Cost and Schedule

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CompX
General Atomics
INEL
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Nova Photonics
New York U
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UC Davis
UC Irvine
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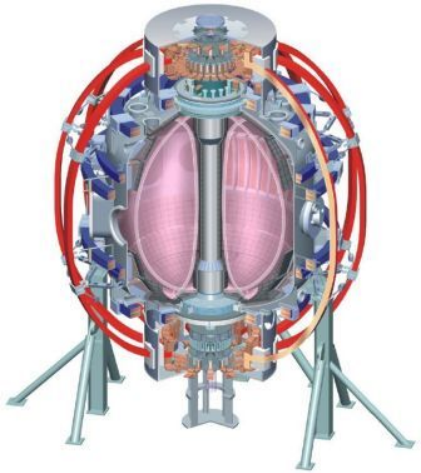
U Rochester
U Washington
U Wisconsin

Ron Strykowsky

NSTX Upgrade Project
Conceptual Design Review
LSB, B318
October 28-29, 2009



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Topics

- **Basis of Estimate**
- **Results**

  (Cost, funding requirements, schedule, staffing)
- **Plans forward**
- **Conclusion**

  (Address charge questions)

Estimate Formulation based on a disciplined process

- Job Managers Prepared Work Authorization Forms (WAF's) - realistic "center-of-errors bars" estimate

  Disciplined and uniform approach for all work

  Excel based spreadsheet includes;

  Tab A – Work scope description

  Tab B – Detail estimate; Tasks, resource estimates (labor hours by skill and material cost), schedule and task durations, basis of estimates

  Tab C – Estimate uncertainty and Risk

  Estimate Uncertainty – Design maturity and complexity

  Risk – Likelihood, cost and schedule impact

  Tab D – Materials, hardware detail and other backup estimate basis

- Internal Engineering Department Review for all Job Estimates
- Prepared resource Loaded Schedule (Primavera)

  1457 tasks, 1751 links, 2259 individual resource loadings

- Quantified Contingency by considering the estimate uncertainty (design complexity and design maturity) and Risk

•The WAF's are the basis of all estimates
•Risks were entered into the project risk registry and used to quantify contingency
•Estimate uncertainty was used to quantify contingency
•The resource loaded schedule is the master schedule and cost estimate data base

Project Scope (WBS) provides basis for estimating and managing

Project WBS

WBS	WAF (Detail of Estimate)	Responsible Job Manager
1.1 Torus Systems		
	1000 CSU Analytical Support	P. Titus
1.1.1 Plasma Facing Components		
	1001 CS- PLASMA FACING COMPONENTS	K. Tresemer
	1002 Passive Plate Analysis and Upgrade Activities	P. Titus
1.1.2 Vacuum Vessel & Support Structure		
	1200 CSU STRUCTURAL SUPPORTS	D. Mangra
1.1.3 Magnet Systems		
	1300 CENTER STACK DESIGN SUPPORT	J. Chrzanowski
1.1.3.1 Outer Polidal Field Coils		
1.1.3.2 Outer Toroidal Field Coils		
	1301 Outer TF Coil Repairs	J. Chrzanowski
1.1.3.3 Center Stack		
	1302 CENTER STACK ASSEMBLY	J. Chrzanowski
1.1.3.3.1 TF Inner legs		
	1303 TF Joint Test Stand & Performance of Test	T. Kozub
	1304 INNER TF BUNDLE- Design & Fabrication	J. Chrzanowski
1.1.3.3.2 Ohmic Heating Solenoid		
	1305 OHMIC HEATING COIL (OH)	J. Chrzanowski
1.1.3.3.3 Shaping Coils		
	1306 Inner POLOIDAL FIELD COILS (IPF)	J. Chrzanowski
1.1.3.3.4 Center Stack Casing		
	1307 CS CASING Assembly- Design & Fabrication	J. Chrzanowski
1.2 Plasma Heating and Current Drive Systems		
1.2.1 High Harmonic Fast Wave		n/a
1.2.2 Coaxial Helicity Injection Current Drive		n/a
1.2.3 Electron Cyclotron Heating		n/a
	2300 ECH	P. Titus
1.2.4 Neutral Beam Injection		
	2420 NBI - Sources	Cropper
	2425 NBI - Beamline Relocation	Denault
	2430 NBI - Decontamination	T. Stevenson
	2440 NBI - Beamline Refurbishment	Denault
	2450 NBI - Services	Denault
	2460 NBI - Armor/Protective Plates	Priniski
	2470 NBI - Power	Raki
	2475 NBI - Controls	Cropper
	2480 NBI - Nozzle/Duct	Priniski
	2490 NBI - Equipment Relocations	E. Perry

