

Work Authorization Document

NSTX Upgrade Project

Control Account #:	5501	Title:	Coil Bus Runs
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WBS	1.5	Title:	Power System
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Period of Performance: 01 January 2010 through 18 June 2014

Authorized Budget:	\$1,131	Control Account Manager:	Smtih
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Revision #:	0	Revision Date:	July-11
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Authorized Work Description:

Definition: This WBS element includes the design and fabrication of the coil bus runs/supports between the NSTX coils and the FCPC cable terminations located in the NSTX test cell.

Attachments:

- 1- A detailed Control Account schedule showing all work packages and planning packages.
- 2- Budgeted Cost by month.
- 3- Original Work Authorization Form (WAF)
- 4- WBS Dictionary sheet that defines the scope of work for this WBS element.

Control Account History

ECP#	Implement Date	Prior Budget	New Budget	Signature

Approvals	Name	Signature	Date
NSTX-U Project Manager	R. Strykowski		
Control Account Manager	Smtih		
Functional Manager	L. Dudek		

Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)	FY11	FY12	FY13	FY14	FY15	FY16
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NSTX Upgrade Project

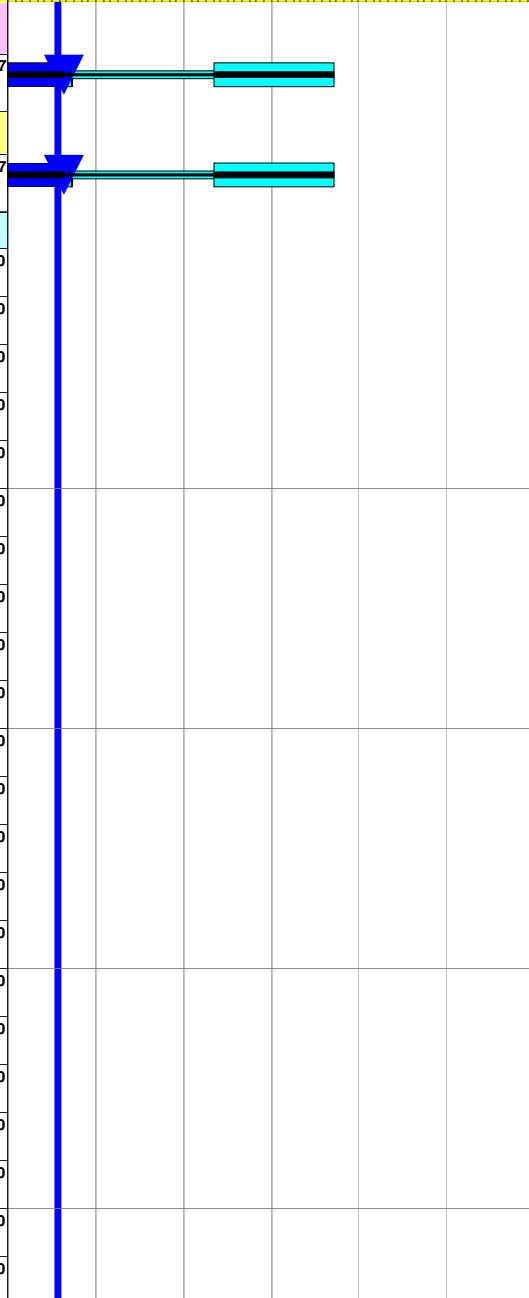
Subtotal		1,114	01JAN10A	01JAN10A	18JUN14	18JUN14	0	57	1,132,094.38		371,621.39	357,319.87						
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Job: 5501 - Coil Bus Runs-SMITH

Subtotal		1,114	01JAN10A	01JAN10A	18JUN14	18JUN14	0	57	1,132,094.38		371,621.39	357,319.87						
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Design

