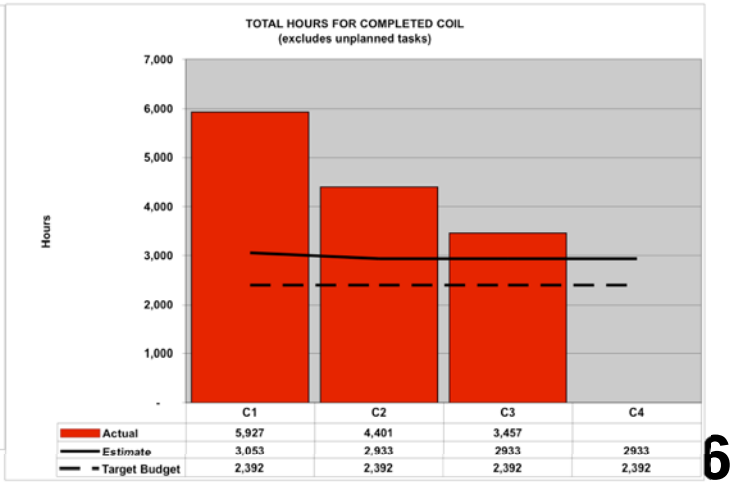
NCSX National Compact Stellarator Experiment

- R&D and first-article cost penalty are behind us.
- We are constantly improving operations.
- Costs are improving.
- Target: get below original estimate.









Improved Cost Performance in Modular Coil Winding Activities is Sustainable

- Further improvements are expected based on recent trends and actions:
  - New winding fixture will improve operations, starting Dec., 2007.
  - New staff added this summer are now up to speed.
  - Type A and B coils are less complex, and could be cheaper, than C.
  - New source for Type A & B chill plates eliminates re-work.
  - Outside source reduces cost of autoclave cleanup.
- Metrology and data analysis risks are being addressed.
  - Identify & train more staff to increase depth.
  - More support for critical hardware and software.

Budget strategy

- Cover estimate growth ($230k) due to new tasks, e.g. installation of I&C, lead boxes, insulation bats.
- Recognize cost risks (but continue efforts to drive costs down):
  - $435k held back @ECP-045. Keep in contingency.
  - $300k future CV growth if current winding ops CPI (~0.9) persists.

Production activities are much more predictable than a year ago. Improvement opportunities exist and are being pursued.

Learning Phase Cost Penalties Can Be Avoided in Assembly Operations

NCSX National Compact Stellarator Experiment

Strategy: Build Field Period #1 as a production prototype.

- There will be problems the first time through.
  - Use a small crew possessing exceptional problem-solving skills to develop the process as cheaply as possible.
- Use VV component layout activity to optimize metrology strategies.
- Perform early modular coil fit-up trials to check for interferences.

We have this opportunity because:

- The VVSA is available to work on.
- The MCWF delivery sequence was optimized. We will soon have all 3 types.
- There is time in the schedule.
- The activity is under our direct control. We determine the resources.