WBS	WAF (Detail of Estimate)	Responsible Job Manager
1.3 Auxiliary Systems		
1.3.1 Vacuum Pumping Systems		
	2485 Vacuum Pumping Systems	Priniski
1.3.2 Coolant Systems		
	3200 Water Cooling System Mods for CSU	M. Denault
1.3.3 Bakeout System		
	3300 Bakeout System mods for CSU	S. Raki
1.3.4 Gas Delivery Systems		
	3400 Gas Delivery System Mods for CSU	W. Blanchard
1.3.5 Glow Discharge Cleaning System		n/a
1.4 Plasma Diagnostics		
	4100 Center Stack Diagnostics for CSU	R. Kaita
1.5 Power Systems		
	5000 CS Power Systems	Raki
	5501 COIL BUS RUNS	J. Chrzanowski
1.6 Central Instrumentation & Control		
	6100 Control System & Data Acquisition System	P. Sichta
1.7 Project Support & Integration		
	7100 Project Management & Integration	E.Perry
	7200 Center Stack Management	L.Dudek
	7300 NB2 Management	T.Stevenson
	7400 Health Physics Support	T.Stevenson
	7700 Direct Allocations	R.Strykowsky
	7710 Upgrade Allocations	R.Strykowsky
	7900 Integrated Systems Test	C. Gentile
1.8 Site Preparation and Torus Assembly		
	8200 Centerstack and Coil structure Installation	M. Viola
	8250 Centerstack removal & re-installation	M. Viola

Key Planning Basis and Assumptions

- TPC - from January 1st, 2009
- Institutional Overhead and Labor Rates
- Standard work week 8hrs/day 5 days/ week
- No overtime or Saturday work planned. Overtime and Saturday used to maintain schedule.
- Holidays included
- Task durations based on deliverables and/or tasks identified by the job managers
- Established tasks, internal milestones (PDR's, FDR's, contract awards)
- Task durations based on realistic resource loadings & crew sizes

Contingency Methodology Recognizes Uncertainty & Risk

- **Lower Range**
  - •Average range of estimate uncertainty (1) (%) x base estimate ($)
  - +
  - •Risk Cost ($) x likelihood *(weighted) (%)*
  - +
  - •Schedule contingency (critical path tasks average uncertainty (%) x total schedule length (mos.) x standing army cost ($/mo.)

- **Upper Range**
  - •High estimate uncertainty (1) (%) x base estimate ($)
  - +
  - •Risk Cost ($) *(not weighted)*
  - +
  - •Schedule contingency (critical path tasks average uncertainty (%) x total schedule length (mos.) x standing army cost ($/mo.)

(1) Estimate uncertainty consistent with AACE cost estimate classification system

Summary Cost Profile

TPC ($K)

No Operations

Base Case	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	TOTAL
Base Estimate	$5,146	$10,690	$13,103	$28,302	$10,725	$237		$68,204
Lower Contingency		$340	$1,359	$2,038	$1,359	$1,699		$6,794
Total Lower Bound	**$5,146**	**$11,030**	**$14,462**	**$30,341**	**$12,084**	**$1,936**		**$74,998**
Upper Contingency		$1,139	$4,555	$6,833	$4,555	$5,694		$22,777
Total Upper Bound	**$5,146**	**$11,829**	**$17,659**	**$35,136**	**$15,281**	**$5,931**		**$90,981**

No Operations

Constrained Case	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	TOTAL
Base Estimate	$5,146	$9,879	$7,898	$9,985	$25,840	$12,964	$17	$71,728
Lower Contingency		$148	$520	$1,485	$1,485	$2,227	$1,559	$7,424
Total Lower Bound	**$5,146**	**$10,027**	**$8,417**	**$11,470**	**$27,325**	**$15,191**	**$1,576**	**$79,152**
Upper Contingency		$483	$1,690	$4,828	$4,828	$7,243	$5,070	$24,142
Total Upper Bound	**$5,146**	**$10,362**	**$9,587**	**$14,814**	**$30,668**	**$20,206**	**$5,087**	**$95,870**

Anticipated Guidance	**$5,146**	**$8,000**	**$8,440**	**$11,880**	**$28,670**	**$29,060**	**$7,840**

Note: Anticipated guidance for the total NSTX Program distributed amongst program elements by PPPL.

