

Work Authorization Document

NSTX Upgrade Project

Control Account #:	2475	Title:	2nd NBI Controls
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WBS	1.2.4	Title:	NB Injection
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Period of Performance: 03 May 2010 through 03 September 2014

Authorized Budget:	\$2,089	Control Account Manager:	Cropper
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Revision #:	0	Revision Date:	July-11
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Authorized Work Description:

Also included in this WBS element are the controls and instrumentation for the NB2. The work covers PLC, programming, control racks, new thermocouples, TC scanner, miscellaneous controls, and control cabling. The work also includes the gradient grid upgrade. System integration and testing will also be performed as part of this effort.

- 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

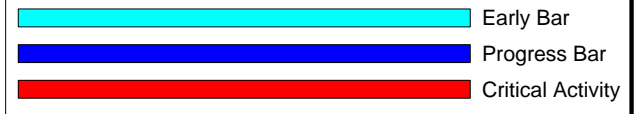
ECP#	Implement Date	Prior Budget	New Budget	Signature

Approvals	Name	Signature	Date
NSTX-U Project Manager	R. Strykowski		
Control Account Manager	Cropper		
Functional Manager	T. Stevenson		

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
NSTX Upgrade Project																		
Subtotal		1,082	03MAY10A	03MAY10A	03SEP14	03SEP14	0	4	2,089,032.40		90,190.27	213,901.38						
Job: 2475 - 2nd NBI Controls-CROPPER																		
Subtotal		1,082	03MAY10A	03MAY10A	03SEP14	03SEP14	0	4	2,089,032.40		90,190.27	213,901.38						
System Testing																		
FY102475A	FY10 Actual Cost	110	03MAY10A	03MAY10A	30SEP10A	30SEP10A	0		1,855.00	100	1,855.00	1,855.00	81=8499					
Control System Layout																		
2475-0002	Control System Lay Out-NBI-Controls & Instrument	30	03MAY10A	03MAY10A	14JUN10A	14JUN10A	0		0.00	100	0.00	0.00						
2475-0003	Update Cost & Sched Estimate-NBI-Control & Instm	5	08JUN10A	08JUN10A	14JUN10A	14JUN10A	0		0.00	100	0.00	0.00						
2475-0004	FMEA Analysis-NBI-Controls & Instrumentation	5	08JUN10A	08JUN10A	14JUN10A	14JUN10A	0		0.00	100	0.00	0.00						
2475-0005	Design Drawings-NBI-Controls & Instrumentation	30	03MAY10A	03MAY10A	14JUN10A	14JUN10A	0		0.00	100	0.00	0.00						
2475-0006	PDR Prep PPL-NBI-Controls & Instrumentation	6	15JUN10A	15JUN10A	22JUN10A	22JUN10A	0		0.00	100	0.00	0.00						
2475-0009	CONDUCT PDR-NBI-Controls & Instrumentation	1	23JUN10A	23JUN10A	23JUN10A	23JUN10A	0		0.00	100	0.00	0.00						
2475-0012	Disposition PDR Chits-NBI-Controls & Instrum	10	23JUN10A	23JUN10A	28JUN10A	28JUN10A	0		0.00	100	0.00	0.00						
2475-0018	Protective Plate Interlocks-Prep Dwgs & Signoff	192*	03JAN11*	03JAN11A	31MAR11	30SEP11	-128	141	24,851.20	40	9,940.48	24,851.20						
2475-0102	PLC Control System Layout-Prep Dwgs & Signoff	296*	28JUL10A	28JUL10A	28FEB11	30SEP11	-151	190	18,413.68	50	9,089.84	18,179.67						
2475-0103	Remote LCC Control Sys Layout-Prep Dwgs & Signoff	209*	01MAR11*	01DEC10A	14MAR11	30SEP11	-141	190	6,212.80	50	3,106.40	6,212.80						
2475-0104	TC scanners/Beamline/P.P-Prep Dwgs & Signoff	192*	15MAR11	03JAN11A	04APR11	30SEP11	-126	190	12,425.60	45	5,591.52	12,425.60						
2475-0105	NBOS Station - Control System Layout	10	05APR11	19SEP11	18APR11	30SEP11	-116	190	6,212.80		0.00	6,212.80						
2475-0106	DWGS CWD's & Cable Diagram-Prep Dwgs & Signoff	250*	01DEC10*	01OCT10A	20MAY11	30SEP11	-92	190	139,376.00	40	55,750.40	121,507.28						
Final Design																		
2475-0110	Design Drawings-NBI-Controls & Instrumentation	272*	29JUN10A	29JUN10A	20MAY11	29JUL11	-48	234	24,383.38	20	4,856.63	22,657.03						
2475-0110A	Update Cost & Sched Estimate-NBI-Controls & Instr	5	23MAY11	31MAY11*	27MAY11	06JUN11	-5	121	6,212.80		0.00	0.00						
2475-0110B	FDR Prep PPL-NBI-Controls & Instrumentation	10*	31MAY11	07JUN11	13JUN11	20JUN11	-5	121	7,455.36		0.00	0.00						
2475-0111	CONDUCT FDR-NBI-Controls & Instrumentation	3	14JUN11*	22JUN11*	14JUN11	24JUN11	-8	121	1,242.56		0.00	0.00						
2475PEER	Peer Review	0			31MAR11	14APR11A	-10		0.00		0.00	0.00						
Procurement																		
2475-0116	Prep Requisition and procurement package	5	02JUL12*	02JUL12*	09JUL12	09JUL12	0	4	6,813.20		0.00	0.00						