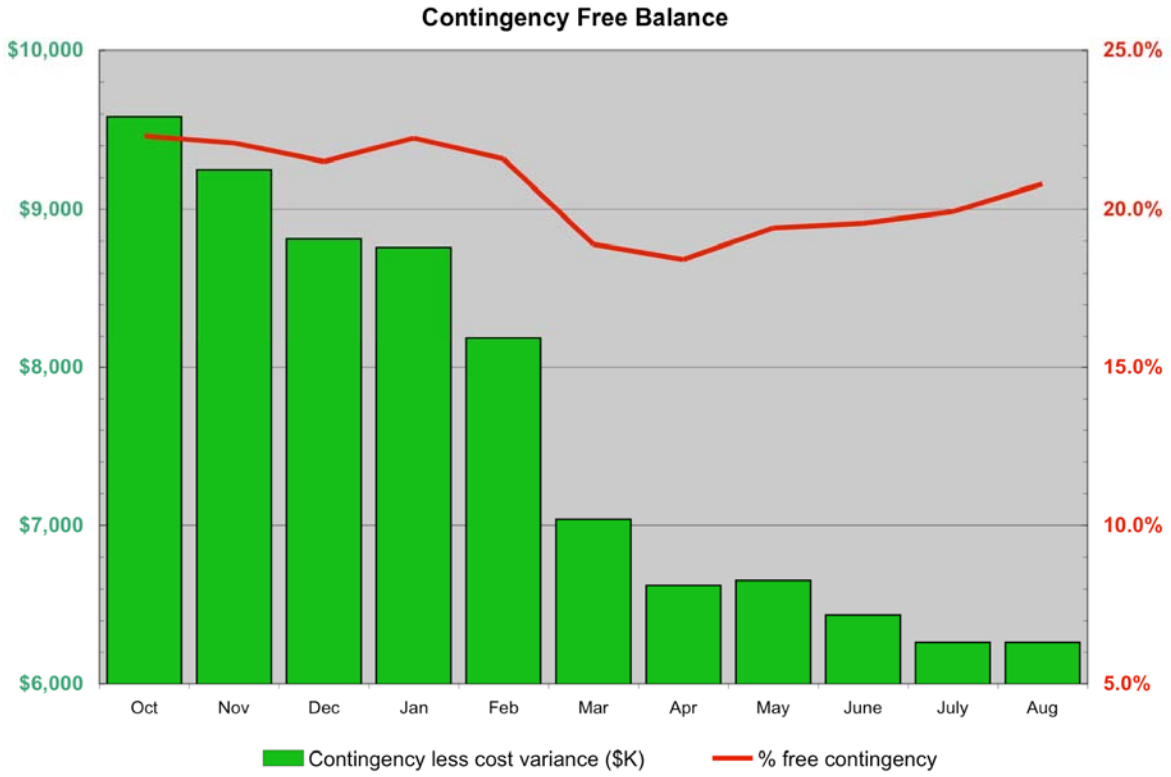
We did not have comparable advantages with the MC and VVSA.

The strategy is working so far.

- Progress: we have scanned VVSA#1 and laid out flux loops and tubing mounts.
- We have encountered and solved problems, with negligible cost variances.

We will status progress and update strategy at FY-07 Lehman reviews.

Contingency Utilization Trends Are Favorable



Rate of contingency drawdown, including cost variances, has slowed dramatically since March.

Avg. drawdown rates

Oct. – Mar.	$509K/mo.
Mar. – Aug.	$155K/mo.

Target: > 20% at end of FY-06. (Metric #3)

Current trends reflect good cost performance but estimate growth for *future* work can cause drops.

New Plan Manages the Most Critical Risks within the Approved Baseline

Overview

- Made changes to reduce risks.
  - MC testing, MC winding fixture, MC fit-up trials; increased FY-07 contingency.
- Adjusted budgets and schedules to reflect trends and new developments.
  - MCWF, MC interfaces, Field Period Assembly.
- Made work reductions to offset growth.
- Identified future risks and opportunities.
- Updated risk / contingency analysis.
- Plan requires contingency drawdown of $973K.

Summary of Budget Changes	**($k)**	
Estimate growth	1,923	
Work reductions	-950	
Proposed contingency drawdow n	**-973**	
Contingency Status Changes		
Current balance (ECP-049)	7,874	
Current CV @8/31/06	-1,609	
Contingency drawdown	-973	
New free balance	**5,292**	**17.0% of BCWR from 8/31/06**

