

## Work Authorization Document

### NSTX Upgrade Project

<b>Control Account #:</b>	1301	<b>Title:</b>	Outer TF Coils
<b>WBS</b>	1.1.4	<b>Title:</b>	Magnet Systems

**Period of Performance:** 01 April 2010 through 18 December 2013

<b>Authorized Budget:</b>	\$338	<b>Control Account Manager:</b> Chrzanowski
<b>Revision #:</b>	0	<b>Revision Date:</b> July-11

**Authorized Work Description:**

The outer Toroidal Field coils subsystem consists of the coil sections that make up the 12 TF outer legs. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication. For the NSTX Upgrade Project two (2) new Outer TF coils will be fabricated to replace existing ones. This WBS element includes the fabrication of (2) new Outer TF coils to replace the existing leaking OTF#7 and OTF#11 in NSTX. The scope includes the procurement of conductor, insulation material, aluminum castings and supports necessary to fabricate a new OTF coils. Coil fabrication will be performed in-house. This scope does not include costs associated with installation. Installations costs are included in WBS 1.8

**Attachments:**

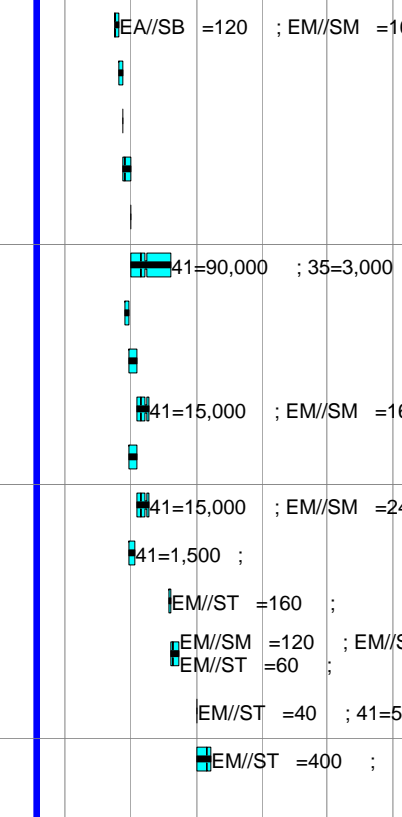
- 1- A detailed Control Account schedule showing all work packages and planning packages.
- 2- Budgeted Cost by month.
- 3- Original Work Authorization Form (WAF)
- 4- WBS Dictionary sheet that defines the scope of work for this WBS element.

#### Control Account History

ECP#	Implement Date	Prior Budget	New Budget	Signature

Approvals	Name	Signature	Date
NSTX-U Project Manager	R. Strykowski		
Control Account Manager	Chrzanowski		
Functional Manager	P. Heitzenroeder		