Data Date: 30APR11 1105
Run Date: 20MAY11 10:56
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**NSTX UPGRADES
RESOURCE LOADED SCHEDULE
CD-2 Schedule
April 2011**



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			
2475-0117	SUBMIT REQ TO PROCUREMENT	1	10JUL12	10JUL12	10JUL12	10JUL12	0	4	1,362.64		0.00	0.00									
2475-0118	Procurement lead time (1)	15	11JUL12	11JUL12	31JUL12	31JUL12	0	4	0.00		0.00	0.00									
2475-0119	AWARD-NBI-Controls & Instrumentation	1	01AUG12	01AUG12	01AUG12	01AUG12	0	4	0.00		0.00	0.00									
2475-0120	Fabricate or delivery--NBI-Controls & Instrument	40	02AUG12	02AUG12	27SEP12	27SEP12	0	4	555,990.00		0.00	0.00									
Fab/Assembly																					
2475-0123	Fab/Assy Procedure	5	21SEP12	21SEP12	27SEP12	27SEP12	0	4	6,813.20		0.00	0.00									
2475-0125	Cable Tray - Fab/Assembly	40	28SEP12*	28SEP12*	26NOV12	26NOV12	0	4	71,054.56		0.00	0.00									
2475-0126	Gradient Grid divider - Fab/Assembly	20	27NOV12	27NOV12	02JAN13	02JAN13	0	4	64,327.44		0.00	0.00									
2475-0127	Control Rack Cage - Fab/Assembly	5	03JAN13	03JAN13	09JAN13	09JAN13	0	4	10,277.68		0.00	0.00									
2475-0128	Rack relocation - Fab/Assembly	25	10JAN13*	10JAN13*	13FEB13	13FEB13	0	4	73,946.00		0.00	0.00									
2475-0129	Penetrations - Fab/Assembly	5	14FEB13*	14FEB13*	20FEB13	20FEB13	0	4	63,077.68		0.00	0.00									
2475-0130	Disconnect remote control	20	21FEB13	21FEB13	20MAR13	20MAR13	0	4	22,068.64		0.00	0.00									
Installation																					
2475-0133	Installation Procedures	10	07MAR13	07MAR13	20MAR13	20MAR13	0	4	12,550.80		0.00	0.00									
2475-0134	Beam Line Cabling - Installation	80	21MAR13	21MAR13	15JUL13	15JUL13	0	4	283,335.68		0.00	0.00									
2475-0135	Aux Cabling - Installation	20	16JUL13	16JUL13	12AUG13	12AUG13	0	4	89,104.80		0.00	0.00									
2475-0136	Protective Plate Interlocks(I/P Pyrometer/IR Cam	20	13AUG13	13AUG13	10SEP13	10SEP13	0	4	37,033.20		0.00	0.00									
2475-0137	TC Scanners - beamline & Protective Plates-Instl	40	11SEP13	11SEP13	05NOV13	05NOV13	0	4	45,532.34		0.00	0.00									
2475-0138	NBOS Station - Installation	10	06NOV13	06NOV13	19NOV13	19NOV13	0	4	29,931.20		0.00	0.00									
2475-0139	LCC Remote - Installation	40	20NOV13	20NOV13	28JAN14	28JAN14	0	4	161,713.60		0.00	0.00									
2475-0140	Power Supply Upgrade - Installation	23	29JAN14	29JAN14	28FEB14	28FEB14	0	4	63,156.96		0.00	0.00									
2475-0141	Protective Plate TC's - Installation	10	03MAR14	03MAR14	14MAR14	14MAR14	0	4	12,088.80		0.00	0.00									
Programming																					
2475-0144	PLC & RSView Programing-NBI-Controls & Instrumen	40	03OCT13*	03OCT13*	27NOV13	27NOV13	0	91	57,536.00		0.00	0.00									
2475-0145	Beamline TC Scanner Program-NBI-Controls & Instr	20	06NOV13*	06NOV13*	05DEC13	05DEC13	0	47	27,398.40		0.00	0.00									
2475-0146	Protective Plate TC Scanner Program-NBI-Controls	20	17MAR14	17MAR14	11APR14	11APR14	0	4	27,398.40		0.00	0.00									
2475-0147	LCC Remote LabView Programing-NBI-Controls/Instr	40	29JAN14	29JAN14	25MAR14	25MAR14	0	17	50,481.60		0.00	0.00									
Testing																					
2475-0149	PTP Testing	20	14APR14	14APR14	09MAY14	09MAY14	0	4	67,398.40		0.00	0.00									