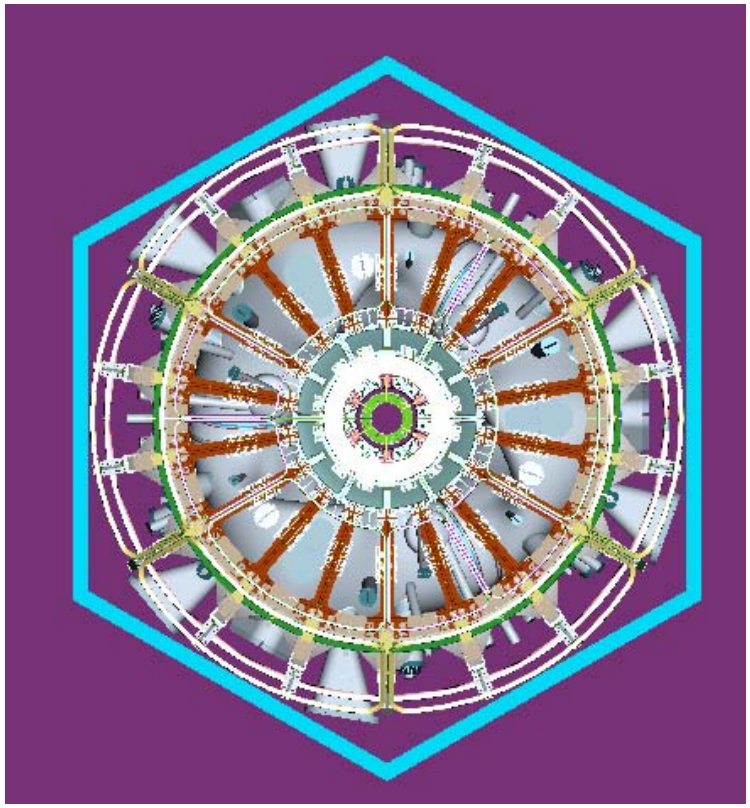
Budget Increases and Reductions

WBS Element	Δ ($k)	Explanation
Increases		
14. MCWF	324	Additional incentives due to better than expected schedule performance.
14. MC Winding Ops	230	Add'l tasks, e.g., I&C, lead boxes, bat ins.
14. MC Facility	63	New fixture
14. MC Testing	278	Validate structural models, qualify strain gauges, improve cryostat cooling.
14. MC Design	207	Interface design, MCWF Title III
12. Vacuum Vessel	81	Cooling Hardware
18. FPA design & tooling	207	Better understanding
18. FPA operations	184	Better understanding & fit-up trials
82. System engineering	193	Construction support: analysis, design, mgt.
Rates & escalation	156	Schedule changes
Subtotal	**1,923**	
Reductions		
17. Cryostat	-278	Simpler design
7. Machine Assy.	-546	Tighten schedule; reduce support crew and oversight costs
18. FPA HP Support	-80	Perform Sta. 4 & 5 in NCSX test cell; move out of TFTR test cell sooner.
15. Coil Structures	-46	Procurement oversight
Subtotal	**-950**	
Total	**973**	

Cost-Saving Cryostat Concept Adopted

NCSX National Compact Stellarator Experiment

- Simple hexagonal cryostat built from foam core panels (similar to the MC test facility cryostat).
- 33 port openings.
- Saves $278K.
- Other alternatives continue to be evaluated.



Cost Risks and Opportunities

Risks

- MC winding ops estimate retained in contingency: $435K.
- MC cost growth if current CPI persists: $300k

Continue to push costs down; re-assess at Lehman reviews.

A new cost reduction opportunity has been identified.