Base Cost Estimate Detail (TPC $K) (Base Case)

WBS/JOB	TOTAL BASE	Uncertainty % Low	Uncertainty % High	Risk Gross risk $	Risk Likelyhood	Contingency Lower	Contingency Upper	ESTIMATE RANGE LOWER	ESTIMATE RANGE UPPER
Job: 1000 - CSU Analytical Support	$238	-20%	40%	50	U	$36	$145	**$275**	**$383**
Job: 1001 - CS Plasma Facing Components	$1,842	-20%	40%	-		$178	$711	**$2,020**	**$2,553**
Job: 1002 -Passive Plate Analysis & Upgrade Act	$173	-20%	40%	?		$17	$69	**$191**	**$242**
Job: 1200 - Vacuum Vessel & Structural Support	$776	-20%	40%	-		$20	$82	**$796**	**$858**
Job: 1201 - Outer TF Structures	$689	-20%	40%	-		$69	$275	**$758**	**$964**
Job: 1202 - Outer PF Coil Structures	$1,111	-20%	40%	-		$111	$444	**$1,222**	**$1,555**
Job: 1203 - Umbrella Structural Reinforcement	$397	-20%	40%	-		$40	$159	**$437**	**$556**
Job: 1204 - CS Support Pedestal	$197	-20%	40%	-		$20	$79	**$217**	**$276**
Job: 1205 - Misc VV Structural Support	$252	-20%	40%	-		$25	$101	**$277**	**$352**
Job: 1301 - Outer Toroidal Field Coils	$671	-10%	15%	240	U	$77	$341	**$748**	**$1,011**
Job: 1303 - TF Joint Test Stand & Perform Test	$341	-15%	25%	75	U	$36	$160	**$376**	**$501**
Job: 1304 - Inner TF Bundle (Dsgn/Fab)	$1,948	-20%	40%	165	U	$236	$944	**$2,184**	**$2,892**
Job: 1305 - OHMIC Heating Coil (OH) DSGN/FAB	$3,993	-20%	40%	750	U	$481	$1,925	**$4,475**	**$5,918**
Job: 1306 - Inner Poloidal Field Coils (Shaping)	$534	-20%	40%	50	U	$66	$264	**$600**	**$798**
Job: 1307 - CS Casing Assembly (DSGN/FAB)	$875	-20%	40%	-		$88	$350	**$963**	**$1,225**
Job: 1302 - Center Stack Assembly	$812	-20%	40%	n/a		$81	$325	**$893**	**$1,137**
Job: 2300 ECH Analysis	$131	-20%	40%	-		$13	$52	**$144**	**$183**
Job: 2420 - 2nd NBI Sources	$1,309	-5%	10%	-		$33	$131	**$1,342**	**$1,440**
Job: 2425 - BL Relocation	$1,712	-15%	25%	-		$85	$424	**$1,797**	**$2,137**
Job: 2430 - 2nd NBI Decontamination	$2,640	-20%	10%	-		-$70	$140	**$2,570**	**$2,780**
Job: 2440 - 2nd NBI Beamline	$2,378	-10%	15%	(184)	L	-$52	$168	**$2,326**	**$2,546**
Job: 2450 - 2nd NBI Services	$3,542	-15%	25%	50	U	$186	$916	**$3,728**	**$4,459**