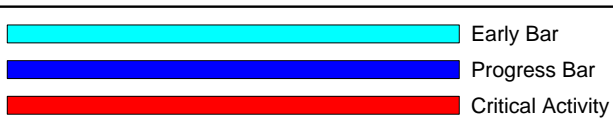
5501-0007	FEMA	5	03MAY10A	03MAY10A	07MAY10A	07MAY10A	0		0.00	100	0.00	0.00						
5501-0009	Eng Dsgn: elect, thermal, EM & stress-OH BUS	4	21MAY10A	21MAY10A	26MAY10A	26MAY10A	0		0.00	100	0.00	0.00						
5501-0010	CAD:Coaxial bus dsgn/bus routing/supports-OH BUS	5	10MAY10A	10MAY10A	14MAY10A	14MAY10A	0		0.00	100	0.00	0.00						
5501-0011	Analysis Mech: thermal, EM & stress-OH BUS	2	17MAY10A	17MAY10A	18MAY10A	18MAY10A	0		0.00	100	0.00	0.00						
5501-0012	Analysis Elec: electrical-OH BUS	2	17MAY10A	17MAY10A	18MAY10A	18MAY10A	0		0.00	100	0.00	0.00						
5501-0014	Eng Dsgn: elect, thermal, EM & stress-PF BUS	4	27MAY10A	27MAY10A	02JUN10A	02JUN10A	0		0.00	100	0.00	0.00						
5501-0015	CAD: bus routing, supports-PF BUS	5	07MAY10A	07MAY10A	13MAY10A	13MAY10A	0		0.00	100	0.00	0.00						
5501-0016	Analysis Mech: thermal, EM & stress-PF BUS	2	14MAY10A	14MAY10A	17MAY10A	17MAY10A	0		0.00	100	0.00	0.00						
5501-0017	Analysis Elec: electrical-PF BUS	2	14MAY10A	14MAY10A	17MAY10A	17MAY10A	0		0.00	100	0.00	0.00						
5501-0019	Eng Dsgn: elect, thermal, EM & stress-TF BUS	4	03JUN10A	03JUN10A	08JUN10A	08JUN10A	0		0.00	100	0.00	0.00						
5501-0020	CAD: bus routing, supports-TF BUS	10	13MAY10A	13MAY10A	26MAY10A	26MAY10A	0		0.00	100	0.00	0.00						
5501-0021	Analysis Mech: thermal, EM & stress-TF BUS	2	27MAY10A	27MAY10A	28MAY10A	28MAY10A	0		0.00	100	0.00	0.00						
5501-0022	Analysis Elec: electrical-TF BUS	2	27MAY10A	27MAY10A	28MAY10A	28MAY10A	0		0.00	100	0.00	0.00						
5501-0024	Eng Dsgn: elect, thermal, EM & stress-CHI BUS	4	09JUN10A	09JUN10A	14JUN10A	14JUN10A	0		0.00	100	0.00	0.00						
5501-0025	CAD:ring bus design/bus routing/supports-CHI BUS	18	26MAY10A	26MAY10A	21JUN10A	21JUN10A	0		0.00	100	0.00	0.00						
5501-0026	Analysis Mech: thermal, EM & stress-CHI BUS	2	22JUN10A	22JUN10A	23JUN10A	23JUN10A	0		0.00	100	0.00	0.00						
5501-0027	Analysis Elec: electrical-CHI BUS	2	22JUN10A	22JUN10A	23JUN10A	23JUN10A	0		0.00	100	0.00	0.00						
5501-0028	Update Cost & Schedule Estimate	3	11JUN10A	11JUN10A	15JUN10A	15JUN10A	0		0.00	100	0.00	0.00						
5501-0029	PDR Prep & PDR	6	16JUN10A	16JUN10A	23JUN10A	23JUN10A	0		0.00	100	0.00	0.00						
5501-0030	Disposition of PDR CHITS	30	24JUN10A	24JUN10A	05AUG10A	05AUG10A	0		0.00	100	0.00	0.00						
5501-0031	Eng Dsn & CAD Model Updates	38	23JUN10A	23JUN10A	25AUG10A	25AUG10A	0		0.00	100	0.00	0.00						
5501-0032	OH Coaxial Bus Prelim Dsgn Updat/Optim Cmpl	8	24JUN10A	24JUN10A	06JUL10A	06JUL10A	0		0.00	100	0.00	0.00						



Data Date: 30APR11 1105
 Run Date: 20MAY11 11:02
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**NSTX UPGRADES
 RESOURCE LOADED SCHEDULE
 CD-2 Schedule
 April 2011**