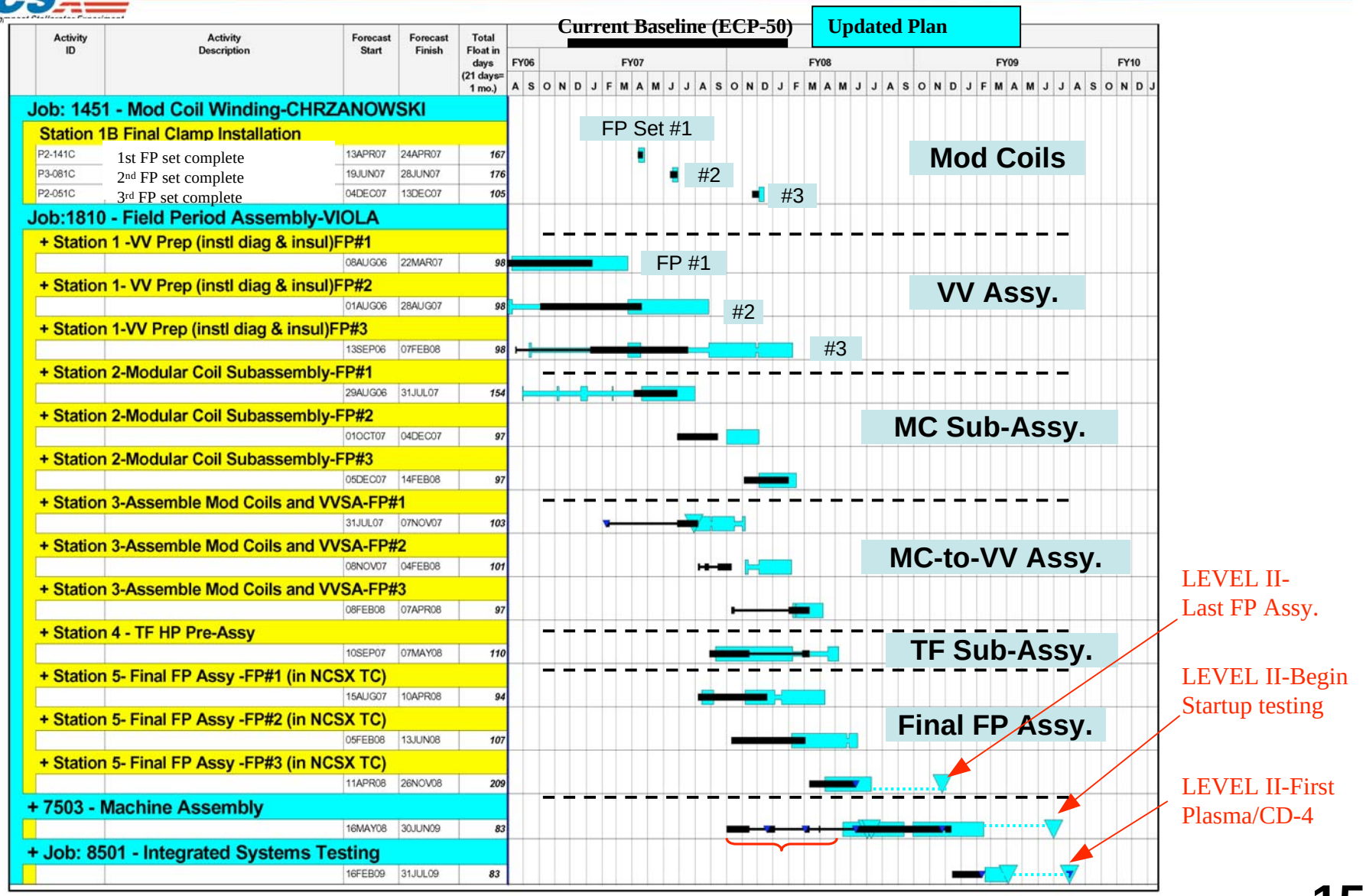
- Electron cyclotron heating (ECH @15 GHz) instead of Ohmic First Plasma.
  - Minimize ECH costs through collaboration and synergy with NSTX.
  - Eliminate several PF circuits.

We will explore and quantify by December Lehman Review.

Contingency is Tight, But Sufficient to Manage the Most Critical Risks

	BCWR ($k)	Conting. ($k)	Conting (%)
MCWF & TF Contracts	3,776	189	5%
MC Winding Operations	4,297	878	20%
Field Period Assy Operations	2,466	863	35%
Balance of Stellarator Core Activities	9,423	1,979	21%
Machine Assembly	2,926	732	25%
Ancillary Systems	3,982	398	10%
Management & System Eng.	4,231	254	6%
	31,103	5,292	17%