Job: 2460 - 2nd NBI Armor	$424	-10%	15%	-		$10	$58	**$433**	**$482**
Job: 2470 - 2nd NBI Power	$2,829	-15%	25%	50	U	$148	$729	**$2,978**	**$3,558**
Job: 2475 - 2nd NBI Controls	$1,691	-15%	25%	-		$85	$423	**$1,775**	**$2,113**
Job: 2480 - 2nd NBI/TVPS Duct	$2,457	-10%	15%	170	U	$99	$511	**$2,556**	**$2,968**
Job: 2485 - Vacuum Pumping System	$314	-5%	10%	-		$8	$31	**$321**	**$345**
Job: 2490 - NTC Equipt Relocations	$3,241	-20%	40%	441	L	$574	$1,680	**$3,815**	**$4,921**
Job: 3200 - Water Cooling System Mods for CSU	$382	-15%	25%	-		$19	$94	**$400**	**$476**
Job: 3300 - Bakeout System Mods for CSU	$80	-5%	10%	-		$2	$8	**$82**	**$88**
Job: 3400 - Gas Delivery System Mods for CSU	$88	-15%	25%	-		$4	$22	**$92**	**$110**
Job: 4100 - Center Stack Diagnostics for CSU	$849	-5%	10%	-		$21	$84	**$870**	**$933**
Job: 5000 - CSU Power Systems	$8,767	-15%	25%			$419	$2,095	**$9,186**	**$10,862**
Job: 5501 - Coil Bus Runs	$702	-20%	40%	-		$70	$281	**$773**	**$983**
Job: 6100 - Control Sys & Data Acquisition Sys	$781	-15%	25%	250	U	$102	$445	**$883**	**$1,226**
Job: 7100 - Project Mgt & Integration CSU & NBI	$4,221	-15%	25%	-		$180	$899	**$4,401**	**$5,120**
Job: 7200 - Center Stack Management	$1,327	-15%	25%	107	L	$131	$439	**$1,458**	**$1,766**
Job: 7300 - NB2 Management	$1,582	-15%	25%	75	L	$121	$455	**$1,703**	**$2,036**
Job: 7400 - Health Physics Support	$2,838	-15%	25%	35	L	$163	$745	**$3,001**	**$3,583**
JOB: 7700 - NSTX Upgrade HP Allocations	$1,836	-15%	25%	130	L	$170	$589	**$2,006**	**$2,425**
Job: 7710 - Upgrade Allocations	$918	-15%	25%	130	L	$98	$228	**$1,016**	**$1,146**
Job; 8200 - Centerstack & Coil Structural Instal	$5,499	-20%	40%	50	U	$562	$2,250	**$6,062**	**$7,749**
Job: 8250 - Remove/Install Centerstack	$749	-30%	60%	287	L	$284	$736	**$1,033**	**$1,485**
Job: 7900 - Integrated System	$69	-20%	40%	-		$7	$28	**$76**	**$96**
schedule (months)	***48***		***7.2***			*$1,742*	*$1,742*	***$1,742***	***$1,742***
Base Estimate =	**$68,204**			2,921		$6,794	$22,777	**$74,998**	**$90,981**
						10%	**33%**		