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
<b>NSTX Upgrade Project</b>																		
Subtotal		930	01APR10A	01APR10A	18DEC13	18DEC13	0	56	337,819.48		19,852.00	19,852.00						
<b>Job: 1301 - Outer TF Coils-CHRZANOWSKI</b>																		
Subtotal		930	01APR10A	01APR10A	18DEC13	18DEC13	0	56	337,819.48		19,852.00	19,852.00						
1301-0010	Revise Outer TF Coil (OTF) Drawings	20	02JUL12*	02JUL12*	30JUL12	30JUL12	0	103	19,198.88		0.00	0.00						
1301-0020	Generate Spec & SOW for OTF Purchase	10	31JUL12	31JUL12	13AUG12	13AUG12	0	103	0.00		0.00	0.00						
1301-0030	Prep Requisition & Submit to Procurement'	5	14AUG12	14AUG12	20AUG12	20AUG12	0	103	0.00		0.00	0.00						
1301-0040	Bid & Award OTF Manufacturing	30	21AUG12	21AUG12	02OCT12	02OCT12	0	103	0.00		0.00	0.00						
1301-0050	Provide Existing OTFtooling to Vendor	1	03OCT12	03OCT12	03OCT12	03OCT12	0	103	0.00		0.00	0.00						
1301-0060	Manufacture (1) OTF Coil	150	04OCT12	04OCT12	14MAY13	14MAY13	0	103	122,790.00		0.00	0.00						
1301-0100	Prep Requisitions & Submit to Procurement	15	04SEP12*	04SEP12*	24SEP12	24SEP12	0	190	0.00		0.00	0.00						
1301-0110	Bid & Award Al Supp Castings & SS Supp Clamps	30	25SEP12	25SEP12	05NOV12	05NOV12	0	190	0.00		0.00	0.00						
1301-0120	Fab & Del Al Supp Castings & SS Supp Clamps	40	06NOV12	06NOV12	11JAN13	11JAN13	0	190	22,625.28		0.00	0.00						
1301-0150	Bid & Award Epoxy/Glass for support blocks	30	25SEP12	25SEP12	05NOV12	05NOV12	0	190	0.00		0.00	0.00						
1301-0160	Fab & Del Epoxy/Glass	40	06NOV12	06NOV12	11JAN13	11JAN13	0	190	24,037.92		0.00	0.00						
1301-0180	Purchase Copper Fittings	20	25SEP12	25SEP12	22OCT12	22OCT12	0	240	1,971.00		0.00	0.00						
1301-0200	Setup work area to install Supports	10	01MAY13	01MAY13	14MAY13	14MAY13	0	103	17,772.80		0.00	0.00						
1301-0210	Install alum blocks & SS support clamps	30	15MAY13	15MAY13	26JUN13	26JUN13	0	103	52,292.00		0.00	0.00						
1301-0300	Fab Drill Jig for add'l holes in all OTF Flags	5	01OCT13*	01OCT13*	07OCT13	07OCT13	0	56	11,343.60		0.00	0.00						
1301-0310	Drill (24) Add'l holes in all OTF Flags	50	08OCT13	08OCT13	18DEC13	18DEC13	0	56	45,936.00		0.00	0.00						
FY101301	FY10 Actual Cost	22	01APR10A	01APR10A	30APR10A	30APR10A	0		1,607.00	100	1,607.00	1,607.00						
FY101301A	FY10 Actual Cost	20	03MAY10A	03MAY10A	28MAY10A	28MAY10A	0		18,245.00	100	18,245.00	18,245.00						



Data Date 30APR11 1105  
 Run Date 20MAY11 10:48  
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NSTX UPGRADES  
 RESOURCE LOADED SCHEDULE  
 CD-2 Schedule  
 April 2011

Sheet 1 of 1  
 Early Bar  
 Progress Bar  
 Critical Activity







1301 Outer TF Coils (Chrzanowski)	31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
BCWS	0	0	0	0	0	0	19	0	0	17	35	36
CUM BCWS	20	20	20	20	20	20	39	39	39	56	92	128
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	20	20	20	20	20	20	20	20	20	20	20	20
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	20	20	20	20	20	20	20	20	20	20	20	20
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	.	.	.	.	.	.	-19.	-19.	-20.	-37.	-72.	-108.
CPI	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SPI	1	1	1	1	1	1	0.51	0.51	0.5	0.35	0.22	0.16

<b>1301 Outer TF Coils (Chrzanowski)</b>	<b>31JAN2013</b>	<b>28FEB2013</b>	<b>31MAR2013</b>	<b>30APR2013</b>	<b>31MAY2013</b>	<b>30JUN2013</b>	<b>31JUL2013</b>	<b>31AUG2013</b>	<b>30SEP2013</b>	<b>31OCT2013</b>	<b>30NOV2013</b>	<b>31DEC2013</b>
BCWS	26	15	16	17	47	30	0	0	0	27	19	11
CUM BCWS	154	170	186	203	250	281	281	281	281	308	326	338
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	20	20	20	20	20	20	20	20	20	20	20	20
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	20	20	20	20	20	20	20	20	20	20	20	20
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	-134.	-150.	-166.	-183.	-230.	-261.	-261.	-261.	-261.	-288.	-306.	-318.
CPI	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SPI	0.13	0.12	0.11	0.1	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06

## 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			<b>NSTX UPGRADE PROJECT</b>
	<b>1.1</b>		<b>Torus Systems</b>
		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
	<b>1.2</b>		<b>Plasma Heating and Current Drive Systems</b>
		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)
	<b>1.3</b>		<b>Auxiliary Systems</b>
		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
	<b>1.4</b>		<b>Plasma Diagnostics</b>
		1.4.1	Plasma Diagnostics
	<b>1.5</b>		<b>Power Systems</b>
		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
	<b>1.6</b>		<b>Central Instrumentation and Controls (I&amp;C)</b>
		1.6.1	Control System
		1.6.2	Data Acquisition System
	<b>1.7</b>		<b>Project Support &amp; Integration</b>
		1.7.1	Project Management and Integration
		1.7.2	Project Physics
		1.7.3	Integrated Systems Tests
	<b>1.8</b>		<b>Site Preparation and Assembly</b>
		1.8.1	Site Preparation
		1.8.2	Torus Assembly and Construction