Sheet 1 of 4



Activity ID	Activity Description	Works Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)	Fiscal Year									
													FY11	FY12	FY13	FY14	FY15	FY16				
5501-0033	PF Bus Prelim Dsgn Updat/Optim Cmpl	10	07JUL10A	07JUL10A	20JUL10A	20JUL10A	0		0.00	100	0.00	0.00										
5501-0034	TF Bus Prelim Dsgn Updat/Optim Cmpl	10	21JUL10A	21JUL10A	03AUG10A	03AUG10A	0		0.00	100	0.00	0.00										
5501-0035	CHI Bus Prelim Dsgn Updat/Optim Cmpl	10	04AUG10A	04AUG10A	17AUG10A	17AUG10A	0		0.00	100	0.00	0.00										
5501-0037	Prep DOE CD-2 (Lehman) Review	5	04AUG10A	04AUG10A	10AUG10A	10AUG10A	0		0.00	100	0.00	0.00										
5501-0038	DOE CD-2 (Lehman) Review	1	11AUG10A	11AUG10A	11AUG10A	11AUG10A	0		0.00	100	0.00	0.00										
1305-0160	N/A OH Bus Bar Analysis(xfer f/j. Chrzanowski)	39*	02AUG10A	02AUG10A	30SEP10A	30SEP10A	0		0.00	100	0.00	0.00										
OH Bus																						
5501-0042	Final Design	195*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		25,166.13	LOE	25,010.31	25,010.31										
5501-0046	Busbar System Design-OH BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		3,170.61	100	3,153.04	3,153.04										
5501-0047	Update CAD - OH BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		12,140.19	100	12,078.34	12,078.34										
5501-0049	Analysis/Calc: EM/Stress/Thermal-OH BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		4,531.33	100	4,500.09	4,500.09										
5501-0050	Detail Drawings-OH BUS	143*	01MAR11	04OCT10A	04APR11	29APR11A	-19		2,997.84	100	2,997.84	2,997.84										
5501-0051	Design Validation-OH BUS	41*	01MAR11	14MAR11A	04APR11	29APR11A	-19		7,855.08	100	7,855.08	7,855.08										
5501-0098	Documentn: Fab/Assy Procedure-OH BUS	5	01OCT13	01OCT13	07OCT13	07OCT13	0	31	19,677.16		0.00	0.00										
5501-0099	Fabricatn: pre-installation components-OH BUS	20	08OCT13*	08OCT13*	04NOV13	04NOV13	0	31	38,946.48		0.00	0.00										
5501-0100	Assembly: pre-installatn components-OH BUS	20	05NOV13*	05NOV13*	04DEC13	04DEC13	0	31	18,374.40		0.00	0.00										
5501-0101	Insulation & Protective Layer-OH BUS	10	19NOV13	19NOV13	04DEC13	04DEC13	0	31	18,374.40		0.00	0.00										
5501-0102	Electrical Testing-OH BUS	5	26NOV13	26NOV13	04DEC13	04DEC13	0	31	5,610.88		0.00	0.00										
5501-0114	Fabricatn: pre-installation components-OH BUS	20	11FEB14*	11FEB14*	10MAR14	10MAR14	0	31	20,572.08		0.00	0.00										
5501-0118	Documentation: Installation Procedure-OH BUS	5	22OCT13*	22OCT13*	28OCT13	28OCT13	0	116	4,395.36		0.00	0.00										
5501-0119	Field Fit Up, Fabrication, Installation-OH BUS	65	11MAR14	11MAR14	10JUN14	10JUN14	0	31	23,541.52		0.00	0.00										
5501-0120	Testing-OH BUS	1	11JUN14	11JUN14	11JUN14	11JUN14	0	62	2,611.60		0.00	0.00										
5501-0051A	Updt Models/Dwgs Ready for Signoff-OH BUS	10	05APR11	11APR11A	09MAY11	29APR11A	6		13,415.25	100	13,415.25	10,195.59										
PF Bus																						
5501-0055	Busbar System Design-PF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		3,170.61	100	3,153.04	3,153.04										
5501-0056	Update CAD-PF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		12,105.10	100	12,039.90	12,039.90										
5501-0058	Analysis/Calc: EM/Stress/Thermal-PF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		4,531.33	100	4,500.09	4,500.09										
5501-0059	Detail Drawings-PF BUS	143*	01MAR11	04OCT10A	04APR11	29APR11A	-19		11,991.36	100	11,991.36	11,991.36										
5501-0060	Design Validation-PF BUS	41*	01MAR11	14MAR11A	04APR11	29APR11A	-19		7,855.08	100	7,855.08	7,855.08										

Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)										
													FY11	FY12	FY13	FY14	FY15	FY16				
5501-0105	Documentn: Fab/Assy Procedure-PF BUS	5	01OCT13*	01OCT13*	07OCT13	07OCT13	0	71	7,373.96		0.00	0.00					EM//EM =24 ; EM//SM =08 ;					
5501-0106	Fabricatn: pre-installation components-PF BUS	20	05DEC13	05DEC13	13JAN14	13JAN14	0	31	20,572.08		0.00	0.00					EM//EM =12 ; EM//ST					
5501-0060A	Updt Models/Dwgs Ready for Signoff-PF BUS	10	05APR11	11APR11A	09MAY11	29APR11A	6		15,413.67	100	15,413.67	11,714.39					EA//SB =93 ; EM//EM=24					
5501-0123	Documentation: Installation Procedure-PF BUS	5	29OCT13*	29OCT13*	04NOV13	04NOV13	0	130	4,395.36		0.00	0.00					EM//EM =24 ;					
5501-0124	Field Fit Up, Fabrication, Installation-PF BUS	60	18MAR14	18MAR14	10JUN14	10JUN14	0	31	161,077.92		0.00	0.00					EM//SM =90 ; EA//EE//EM =04 ; EM//					
5501-0125	Testing-PF BUS	6	11JUN14	11JUN14	18JUN14	18JUN14	0	57	15,669.60		0.00	0.00					EE//SB =48 ; EM//SM =48 ;					
TF Bus																						
5501-0063	Busbar System Design-TF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		3,170.61	100	3,153.04	3,153.04					EM//EM =16 ; EE//EM =04 ;					
5501-0064	Update CAD-TF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		14,514.40	100	14,436.14	14,436.14					EM//EM =34 ; EA//SB =75 ;					
5501-0066	Analysis/Calc: EM/Stress/Thermal-TF BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		6,041.77	100	6,000.12	6,000.12					EA//EM =32 ;					
5501-0067	Detail Drawings-TF BUS	123*	01MAR11	01NOV10A	04APR11	29APR11A	-19		6,994.96	100	6,994.96	6,994.96					EA//SB =56 ;					
5501-0068	Design Validation-TF BUS	41*	01MAR11	14MAR11A	04APR11	29APR11A	-19		7,855.08	100	7,855.08	7,855.08					EE//EM =12 ; EA//EM =30 ;					
5501-0109	Documentn: Fab/Assy Procedure-TF BUS	5	08OCT13	08OCT13	14OCT13	14OCT13	0	86	7,373.96		0.00	0.00					EM//EM =24 ; EM//SM =08 ;					
5501-0110	Fabricatn: pre-installation components-TF BUS	20	14JAN14*	14JAN14*	10FEB14	10FEB14	0	31	20,572.08		0.00	0.00					EM//EM =12 ; EM//ST					
5501-0068A	Updt Models/Dwgs Ready for Signoff-TF BUS	10	05APR11	11APR11A	09MAY11	29APR11A	6		12,091.12	100	12,091.12	9,189.25					EA//SB =74 ; EM//EM=18					
5501-0129	Documentation: Installation Procedure-TF BUS	5	05NOV13*	05NOV13*	11NOV13	11NOV13	0	130	4,395.36		0.00	0.00					EM//EM =24 ;					
5501-0130	Field Fit Up, Fabrication, Installation-TF BUS	65	11MAR14	11MAR14	10JUN14	10JUN14	0	31	51,681.52		0.00	0.00					EM//SM =20 ; EA//EE//EM =04 ; EM//					
5501-0131	Testing-TF BUS	2	11JUN14	11JUN14	12JUN14	12JUN14	0	61	7,834.80		0.00	0.00					EE//SB =24 ; EM//SM =24 ;					
CHI Bus																						
5501-0071	Busbar System Design-CHI BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		3,170.61	100	3,153.04	3,153.04					EM//EM =16 ; EE//EM =04 ;					
5501-0072	Update CAD-CHI BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		16,982.31	100	16,891.09	16,891.09					EM//EM =38 ; EA//SB =90 ;					
5501-0074	Analysis/Calc: EM/Stress/Thermal-CHI BUS	176*	17AUG10A	17AUG10A	28FEB11	29APR11A	-44		4,531.33	100	4,500.09	4,500.09					EA//EM =24 ;					
5501-0075	Detail Drawings-CHI BUS	123*	01MAR11	01NOV10A	04APR11	29APR11A	-19		13,989.92	100	13,989.92	13,989.92					EA//SB =112 ;					
5501-0076	Design Validation-CHI BU	41*	01MAR11	14MAR11A	04APR11	29APR11A	-19		7,855.08	100	7,855.08	7,855.08					EE//EM =12 ; EA//EM =30 ;					
5501-0113	Documentn: Fab/Assy Procedure-CHI BUS	5	15OCT13	15OCT13	21OCT13	21OCT13	0	101	7,373.96		0.00	0.00					EM//EM =24 ; EM//SM =08 ;					
5501-0076A	Updt Models/Dwgs Ready for Signoff-CHI BUS	10	05APR11	11APR11A	09MAY11	29APR11A	6		18,669.62	100	18,669.62	14,188.91					EA//SB =114 ; EM//EM=28					
5501-0077	Update Cost & Schedule Estimate	5	10MAY11	24MAY11*	16MAY11	31MAY11	-10	122	1,265.68		0.00	0.00					EM//EM =08 ;					
5501-0078	FDR Prep	14*	10MAY11	01JUN11	23MAY11	20JUN11	-19	122	6,328.40		0.00	0.00					EM//EM =40 ;					
5501-0078A	Coil Bus Runs - Peer review	0				18MAY11*	0	147	0.00		0.00	0.00										
5501-0079	FDR 5500	3	15JUN11	22JUN11*	15JUN11	24JUN11	-7	121	1,265.68		0.00	0.00					EM//EM =08 ;					

Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)	FY11	FY12	FY13	FY14	FY15	FY16			
5501-0135	Documentation: Installation Procedure-CHI BUS	5	12NOV13*	12NOV13*	18NOV13	18NOV13	0	130	4,395.36		0.00	0.00							EM//EM =24 ;		
5501-0136	Field Fit Up, Fabrication, Installation-CHI BUS	65	11MAR14	11MAR14	10JUN14	10JUN14	0	60	85,489.52		0.00	0.00							EM//SM =40 ; EA//EE//EM =04 ; EM//		
5501-0137	Testing-CHI BUS	3	11JUN14	11JUN14	13JUN14	13JUN14	0	60	7,834.80		0.00	0.00	EE//SB =24 ;						EM//SM =24 ;		
Inner TF Bundl;e Design																					
1304-0120	N/A Analyze TF Bus Bar (xfer f/j. Chrzanowski)	17	30SEP10A	30SEP10A	30SEP10A	30SEP10A	0		0.00	100	0.00	0.00	EA//EM =100 ;								
5501-0082	Prep Req & Procurement Package	10	01FEB13*	01FEB13*	14FEB13	14FEB13	0	42	14,171.20		0.00	0.00							EM//EM =80 ;		
5501-0083	Submit Req to Procurement	1	15FEB13	15FEB13	15FEB13	15FEB13	0	42	0.00		0.00	0.00									
5501-0084	Procurement Lead Time	30	18FEB13	18FEB13	29MAR13	29MAR13	0	42	0.00		0.00	0.00									
5501-0085	Award Coil Bus Run	1	01APR13	01APR13	01APR13	01APR13	0	42	0.00		0.00	0.00									
5501-0086	Copper Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	22,455.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=15,000		
5501-0087	Insulation & Protection Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	13,215.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=8,000 ;		
5501-0088	SS Hardware, Fittings, Materials Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	23,775.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=16,000		
5501-0089	G10 FR4 Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	11,895.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=7,000 ;		
5501-0090	Fab & Safety Comsumables Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	9,255.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=5,000 ;		
5501-0091	Struc Support Material Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	6,615.56		0.00	0.00							EM//EM =02 ; EM//SM =0 EM//ST =08 ; 41=3,000 ;		
5501-0092	Misc Total	80	02APR13	02APR13	25JUL13	25JUL13	0	42	8,552.04		0.00	0.00							EM//EM =30 ; EM//SM =1 EA//SB =08 ;		
5501-0097	Fab/Assembly	140	26JUL13*	26JUL13*	21FEB14	21FEB14	0	42	41,212.99		0.00	0.00							EM//EM =210 ; EE//E		
5501-0080	Procurementsupport	173	01OCT13*	01OCT13*	13JUN14	13JUN14	0	31	41,661.48		0.00	0.00							EM//EM =210 ; EE		
FY105501	FY10 Actual Cost	85	01JAN10A	01JAN10A	30APR10A	30APR10A	0		55,211.00	100	55,211.00	55,211.00									
FY105501A	FY10 Actual Cost	110	03MAY10A	03MAY10A	30SEP10A	30SEP10A	0		76,858.00	100	76,858.00	76,858.00	81=129700								

5501 Coil Bus Runs (Smith)	31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
BCWS	0	14	0	24	27	23	23	6	6	95	58	35
CUM BCWS	380	395	395	419	445	468	491	497	503	598	656	691
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	372	372	372	372	372	372	372	372	372	372	372	372
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	305	305	305	305	305	305	305	305	305	305	305	305
CV	67	67	67	67	67	67	67	67	67	67	67	67
SV	-9.	-23.	-23.	-47.	-74.	-97.	-120.	-126.	-131.	-227.	-285.	-319.
CPI	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
SPI	0.98	0.94	0.94	0.89	0.83	0.79	0.76	0.75	0.74	0.62	0.57	0.54

Annex I – WBS Dictionary

This Work Breakdown Structure (WBS) organizes and defines the scope of the NSTX Upgrade using the WBS as established by the original NSTX project and modified to accommodate the NSTX Upgrade.