- **Base Estimate = $68.2M**
- **Contingency range 10% - 33%**
- **TPC range $75M - $91M**
- **Schedule Contingency 7.2months**

Cost and Schedule Opportunities

The project is currently pursuing potential reductions to the base estimate.

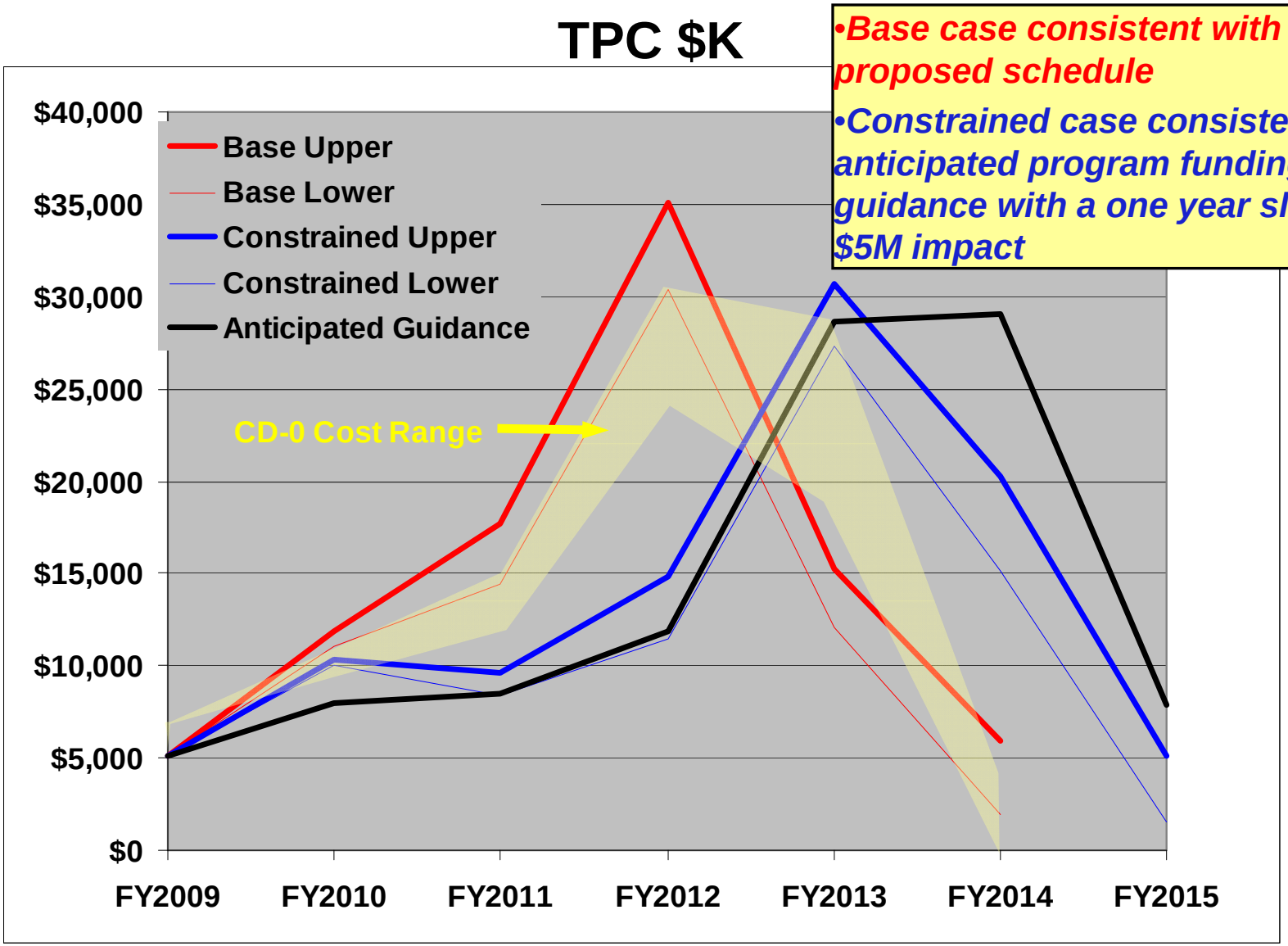
1) Simplification and optimization of the coil support structures.

The current proposed design assumes an over powering of the TF and PF coils scenario which would require significant structural bracing to confine the coils. The addition of the Machine Protection System (MPS) would control and limit power to the coils which would negate the need for such a robust structure. Savings would result from reduced material cost AND significantly less ancillary hardware removals and re-installations. Estimate cost savings $1.6M

2) Hardware Installation.