## Annex I – WBS Dictionary

does not include installation costs. Installations costs are included in WBS 1.8. {Vacuum Vessel & Support Structure (Job 1200)}

**WBS Element: 1.1.3**

**WBS Level: 3**

**WBS Title: Magnet Systems**

**Definition:** The magnet system consists of the outer Poloidal Field (PF) coils (PF#2-5), the outer Toroidal Field (TF) coil legs, and the Center Stack Assembly (CSA). The CSA contains the inner TF coil legs, the TF coil joint (flex bus assembly), the OH solenoid, the shaping coils, and the center stack casing. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication of the magnet systems up to and including the magnet system coil buswork, but does not include installation costs. Installations costs are included in WBS 1.8

The NSTX Upgrade Project will require engineering, analysis, design procurement and fabrication of a new CSA, replacement of two outer TF coil legs, and a fabrication of a new TF coil joint

This WBS element provides CAD design support for the overall assembly drawings associated with the CSA upgrade. It also includes some time for space allocation studies associated with the magnet upgrades. CAD design support for individual components is included in the specific component jobs.

{Center Stack Upgrade Project Design Support (Job 1300)}

**WBS Element: 1.1.3.1**

**WBS Level: 4**

**WBS Title: Outer Poloidal Field Coils (PF #3-5)**

**Definition:** The outer Poloidal Field coils (PF 3-5) consist of 5 poloidal field coils PF 3 upper and lower, PF 4 upper and lower and PF 5. There are no changes to the outer PF coils as part of the NSTX Upgrade Project scope.

**WBS Element: 1.1.3.2**

**WBS Level: 4**

**WBS Title: Outer Toroidal Field Coils**

**Definition:** The outer Toroidal Field coils subsystem consists of the coil sections that make up the 12 TF outer legs. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication. For the NSTX Upgrade Project two (2) new Outer TF coils will be fabricated to replace existing ones. This WBS element includes the fabrication of (2) new Outer TF coils to replace the existing leaking OTF#7 and OTF#11 in NSTX. The scope includes the procurement of conductor, insulation material, aluminum castings and supports necessary to fabricate a new OTF coils. Coil fabrication will be performed in-house. This scope does not include costs associated with installation. Installations costs are included in WBS 1.8

{Outer Toroidal Field Coil Repairs (Job 1301)}

## Work Approval Form (WAF)

**Cost Center:** 9417  
**Job Number:** 1301  
**Job Title:** Outer Toroidal Field Coils  
**Job Manager:** James H. Chrzanowski  
**Rev 1 6/16/2010**

**Description:**

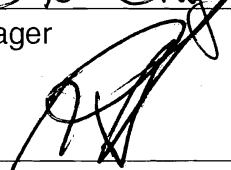
This job includes the fabrication of (1) new Outer TF coil (OTF) by OS vendor to replace the existing [leaking] OTF#7 in NSTX. Also procurement of insulations, aluminum castings and supports for new OTF coil. Field Work: Includes drilling of additional holes in each OTF coil lead to accommodate upgrade requirements [288 holes]. This estimate does not include costs associated with installation of coils into NSTX.

