Work Authorization Document

NSTX Upgrade Project

Control Account #:	1302	**Title:**	Center Stack Assembly
WBS	1.1.11	**Title:**	Magnet Systems
Period of Performance:	26 September 2011 through 11 April 2014		
Authorized Budget:	$990	**Control Account Manager:**	Chrzanowski
Revision #:	0	**Revision Date:**	July-11

Authorized Work Description:

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.

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.

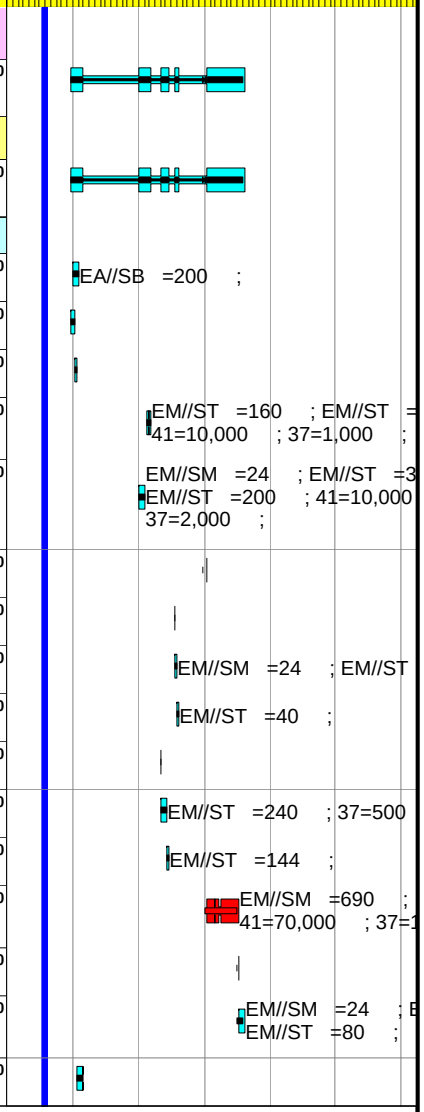
Control Account History

ECP#	Implement Date	Prior Budget	New Budget	Signature

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

NSTX Upgrade Project

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)
Subtotal		651	26SEP11	26SEP11	28APR14	09MAY14	-9	1,586	990,057.80		0.00	0.00
Job: 1302 - Center Stack Assembly-CHRZANOWSKI												
Subtotal		651	26SEP11	26SEP11	28APR14	09MAY14	-9	1,586	990,057.80		0.00	0.00
1302-0050	CAD Support for Setup of CS Assembly Area	25	03OCT11*	03OCT11*	04NOV11	04NOV11	0	381	27,396.00		0.00	0.00
1302-0060	Generate CS Assembly Procedure	10	26SEP11	26SEP11*	07OCT11	07OCT11	0	366	0.00		0.00	0.00
1302-0070	Generate CS Installation Procedure	10	10OCT11	10OCT11	21OCT11	21OCT11	0	366	0.00		0.00	0.00
1302-0080	Modify CS Assembly Fixture	20	12NOV12	12NOV12	11DEC12	11DEC12	0	157	45,302.40		0.00	0.00
1302-0090	Setup CS Assembly Area	30	01OCT12*	01OCT12*	09NOV12	09NOV12	0	157	81,642.72		0.00	0.00
1302-0150	Receive OH/TF Assembly	1	24SEP13	11OCT13	24SEP13	11OCT13	-13	-19	0.00		0.00	0.00
1302-0160	Receive Inner PF Coils	1	23APR13*	23APR13*	23APR13	23APR13	0	90	0.00		0.00	0.00
1302-0170	Perf Accept Elect & Hydr test on PF Coils	5	24APR13	24APR13	30APR13	30APR13	0	90	6,903.84		0.00	0.00
1302-0180	Wrap PF1A Coil with Microtherm	5	01MAY13	01MAY13	07MAY13	07MAY13	0	90	4,443.20		0.00	0.00
1302-0200	Receive CS Vacuum Casing	1	05FEB13	05FEB13	05FEB13	05FEB13	0	125	0.00		0.00	0.00
1302-0210	Install Inconel Weld Studs on Casing Wall	20	06FEB13	06FEB13	05MAR13	05MAR13	0	125	27,159.20		0.00	0.00
1302-0220	Mount Upper & Lower PF1B Coils to CS Casing	10	06MAR13	06MAR13	19MAR13	19MAR13	0	125	15,995.52		0.00	0.00
1302-1500	Assemble CS (OH Diag, Microtherm, Casing PFCs)	120	01OCT13*	14OCT13	31MAR14	11APR14	-9	-19	726,313.00		0.00	0.00
1302-1550	Deliver CS to NTC	1	01APR14	14APR14	01APR14	14APR14	-9	-19	0.00		0.00	0.00
1302-1600	Tear Down Assembly Area	20	01APR14	14APR14	28APR14	09MAY14	-9	1,586	54,901.92		0.00	0.00
1305-0200	Analysis of Mfg Tooling & CS Support Fixture	25	24OCT11*	24OCT11*	29NOV11	29NOV11	0	366	0.00		0.00	0.00