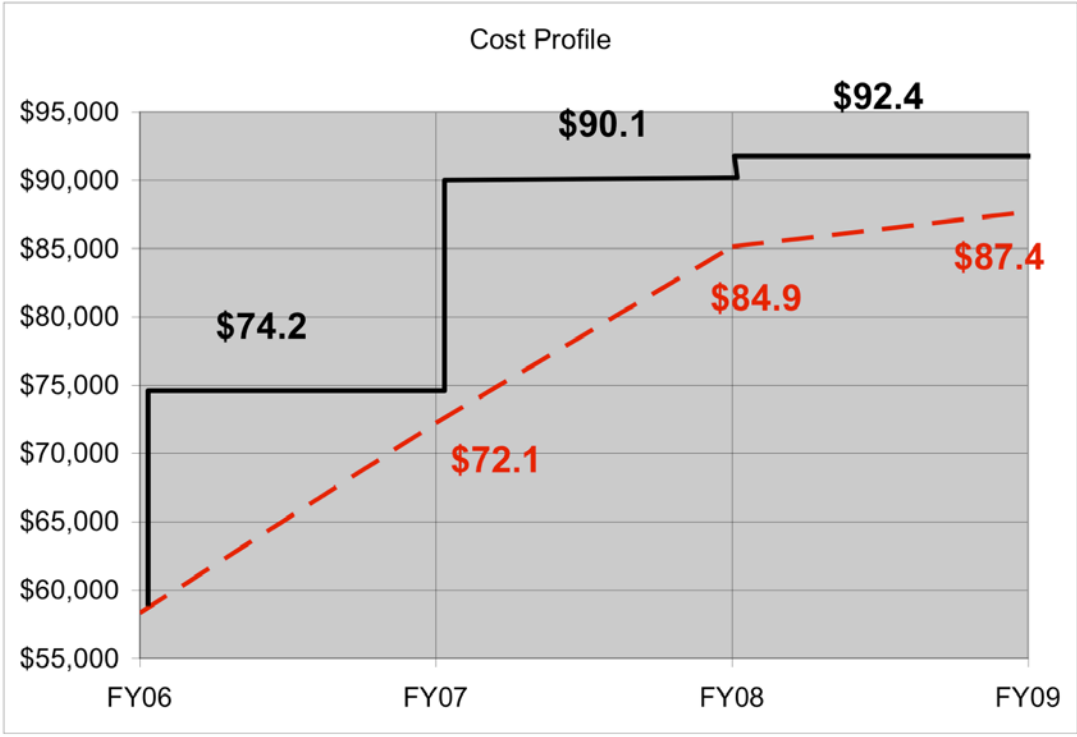
Work Has Been Re-scheduled to Provide Adequate Budget Contingency in FY-07 & -08



Schedule contingency is adequate: 4 months (*vs.* 5 months @CD-2).

Improved Contingency Profile Reduces Schedule Risk

- Contingency made available when needed to manage the critical risks.
- More BA (e.g., $2M) in FY–07 would reduce risks:
  - Advance FPA operations, coil structure procurements, and some contingency.
  - Increase schedule contingency to 5 months.



	FY07	FY08	FY09	Total
BA	15.8	15.9	2.3	34.1
Work	13.7	12.8	2.5	29.0
Contingency	2.1	2.8	0.2	5.1

Summary

We have a sound plan for project completion, which manages the most critical risks within the approved baseline.

- Major component procurement risks are largely retired.
- Remaining component production work is relatively predictable.
- Field Period Assembly risks are significant but can be managed at relatively low cost. Status progress at Lehman reviews.
- Work is re-scheduled to make contingency available in FY07-08.
- Schedule contingency is slightly reduced, but still adequate.
- Budget contingency is tight but sufficient to manage the most critical risks.

Path forward: Continue to manage risks within the baseline, maintain tight cost controls, reduce work where possible.
Review progress and trends at Lehman reviews.

NCSX Research Plan
FY09 – FY11

M.C. Zarnstorff, NCSX Physics Head

For Princeton Plasma Physics Laboratory

& Oak Ridge National Laboratory

DOE/PSO Briefing

9 September 2006

Overview

- MIE project will supply core capability to confine plasma with stellarator fields

- As with previous experiments, this core capability will be augmented for fusion research
  - diagnostics
  - heating systems
  - full control system
  - full power supply system

- NCSX Mission and Goals for operating phases 2-4 are unchanged

- Plan accomplishes High Priority Goals through phase 4 by end of FY11 with alternate year operation, within budgets.