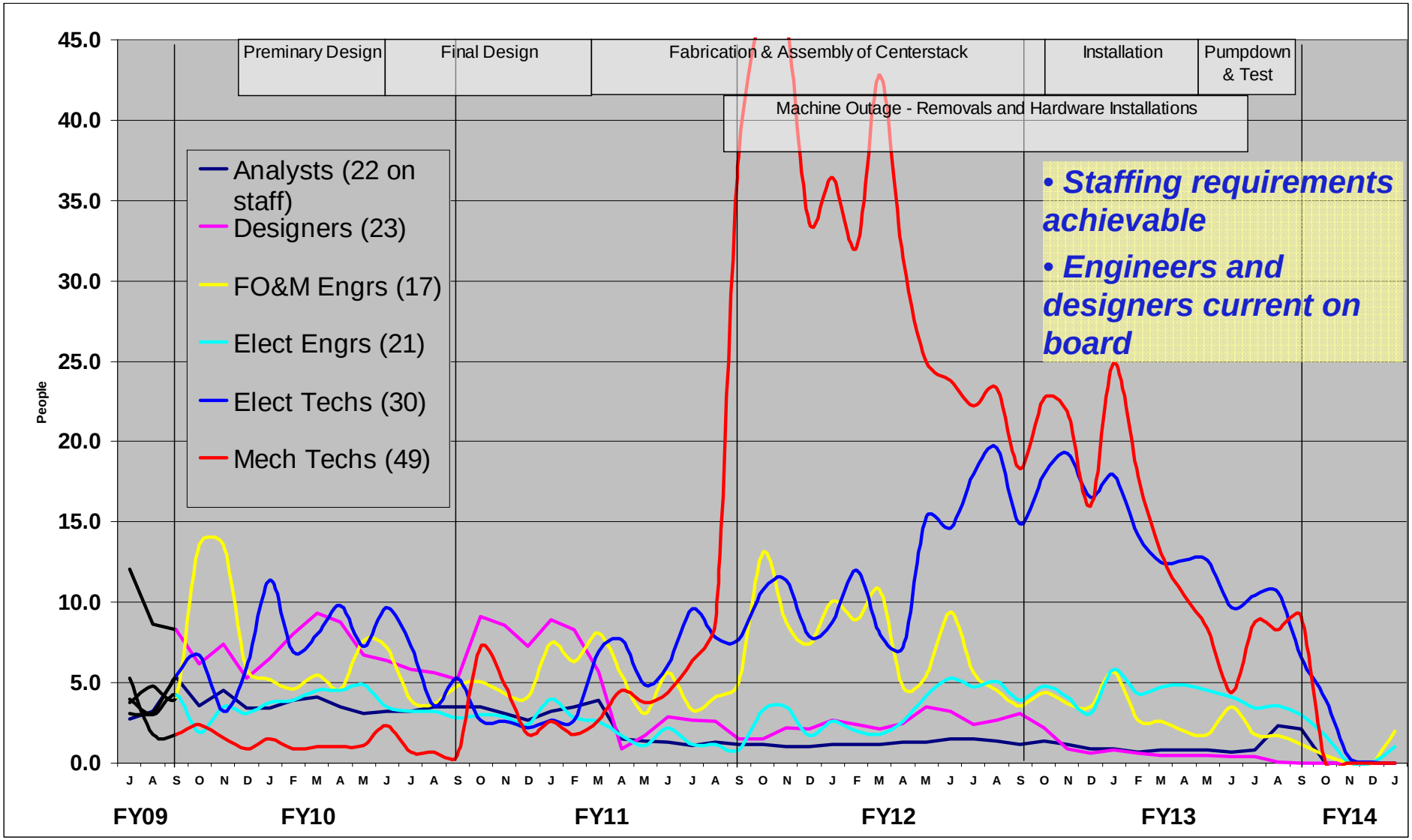
Further review of the assembly plan reveals potential optimization of steps required and labor reductions. Estimated savings $0.6M