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						
Commissioning in Ops																			
2475-0154	Commissioning & Testing of 4A Power System	20	12MAY14	12MAY14	09JUN14	09JUN14	0	4	0.00		0.00	0.00						EE//SM =320 ; EE//SB=160	
2475-0155	Commissioning & Testing of 4B Power System	20	10JUN14	10JUN14	08JUL14	08JUL14	0	4	0.00		0.00	0.00						EE//SM =320 ; EE//SB=160	
2475-0156	Commissioning & Testing of 4C Power System	20	09JUL14	09JUL14	05AUG14	05AUG14	0	4	0.00		0.00	0.00						EE//SM =320 ; EE//SB=160	
2475-0157	40 kv Beam Operation	20	06AUG14	06AUG14	03SEP14	03SEP14	0	4	0.00		0.00	0.00	EE//SM =160 ; EE//TB =480 ; EE//SB=160						

2475 2nd NBI Controls (Cropper)	31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
BCWS	0	0	0	0	0	0	8	298	266	39	40	50
CUM BCWS	248	248	248	248	248	248	256	555	821	860	900	950
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	90	90	90	90	90	90	90	90	90	90	90	90
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	50	50	50	50	50	50	50	50	50	50	50	50
CV	40	40	40	40	40	40	40	40	40	40	40	40
SV	-159.	-159.	-159.	-159.	-159.	-159.	-167.	-465.	-731.	-770.	-810.	-860.
CPI	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81
SPI	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.16	0.11	0.1	0.1	0.09

2475 2nd NBI Controls (Cropper)	31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
BCWS	62	96	52	75	79	68	91	60	28	57	109	76
CUM BCWS	1,012	1,109	1,160	1,236	1,314	1,382	1,473	1,534	1,562	1,618	1,727	1,803
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	90	90	90	90	90	90	90	90	90	90	90	90
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	50	50	50	50	50	50	50	50	50	50	50	50
CV	40	40	40	40	40	40	40	40	40	40	40	40
SV	-923.	-1019.	-1071.	-1146.	-1224.	-1293.	-1384.	-1444.	-1472.	-1529.	-1638.	-1714.
CPI	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81
SPI	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.05	0.05

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

replacing copper impinged parts as required and refurbishment of the seals, thermocouple wiring, and bellows (cal and spool) as needed.

{NSTX Beamline 2 Refurbishment (Job 2440)}

Also included in this WBS element are the efforts necessary to relocate a TFTR neutral beam line and ancillary equipment into the NSTX test cell. This includes High Voltage Enclosures (HVEs) and the complete beam box.

{NSTX Beamline 2 Relocation (Job 2425)}

WBS Element: 1.2.4.5

WBS Level: 4

WBS Title: NSTX Beamline 2 Services

Definition: This WBS element includes the efforts to provide services to the new neutral beam beamline and ancillary equipment in NSTX test cell. These services include water, cryogenic systems, gas supplies, and vacuum lines.

{NSTX Beamline 2 Services (Job 2450)}

WBS Element: 1.2.4.6

WBS Level: 4

WBS Title: NBI Armor

Definition: This WBS element includes the design, fabrication, and installation of upgraded and relocated neutral beam armor including cooling and instrumentation work.

{NBI Armor (Job 2460)}

WBS Element: 1.2.4.7

WBS Level: 4

WBS Title: NBI Beamline 2 Power and Controls

Definition: This WBS element includes providing power, controls and instrumentation for the 2nd Neutral beamline.