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NSTX UPGRADES
RESOURCE LOADED SCHEDULE
CD-2 Schedule
April 2011

Early Bar
Progress Bar
Critical Activity

1302 Center Stack Assembly (Chrzanowski)	START	28FEB2009	31MAR2009	30APR2009	31MAY2009	30JUN2009	31JUL2009	31AUG2009	30SEP2009	31OCT2009	30NOV2009	31DEC2009
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	0	0	0	0	0	0	0	0	0	0	0	0
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	.	.	.	.	.	.	.	.	.	.	.	.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1302 Center Stack Assembly (Chrzanowski)	31JAN2010	28FEB2010	31MAR2010	30APR2010	31MAY2010	30JUN2010	31JUL2010	31AUG2010	30SEP2010	31OCT2010	30NOV2010	31DEC2010
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	0	0	0	0	0	0	0	0	0	0	0	0
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	26
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	26
CV	0	0	0	0	0	0	0	0	0	0	0	-26
SV	.	.	.	.	.	.	.	.	.	.	.	.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1302 Center Stack Assembly (Chrzanowski)	31JAN2011	28FEB2011	31MAR2011	30APR2011	31MAY2011	30JUN2011	31JUL2011	31AUG2011	30SEP2011	31OCT2011	30NOV2011	31DEC2011
BCWS	0	0	0	0	0	0	0	0	0	23	4	0
CUM BCWS	0	0	0	0	0	0	0	0	0	23	27	27
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	-21	3	2	0	0	0	0	0	0	0	0	0
CUM ACWP	5	8	10	10	10	10	10	10	10	10	10	10
CV	-5	-8	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
SV	.	.	.	.	.	.	.	.	.	-23.	-27.	-27.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1302 Center Stack Assembly (Chrzanowski)	31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
BCWS	0	0	0	0	0	0	0	0	0	63	50	14
CUM BCWS	27	27	27	27	27	27	27	27	27	90	140	154
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	10	10	10	10	10	10	10	10	10	10	10	10
CV	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
SV	-27.	-27.	-27.	-27.	-27.	-27.	-27.	-27.	-27.	-90.	-140.	-154.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1302 Center Stack Assembly (Chrzanowski)	31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
BCWS	0	23	20	7	4	0	0	0	0	129	117	123
CUM BCWS	154	177	197	204	209	209	209	209	209	337	455	578
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	10	10	10	10	10	10	10	10	10	10	10	10
CV	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
SV	-154.	-177.	-197.	-204.	-209.	-209.	-209.	-209.	-209.	-337.	-455.	-578.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

1302 Center Stack Assembly (Chrzanowski)	31JAN2014	28FEB2014	31MAR2014	30APR2014	31MAY2014	30JUN2014	31JUL2014	31AUG2014	30SEP2014	31OCT2014	30NOV2014	31DEC2014
BCWS	129	112	117	55	0	0	0	0	0	0	0	0
CUM BCWS	706	818	935	990	990	990	990	990	990	990	990	990
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	10	10	10	10	10	10	10	10	10	10	10	10
CV	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
SV	-706.	-818.	-935.	-990.	-990.	-990.	-990.	-990.	-990.	-990.	-990.	-990.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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.