NCSX Research Mission - Unchanged

Acquire the physics data needed to assess the attractiveness of compact stellarators; advance understanding of 3D fusion science.
(FESAC-99 Goal)

Understand…

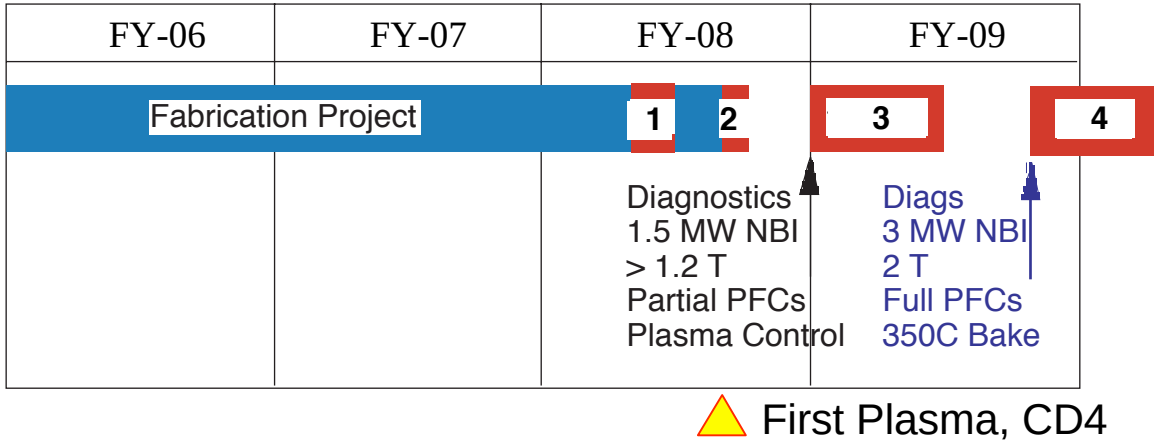
- Pressure limits and limiting mechanisms in a strongly shaped 3D plasma
- Effect of 3D magnetic fields on disruptions
- Reduction of neoclassical transport by quasi-symmetric design.
- Confinement scaling with quasi-symmetry; transport barrier formation and reduction of turbulent transport by flow shear control with 3D field.
- Equilibrium islands and tearing-modes, including effects of magnetic shear, seed perturbations and ion-kinetics
- Effect of stochasticity and 3D shaping on the SOL plasma and power and particle exhaust methods. Compatibility with good core confinement.
- Energetic-ion stability and confinement in 3D magnetic fields

Demonstrate…

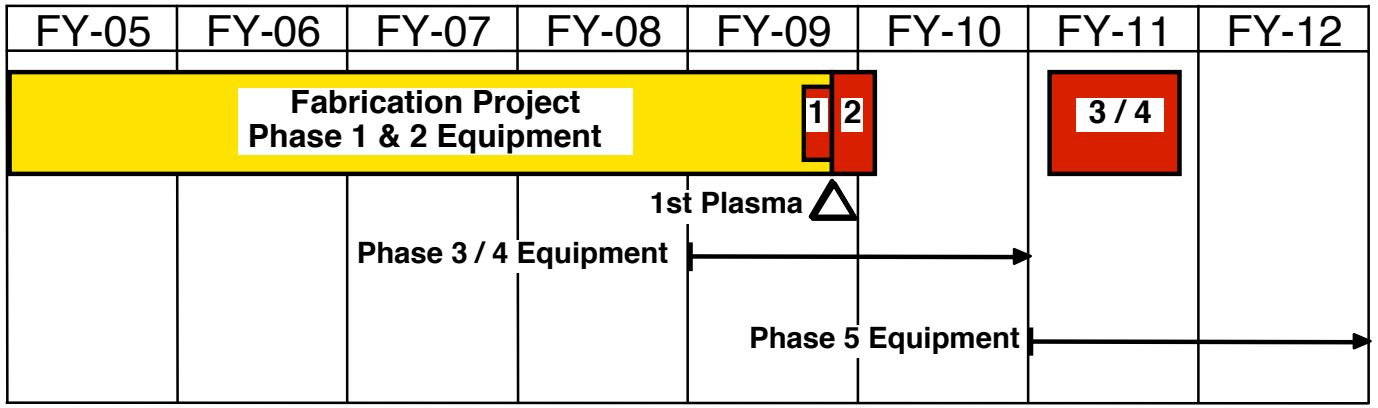
- Conditions for high-β disruption-free operation
- High pressure, good confinement, compatible with steady state