Project Funding Requirements

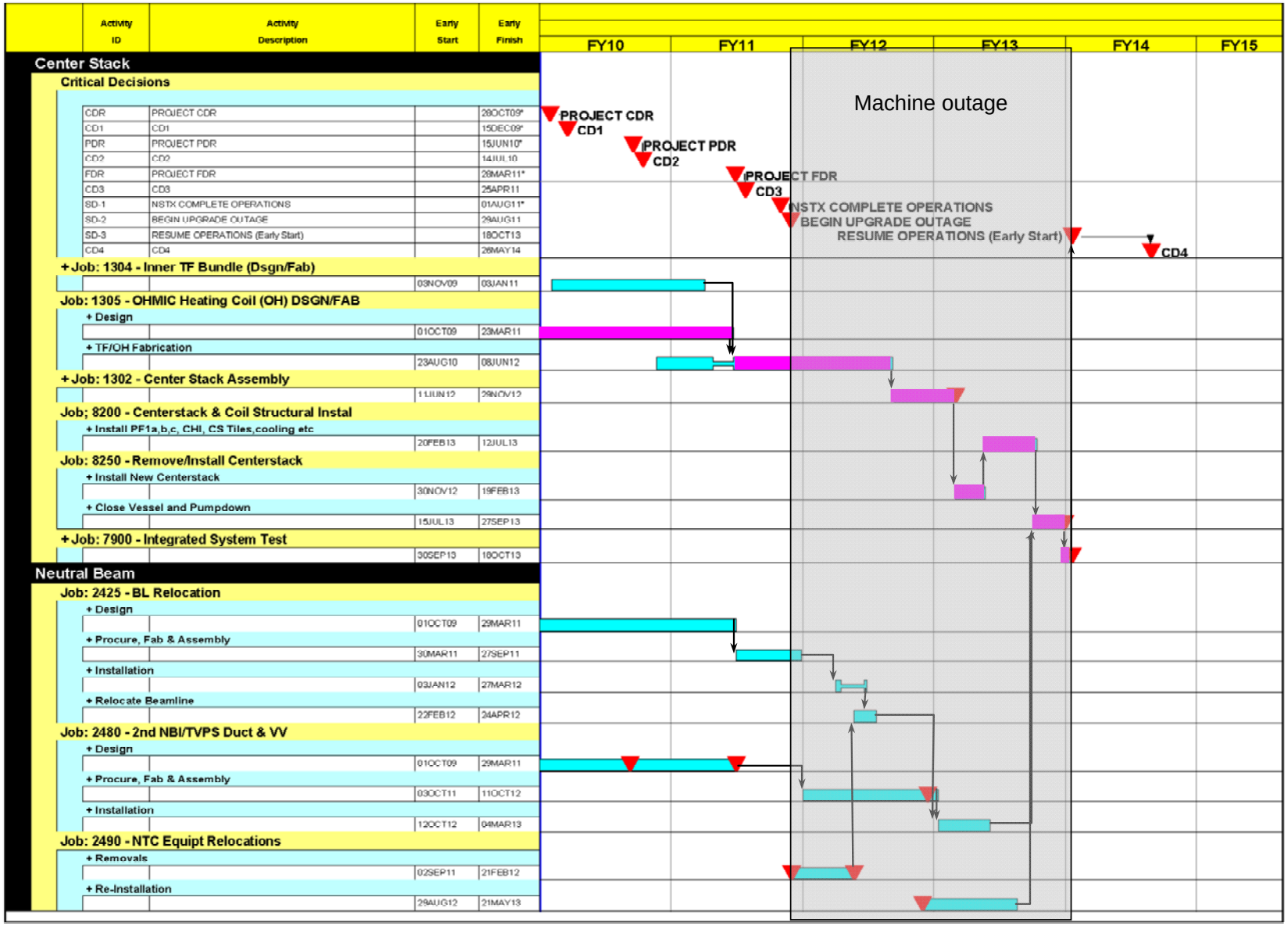


- *Base case consistent with CD-0 proposed schedule*
- *Constrained case consistent with anticipated program funding guidance with a one year slip and $5M impact*

Project Staffing Requirements



Project Schedule (Base Case)



Major Procurements

(Procurements > $100,000)