Included in this WBS element is providing power for the NBI beamline 2. NB2 is planned to be powered from the TFTR NB4 A, B, & C line ups. The electrical equipment in these line ups will be reactivated. The TFTR NB4 HVEs will be relocated to the NSTX Test Cell as part of WBS element 1.2.4.4. New triax cables will be installed with terminations from the Modregs to the HVEs. New Decel coaxial cables will be installed from the Decel supplies to the Sources. The Arc, Filament, Magnet, and the 208 feeds, to HVEs cables, will be spliced in the TFTR Test Cell basement to new cabling designed and installed from the TFTR Basement to the NSTX Test Cell. The fiber cables also will be spliced with additional lengths recovered from other TFTR line ups. The AC auxiliaries and Grounding for the NB2 will be designed and installed.

{NBI Power System (Job 2470)}

Also included in this WBS element are the controls and instrumentation for the NB2. The work covers PLC, programming, control racks, new thermocouples, TC scanner, miscellaneous controls, and control cabling. The work also includes the gradient grid upgrade. System integration and testing will also be performed as part of this effort.

Annex I – WBS Dictionary

{NBI Controls & Instrumentation (Job 2475)}

WBS Element: 1.2.4.8 **WBS Level:** 4

WBS Title: NSTX Beamline 2 Duct & vacuum Vessel Modifications

Definition: This WBS element includes the design, and fabrication of all components connecting the Neutral Beam Box to NSTX, and the connecting ductwork and modifications to NSTX Vacuum Vessel to accommodate the second beamline.

{NSTX NB2 Duct & VV Mods (Job 2480)}

WBS Element: 1.2.4.9 **WBS Level:** 4

WBS Title: NSTX Test Cell Equipment Removals/Relocations

Definition: This WBS element covers moving of racks and diagnostics to clear space in the NSTX Test Cell (NTC) for the second Neutral Beamline. Racks to be removed and re-installed in a new location are #419, 431-435, 440-445, 447-449, 488. Racks 456 and 489 will be removed and excess. This scope also includes the fabrication and installation of five sections of platform at elevation 118' on the west side of the NTC to accommodate the racks being re-installed in the NTC. Racks #441-445 will be relocated to the Gallery east of the NTC. Diagnostics to be removed are those from the midplanes of Bay J and Bay K as well as those on the present pump duct. The diagnostics from Bay J will be re-installed ~5" outboard of their present position. IR windows and the Transmission Grating Spectrometer will be relocated to the new NB duct. Ion gages, filaments and the RGA will be relocated to the new pump duct under the NB2 duct. SPRED and LOWEUS will be relocated to Bay L. The Thomson Scattering Beam Dump Window will be relocated to between Bays K and L.

{NTC Equipment Removals/Relocations (Job 2490)}

WBS Element: 1.3 **WBS Level:** 2

WBS Title: Auxiliary Systems

Definition: The auxiliary systems include all the mechanical non-torus support systems for NSTX. This WBS element includes the Vacuum Pumping System, the Coolant Systems, the Bakeout Heating System, Gas Delivery System and the Glow Discharge Cleaning System. The scope of the work contains engineering design, R&D, mockups, procurement activities, component fabrication, and System Testing. Installation of the WBS 3 systems is included in the individual WBS 3, level 3 elements.

WBS Element: 1.3.1 **WBS Level:** 3

WBS Title: Vacuum Pumping System

Definition: The Vacuum Pumping System provides the source and distribution of all vacuum pumping to NSTX. This includes the roughing pumps as well as the turbo pumps and any backing pumps to:

- Provide the initial high vacuum environment with minimum impurities for plasma formation;

Work Approval Form (WAF)

Cost Center: 9418
Job Number: 2475
Job Title: NBI-Controls & Instrumentation
Job Manager: Mark Cropper

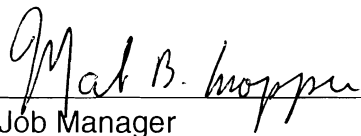
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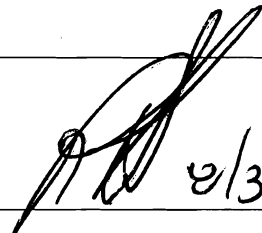
This work covers the controls and instrumentation for the NB2. The work covers PLC, programming, control racks, new thermocouples, TC scanner, miscellaneous controls, and control cabling. The work also includes the gradient grid upgrade. System integration and testing will be performed


Schedule:

Refer to Primavera Data-Base

Approvals:

 7/20/10
Job Manager

 7/20/10  8/3/10
Project Manager

 8/3/10
Engineering Department Head