<u>WBS</u>			
<u>L1</u>	<u>L2</u>	<u>L3</u>	<u>Description</u>
1			NSTX UPGRADE PROJECT
	1.1		Torus Systems
		1.1.0	Project Integrated Model
		1.1.1	Plasma Facing Components
		1.1.2	Vacuum Vessel and Support Structure
		1.1.3	Magnet Systems
	1.2		Plasma Heating and Current Drive Systems
		1.2.1	High Harmonic Fast Wave (HHFW)
		1.2.2	Coaxial Helicity Injection (CHI) Current Drive
		1.2.3	Electron Cyclotron Heating (ECH)
		1.2.4	Neutral Beam Injection (NBI)
	1.3		Auxiliary Systems
		1.3.1	Vacuum Pumping System
		1.3.2	Coolant Systems
		1.3.3	Bakeout Heating System
		1.3.4	Gas Delivery System
		1.3.5	Glow Discharge Cleaning System
	1.4		Plasma Diagnostics
		1.4.1	Plasma Diagnostics
	1.5		Power Systems
		1.5.1	AC Power Systems
		1.5.2	AC/DC Converters
		1.5.3	DC Systems
		1.5.4	Control and Protection System
		1.5.5	General Power Systems and Integration
	1.6		Central Instrumentation and Controls (I&C)
		1.6.1	Control System
		1.6.2	Data Acquisition System
	1.7		Project Support & Integration
		1.7.1	Project Management and Integration
		1.7.2	Project Physics
		1.7.3	Integrated Systems Tests
	1.8		Site Preparation and Assembly
		1.8.1	Site Preparation
		1.8.2	Torus Assembly and Construction

Annex I – WBS Dictionary

and TF bundle assembly. A single vendor will fabricate both components.
{Ohmic Heating Solenoid (Job 1305)}

WBS Element: 1.1.3.3.3

WBS Level: 5

WBS Title: Inner Poloidal Field Coils

Definition: The inner poloidal/shaping coils subsystem consists of the new coils that will make up the poloidal field coils 1A, 1B and 1C. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication.

For the NSTX Upgrade three new sets of inner poloidal field coils will be installed. This WBS element include the design and procurement of the Inner poloidal field coils and supports which includes all analytical and CAD design efforts for these components. It includes the early procurement of the PF conductor and co-wound [Glass/Kapton] insulation.
{Inner Poloidal Field Coils (Job 1306)}

WBS Element: 1.1.3.3.4

WBS Level: 5

WBS Title: Center Stack Casing and Assembly

Definition: This WBS element includes the design and fabrication of the Center Stack casing and ceramic break assembly for the upgraded Center Stack as well as the assembly of the new Center Stack.

The Center Stack Casing effort includes analysis and CAD design for the casing components; the procurement of the Inconel tubing, forgings, bellows and organ pipes; the fabrication of Center Stack support legs; the procurement/fabrication of a new ceramic break assembly; the in-house assembly of the casing components; and mounting of the PF1A and PF1B structure/coils to the casing.
{CS Casing (Job 1307)}

The Center Stack Assembly effort involves all activities associated with the assembly of the Center Stack and includes design modifications and upgrade of the coil assembly stand; procedures for assembling the Center Stack and for installation; assembly of the Center Stack components including the OH/TF coil supports, mounting of the surface diagnostics and thermal blanket, inconel casing and inner PF coils and setup and tear down of the Center Stack assembly area.
{Center Stack Assembly (Job 1302)}

WBS Element: 1.1.3.4

WBS Level: 4

WBS Title: Coil Bus Runs

Definition: This WBS element includes the design and fabrication of the coil bus runs/supports between the NSTX coils and the FCPC cable terminations located in the NSTX test cell.
{Coil Bus Runs (Job 5501)}

Work Approval Form (WAF)

Cost Center: 9417
Job Number: 5501
Job Title: Coil Bus Runs
Job Manager: Mark Smith

Description:

This job includes design and fabrication of bus runs/supports between the NSTX coils and the FCPC cable terminations located in the NSTX test cell west side. Includes new air-cooled TF bus; relocation of OH cable bus from top to bottom of machine; new CHI ring bus and bus links to lower VV and new bus for the inner PF coils.