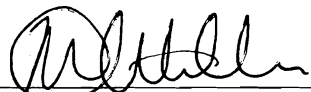
**Schedule:**

Refer to the Primavera Data-Base

**Approvals:**

 7/20/10  
\_\_\_\_\_  
Job Manager

 8/3/10  
\_\_\_\_\_  
Project Manager

 8/3/10  
\_\_\_\_\_  
Engineering Department Head



Cost Center	Work Package	Job #	Activity Name	Responsible Cog Engr	Duration (Weeks)	Start Date	EAEM1 mhrs (Chrzan.)	EASB7 mhrs (Paluzzi)	EASB8 mhrs (Elect)	EMSM1 mhrs (Meighan)	EMTB1 mhrs (Tech)	EMTB2 mhrs (Machinist)	M&S K\$	OS K\$	Travel K\$	Skrm. K\$	Subtotal M&S K\$	Basis of Estimate	Category	Contingency %		
9417	1000	1301	<i>Revise OTF drawings</i>	Chrzanowski		25-Apr-11	See Job 1300	120		16										2	10%	
			<i>Purchase &amp; Fabrication</i>																			
			<i>Generate Spec &amp; SOW for outside procurement</i>		2	1-May-12															2	10%
			<i>Prep requisition &amp; submit to procurement</i>		1	15-May-12															2	10%
			<i>Bid &amp; award OTF manufacturing</i>		5	1-Jul-12															2	10%
			<i>Manufacture (1) OTF colls</i>		30	1-Jul-12											\$90.0	\$93.0			4	30%
			<i>Delete</i>																			
			<i>Miscellaneous parts and materials</i>																			
			<i>Prep requisition &amp; submit to procurement</i>			1-Oct-12																
			<i>Procure aluminum support castings and S.S. support clamps</i>			15-Oct-12			16				\$15.0				\$15.0				2	10%
			<i>Procure hardware, epoxy/glass for support blocks, misc</i>			22-Oct-12			24				\$15.0				\$15.0				4	25%
			<i>Copper fittings, etc</i>			22-Oct-12							\$1.5				\$1.5				4	15%
			<i>In-house Fabrication</i>								160						\$0.0				4	25%
			<i>Setup work area for installing supports</i>		2	7-Jan-13			120		220	60					\$0.0				4	25%
			<i>Install alum blocks &amp; SS support clamps</i>		6	28-Jan-13											\$0.0				4	25%
			<i>OTF Field Work</i>																			
			<i>Fabricate drill jig</i>		1	1-Oct-12											\$5.0				2	15%
			<i>Drill (24) additional holes in OTF flags- [12 colls]</i>		10	TBD															2	25%
<b>CATEGORIZATION CODES:</b> 1 - National Standards 2 - Engineering Judgement/Experience 3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.) 4 - Previous PPPL/ORNL Experience (e.g., TFR, NSTX, PLT, etc.) 5 - Prototype Data/Test Results 6 - Catalogue Price/Vendor Quote 7 - Placed Contracts 8 - Actual experience for NSTX Work 9 - Other																						



Residual Impacts	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact		Schedule Impact		
					Low (\$K)	High (\$K)	Low (weeks)	High (Weeks)	
1	After press mold operation- numerous dry areas are found	U	Attempt local repair- if unsuccessful, Rebuild coil			X	50	critical path	
2	Coil does not pass final acceptance tests	U	Attempt local repair- if unsuccessful, Rebuild coil			X	50	critical path	
3									
4									
5									
Notes:									
(1) Cost impacts should NOT include standing army costs which are separately calculated from the schedule impact									
(2) The schedule impacts should be entered as the min and max impacts on the critical path. If there is no critical path impact then the schedule entries should be zero.									
(3) Likelihood of occurrence should be entered consistent with our risk classification methodology, i.e. VL= Very Likely (P>80%), L=Likely (80%>P>40%), U=Unlikely (40%>P>10%), VU=Very Unlikely (P<10%), NC=Non-credible (P<1%)									
<u>Uncertainty of the Estimate</u>				<u>Comments/Other Considerations</u>					

**Cost Center:** 9417

**Job Number:** 1301

**Job Title:** Outer Toroidal Field Coils

**Job Manager:** James H. Chrzanowski

Uncertainty of the Estimate

<b>High</b>	<b>Medium</b>	<b>Low</b>
	X	

**Design Maturity**

**Design Complexity**

Design Maturity		Design Complexity			Design Maturity Definition		
Low	Medium	High	Low	Medium	High		
Low	-15%	+25%	-20%	+40%	-30%	+60%	Final design available. All design features/requirements well known. No further design development or evolution expected that will impact estimate.
Medium	-10%	+15%	-15%	+25%	-20%	+40%	Preliminary design available. Some additional design evolution likely. Further developments can be somewhat expected or anticipated and reflected in estimate.
High	-5%	+10%	-10%	+15%	-15%	+25%	No better than conceptual design basis currently available. Design details, procedures, etc. still need much development and evolution of requirements beyond estimate basis is likely and expected.
Design Complexity Definition							
Low							Work is fairly well understood -- either standard construction or repetition of activities performed in past. Little likelihood of estimate not being well understood and requirements not being well defined.
Medium							More complex work requirements that have potential to impact cost and schedule estimates. Limited experience performing similar tasks, so ability to estimate accurately is somewhat suspect
High							Extremely challenging tasks and/or requirements. Unique or first-of-a-kind assembly or work tasks. No good basis for estimating work exists so there is a high degree of estimate uncertainty. Based on standard industry and DOE estimate classifications (Per AACEI Recommended