Current Plan Accomplishes Phase 3&4 in FY-11

2004 CD2 Plan



2006 Plan



Research & Operating budget ($M): 0.7 0.7 17.7 22.5 45.2 21.1

Phases:
1. Initial checkout
2. Magnetic configuration studies
3/4. Initial Heating Experiments

- Change in 1st Plasma date due to OFES rebaselining in 2005
- Change in 2006 operating plan due to alternating-year op schedule

Research Goals - Unchanged

2. Magnetic Configuration Mapping (FY09)
   - Document vacuum flux surface characteristics
   - Document control of vacuum field characteristics using coil current

3/4. Initial Heating Experiments (FY11)

Merged goals from previous phases 3 & 4 (1.5MW and 3MW phases)

   - Explore and establish plasma operating space
   - Characterize global confinement, stability, and operating limits, and their dependence on plasma 3D shape
   - Investigate local ion, electron, and momentrum transport and effects of quasi-symmetry
   - Test plasma stability at moderate β, dependence on 3D shape
   - Characterize SOL properties for different 3D geometries, prepare for the first divertor design.
   - Explore ability to generate transport barriers and enhanced confinement regimes.

Plan uses FY09 & FY10 Funding to Operate and Prepare for FY11 Run

	FY09	FY10	FY11
Research (incl. diagnostics)	6.0	6.5	19.6
Facility (incl. upgrades)	11.7	16.0	22.6
Total	17.7	22.5	42.2

As spent $

FY09 and FY10 funding covers

- Operation and Research for Phase 2: Magnetic Configuration studies
- Design and implementation of upgrades (diagnostic and facility) to accomplish phase 3&4 goals in FY11

- Research priorities will be reviewed at upcoming meetings
  - PAC, 9-10 November 2006
  - Research Forum, 7-8 December 2006
- Details of research goals and upgrade plans may evolve in consequence

- Expect ~25% of the diagnostic upgrades will be funded via independently reviewed proposals for collaboration
  - First call in 2008 for FY09 funding

Diagnostic Upgrades Planned and Budgeted

During FY09 and FY10, will add diagnostics for:

- n_e, T_e, T_i, v_ϕ, B_p profiles
- Magnetic measurements of equilibrium and MHD activity
- Radiated power, impurity content (via spectrometry)
- Scrape off layer density and temperature, power losses to wall.

Diagnostic upgrading will continue throughout the Research Program

Equipment Upgrades Planned and Budgeted

Major elements in FY09 & FY10 :

- Data acquisition and control
  - acquisition of diagnostics, data infrastructure
  - diagnostic control; initial plasma feedback control
- Heating systems
  - NBI refurbishment and installation
  - ECH heating may be possible via collaboration, under evaluation
- Plasma facing components and NB armor
  - partial liner inside vacuum vessel
  - wall conditioning & boronization
- Power systems
  - Modular coils and TF powered from D-site, PF coils from C-site
  - Merged C/D-site interlocks and controls
  - Power for diagnostics

Equipment upgrading will continue throughout the Research Program

FY11 Capability Exceeds CD2 plan for Key Systems

	CD2 Plan	Current Plan for FY11
Neutral beams	One beam refurbished, Not installed	Two beams refurbished and installed
Magnet power supplies	6 D-site circuits	4 D-site circuits, 5 C-site circuits: all coils powered
Central solenoid coils	6 coils (PF1-3)	6 coils (PF1 – 3)
Vacuum systems	2 turbo-pumps	4 turbo-pumps
Cryostat cooling system	Complete: 15 min rep-rate	Complete: 15 min rep-rate
Central Instrumentation and Controls	Ready for phase 3	Ready for phase 3 and 4
VV Bakeout	150 C	150C
Trim coils	18 trim coils installed	MIE capability: 2 trim coils for n=1 modes (sufficient for 3/4 goals)

Summary

- NCSX Mission and Research Goals (by operating phase) have not changed
- With alternating-year operation schedule, Initial Heating phases 3&4 will be in FY11
- MIE project will supply core stellarator confinement facility
- Upgrades are planned and budgeted for FY09 & FY10 to accomplish Research Goals
  - Diagnostics
  - Heating systems
  - Control and data acquisition
  - Plasma facing components
  - Power systems