Busbar System Includes:

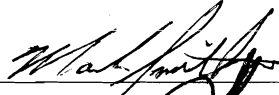

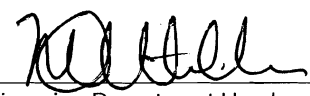
TF air-cooled [From TC water fall to bottom of machine]
OH Coax [Inside umbrella]
Inner PF coils [U/L PF1a, 1b and 1c]
CHI/bakeout [Lower ring bus & ring to VV bus]

NOTE: Installation costs are included.

Schedule:

See Tab B or attached

Approvals:

		7/24/10
Job Manager		
		8/3/10
Project Manager		
		8/3/10
Engineering Department Head		

- CATEGORIZATION CODES:
- 1 - No standards
 - 2 - Engineering Judgment/Experience
 - 3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.)
 - 4 - Previous PPPL/ORNL Experiences (e.g., TFR, NSTX, PLT, etc.)
 - 5 - Prototype Data/Test Results
 - 6 - Catalogue Price/Vendor Quote
 - 7 - Placed Contracts
 - 8 - Actual experience for NCSX Work
 - 9 - Guidance from experienced others: engineers, physicists, technicians, etc.
 - 10 - Direct estimate from others: engineers, analyst, physicists, procurement, etc.
 - 11 - Derived from existing and/or new designed CAD models, drawings, systems, etc
 - 12 - Other

Cost Center: 9417
Job Number: 5501
Job Title: Coil Bus Runs
Job Manager: Mark Smith

Materials and Subcontracts (M&S)

Description:	Quantity	Unit, Set, or Group	Unit Cost \$	per unit	Total # of Units/Sets	Total Cost	Contingency %
Copper							
CHI main ring	1	lb	2.9	lb	194.0	\$563	20
CHI busbar	1	lb	2.9	lb	270.2	\$784	20
PF1	1	lb	2.9	lb	1351.0	\$3,918	20
TF	1	lb	2.9	lb	3340.8	\$9,688	20
OH Inner	1	lb	2.9	lb	30.4	\$88	20
OH Outer	1	lb	2.6	lb	80.3	\$209	20
Insulation & Protection							
Kapton	1	1 roll	80	1 roll	41.0	\$3,280	20
Fiberglass	1	1 roll	7	1 roll	149.0	\$1,043	20
Epoxy	1	1	1000	1	5.0	\$5,000	20
SS Hardware							
Bolts	1	each	3.45	each	820.0	\$2,829	20
Flatwasher	1	25/pack	9.7	1 pack	32.8	\$318	20
Belleville Washer	1	5/pack	7.1	1 pack	164.0	\$1,164	20
Nut	1	10/pack	5.5	1 pack	82.0	\$451	20
SS Water Fittings							
316 SS Tube (Cooling tube OH)	1	per fitting	125	per fitting	74.0	\$9,250	20
G10 FR4 @ 1.5in thickness (36 in x 48 in)	1	each	300	each	8.0	\$2,400	20
G10 FR4 @ 0.75in thickness (36 in x 48 in)	1	sheet	1500	sheet	3.0	\$4,500	20
G10 FR4 @ 0.25in thickness (36 in x 48 in)	1	sheet	565	sheet	3.0	\$1,695	25
Fabrication Items (consumable)							
Safety Items (consumable)							
Structural Support Materials							
Miscellaneous: rework & additional materials, unforeseen items							
Misc						\$9,781	25
Misc During Field Fit up & Installation						\$10,962	25
Total M&S						\$80,553	

Notes:
 Fabrication items (consumable) are items such as: materials for prototypes and fixtures; machine blis; epoxy buckets and mixers; rags; etc.
 Safety Items (consumable) are items such as: Tyvek suits, gloves, clean up supplies etc.