Job:	Description	Award/Begin Work		Amount
Job: 1304 - Inner TF Bundle (Dsgn/Fab)	Manufacture Inner TF Copper extrusions [80]	FY10	15-Mar-10	$ 242,000
Job: 1304 - Inner TF Bundle (Dsgn/Fab)	Machine Inner TF conductors [grooves, lead area]	FY10	21-Jul-10	$ 250,000
Job: 1305 - OHMIC Heating Coil (OH) DSGN/FAB	Manufacture OH Copper conductor [extrusion]	FY11	08-Oct-10	$ 105,600
Job: 1304 - Inner TF Bundle (Dsgn/Fab)	Friction Stir-Weld coil leads conductors- 40	FY11	21-Oct-10	$ 250,000
Job: 1305 - OHMIC Heating Coil (OH) DSGN/FAB	Fabricate Inner TF/OH Coil Assembly	FY11	31-Mar-11	$ 1,972,600
Job: 2450 - 2nd NBI Services	Ion Dump Water Lines	FY11	01-Jul-11	$ 135,000
Job: 5000 - CSU Power Systems	531- FCPC DC Systems -Procure 1000MCM Cable & Tr	FY11	10-Aug-11	$ 143,000
Job: 5000 - CSU Power Systems	531- FCPC DC Systems -Procure OH Reactors	FY11	10-Aug-11	$ 100,000
Job: 1201 - Outer TF Structures	Fabricate Outer TF Structure components	FY11	15-Aug-11	$ 297,600
Job: 1306 - Inner Poloidal Field Coils (Shaping)	Fabricate Inner [6] Inner PF coils	FY11	19-Aug-11	$ 180,000
Job: 1001 - CS Plasma Facing Components	Fabricate or delivery - PFC Tiles	FY11	30-Aug-11	$ 650,000
Job: 1001 - CS Plasma Facing Components	Fab or delivery PFC Hardware & Materials	FY12	03-Oct-11	$ 150,000
Job: 5000 - CSU Power Systems	541 - Electrical Interlocks -Procurement PLC	FY12	03-Oct-11	$ 102,000
Job: 5000 - CSU Power Systems	544 -PC Link/FD/FG changes -Procure control link	FY12	03-Oct-11	$ 830,000
Job: 5000 - CSU Power Systems	545 - Instrumentation -Procure Transducers	FY12	03-Oct-11	$ 229,000
Job: 5000 - CSU Power Systems	MPS -Procurement	FY12	03-Oct-11	$ 298,000
Job: 2480 - 2nd NBI/TVPS Duct	Fabricate / Delivery - NBI RWM Coil	FY12	05-Oct-11	$ 170,000
Job: 2475 - 2nd NBI Controls	Fabricate or delivery 2nd NBI Controls	FY12	18-Oct-11	$ 312,000
Job: 1202 - Outer PF Coil Structures	Fabricate Outer PF Cage [PF-3/4/5]	FY12	08-Nov-11	$ 350,000
Job: 1202 - Outer PF Coil Structures	Fabricate PF-2/PF-1c support modifications	FY12	09-Nov-11	$ 118,800
Job: 2480 - 2nd NBI/TVPS Duct	Fabricate / Delivery - NBI 40" VAT Valves (2)	FY12	11-Nov-11	$ 250,000
Job: 2450 - 2nd NBI Services	HVE Water Lines	FY12	15-Nov-11	$ 100,000
Job: 2480 - 2nd NBI/TVPS Duct	Fabricate / Delivery - NBI 40" Bellows Section	FY12	15-Nov-11	$ 300,000
Job: 2470 - 2nd NBI Power	Procurement/Fab/Assembly - 2nd NBI Cables	FY12	18-Jan-12	$ 422,200
Job: 1203 - Umbrella Structural Reinforcement	Fabricate umbrella lids	FY12	19-Jan-12	$ 100,000
Job: 5000 - CSU Power Systems	531- FCPC DC Systems - Instl cable & misc h/w	FY12	01-May-12	$ 535,000
Job: 2470 - 2nd NBI Power	Installation - 2nd NBI Raceway	FY12	09-Aug-12	$ 480,000

- ***Center stack Hardware***
- ***On or near critical path***
- ***Required before CD-3 (April 2011)***

Management Process

The NSTX Upgrade project will be managed using PPPL's cost and schedule control processes

(Project Management System Program Description (PMSPD) Revision 0 July 2009)

- **Adopt the conceptual design plan as our baseline through preliminary design (CD-2) (will adjust in response to CDR and OFES findings)**
- **Monthly progress measurement including;**
  - **Earned value**
  - **Risk registry review**
  - **EAC assessment**
- **Monthly reporting including**
  - **Status barcharts**
  - **Cost performance reports (CPR's) including EAC's**
  - **Updated risk registry**
- **Change control process – changes documented via engineering change proposals (ECP's)**

Conclusions

- **Is the proposed cost range adequate for CD-1?**
  - ***The conceptual design estimate was prepared following a disciplined process and is credible for this stage of the project.***
  - ***The work scope is complete, well organized with clear assignment of responsibilities.***
  - ***A well detailed resource loaded schedule exists and provides the basis for all cost and schedule estimates.***
  - ***The contingency and methodology used to established the upper and lower cost range is reasonable for this stage of the project.***
- **Is the proposed schedule realistic for CD-1?**
  - ***The schedule is realistic and achievable based on the resource availability and level of schedule detail.***
- **Is the project organization/staffing appropriate?**
  - ***Staffing requirements have been clearly defined and are achievable.***
  - ***The project is currently staffed to begin the preliminary design phase.***
  - ***The project has been responsive in addressing both programmatic mission goals (base case) as well as anticipated funding guidance (constrained case).***
  - ***The project is poised to initiate and effectively manage the preliminary design phase of the project.***