Copper Total	\$15
Insulation & Protection Total	\$9
SS Hardware, Fittings, Materials Total	\$16
G10 FR4 Total	\$7
Fab & Safety Consumables Total	\$8
Struct Support Material Total	\$3
Misc Total	\$10
Misc During Field Fit up & Installation	\$11

Cost Center:
Job Number:
Job Title:
Job Manager:

9417
 5501
 Coil Bus Runs
 Mark Smith

<u>Uncertainty of the Estimate</u>		<u>Uncertainty Range (%)</u>		<u>Comments/Other Considerations</u>	
		<u>High</u>	<u>Medium</u>	<u>Low</u>	
Design Maturity			x		
Design Complexity				x	

Residual Impacts

Job	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact		Schedule Impact	
					Low (\$K)	High (\$K)	Low (weeks)	High (Weeks)
Design of Bus Routes	Final design (including optimization) is contingent upon the designs of the center stack, pedestal, umbrellas and umbrellas lids being frozen / completed. This could impact Designer, Eng. Analyst man hours along with schedule.			2, 4, 9		0	0	0
Installation is Field Fit Up	Uncertainty during installation of the required modifications from the designed bus routes. Could impact estimates for man power, duration of tasks, and M&S.			2, 4, 9		0	0	0

Total Hardware Sets		
Bolt	820	\$3.45 each
Flat Washer	25	\$9.70 pack 25
Bevel Washer	5	\$7.10 pack 5
Nut	10	\$5.50 pack 10
		\$4,782.56

# Complete Circuits	# Busbars	Busbar Dims (inches)		L2	Radius	CrossSectional Area		Length (in)	Total Length (in)	lb/ft	Cooling # fittings	Total Fittings
		L1	L2			Area	Perimeter					
CHI main ring	1	1	1	48	1	302	603	3.86	8	16		
CHI busbar	3	1	1	-	1	140	840	3.86	8	48		
PF1	6	2	1	-	2	175	2100	7.72	0	0		
TF	2	6	1	-	6	432	1728	23.2	0	0		
OH	1							3.04	10	10		
				0.175	0.79	120	120	8.03				
				0.625	0.78	120	120					

Cost @ \$2.9/lbf	Total Fittings
\$563	16
\$784	48
\$3,918	0
\$9,688	0
\$88	10
\$233	
\$15,274	\$9,250

# Complete Circuits	# of HW Sets	# of HW Sets/Bracket	Total HW Sets	G10 1.5 inch thick	Area / Bracket	L1	L2	Total Area	Total G10 Area	Total G10 Area
CHI main ring	1	22	4	4	12	4	3	125		
CHI busbar	3	12	4	4	12	4	3	212		
PF1	6	7	84	6	18	6	3	741		
TF	2	18	144	9	36	9	4	2520		
OH	1	6	14	6	36	6	6			
				14	36	6	6			
				required	Account for waste / scrap: add 25%	Sum	Sum	3826	4782	
				Kapton 2 mil	epoxy	Fiberglass	cubic inches			
CHI main ring	1	3016	6032	3016	60					
CHI busbar	3	4200	8400	4200	84					
PF1	6	15750	31500	15750	315					
TF	2	30240	60480	30240	605					
OH	1	471	942	471	9					
				Totals	107354	107354	1074			

G10 FR4 @ 1.5in thickness (36 in x 48 in)
 0 per sheet
 1728 in² / sheet
 2.8
 \$4,151

\$9,994

1.5 lap kapton
 2 wraps 2 inch Fiberglass

rolls cost \$3,303 \$1,044 \$4,647

Basis Notes for Estimates: CAD Models & Drawings

Detail CAD Designer mh @ 3mh/FD model, Eng @ [0.3 to 0.5]"(total Designer mh)
Update FD drawings: Designer @ 8 mh/drawing, Eng @ (0.75mh)/drawing

Validation update CAD: Designer @ 1mh/model
Validation update Drawings: Designer @ 4mh/drw

Check Drawings: Other Designer @ 2 hr/drawing
Check & signoff: Eng @ 2 to 3.0mh/draw : includes 0.5h for oversite

=====

Designer man hr during installation, function of: bus complexity, # of circuits, # of joints.
complexity (subjective): use simple @ 2 mh/ circuit, complex @ 3mh.

mh needed = (complex*# of cir)+(complex*# of cir)*(.33**# of jnts)

Basis Notes for Estimates:

For PD, and FD Activities:
Eng project management @ 1 mh/md for various activities.

For Procurement Activities:
Eng project management @ 0.25 mh/md for various activities.

For Fab Activities:
Eng project management @ 1.5 mh/md for various activities.

Eng support @ 1-2mh/md of installation

Tech support during installation:
2m for 2mw/each circuit.

During installation
Need rigging crew (2m) @ 25% of duration time for heavy lifting (TF, PF only)
Need RESA machinist @ 25% time for each bus.
Electrical testing is 1md/circuit.