WBS L1	L2	L3	Description
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

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: 1302
Job Title: Centerstack Assembly
Job Manager: James H. Chrzanowski

Description:

This job includes activities associated with the assembly of the new centerstack. Details include:
CAD support for setup of the CS assembly area
Generating Assembly and Installation Procedures
Setup and Tear down of the assembly area
Assembly of the CS

Assembly includes the inner TF bundle/ OH Coil assembly, mounting of the OH surface diagnostics, installation of the micro-therm insulation, installation of the casing and inner PF coils and installation of the CS PFCs.

Schedule:

Refer to the Primavera Data-Base

Approvals:

James H Chrzanowski Jr. 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)	EMSM1 mhrs (Meighan)	EMTB1 mhrs (Technician)	EMTB3 mhrs (Welder)	EMTB4 mhrs (electrical)	M&S K$	OS k$	Stkrm. k$	Subtotal M&S k$	Basis of Estimate	Category	Contingency %
9417	1***	1302		Chrzanowski			See Job 1300												
			Cad support for setup of centerstack assembly area		5	20-Jul-12		200										4	20%
			Generate CS Assembly procedure		2	1-Jun-12												4	10%
			Generate CS Installation procedure		2	4-Jan-13												4	10%
			Modify CS Assembly Fixture		4	20-Jul-12				160	120		$10.0		$1.0	**$11.0**		2	25%
			Setup CS Assembly Area		6	24-Aug-12			24	360		200	$10.0		$2.0	**$12.0**		4	25%
			Receive OH/TF Assembly		1	**17-Aug-12**													
			Receive Inner PF coils		1	**7-Sep-12**													
			Perform acceptance electric and hydraulic tests on PF coils			14-Sep-12			24	24									10%
			Wrap PF1A coil with Microtherm insulation			26-Oct-12				40									20%
			Receive CS Vacuum Casing		1	**7-Sep-12**													
			Install inconel weld studs or nuts to casing wall		4	5-Oct-12					240				$0.5	**$0.5**		2	25%
			Mount upper & lower PF1b coils to CS casing		2	9-Nov-12					144							2	25%
			Assemble Centerstack Components		24	14-Dec-12			690	4320			$20.0		$10.0	**$30.0**		4	30%
			Apply groundplane to OH coil bundle																
			Mount surface diagnostics to OH surface																
			Wrap OH bundle with Micro-therm insulation																
			Install Lower PF1A coil to CS Casing																
			Install CS support structure																
			Install CS Vacuum Casing																
			Install upper PF1A coil & support																
			Mount diagnostics & wiring on surface of CS casing [Diag cost & respons Job 4100]																
			Mount PFC tiles to surface of casing																
			In field tile modifications- Responsibility of PFC Job 1001																
			Terminate organ pipe feed-thru's [Diagnostic cost & respons Job 4100]																
			Deliver CS assembly to the NSTX Test Cell		1	**7-Jun-13**													
			Tear down assembly area		4	1-Oct-13			24	360		80						8	15%
								200	762	5264	504	280	$40.0		$13.5	**$53.5**			

CATEGORIZATION CODES:
1 - National Standards
2 - Engineering Judgement/Experience
3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.)
4 - Previous PPPL/ORNL Experieince (e.g., TFTR, NSTX, PLT, etc.)
5 - Prototype Data/Test Results
6 - Catelogue Price/Vendor Quote
7 - Placed Contracts
8 - Actual experience for NCSX Work
9 - Other

Cost Center:	**9417**
Job Number:	**1302**
Job Title:	**Centerstack Assembly**
Job Manager:	**James H. Chrzanowski**

Uncertainty of the Estimate

		High	Medium	Low	Uncertainty Range (%)	Comments/Other Considerations
	Design Maturity		x			
	Design Complexity		X			

Residual Impacts

	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact Low ($K)	Cost Impact High ($K)	Schedule Impact Low (weeks)	Schedule Impact High (Weeks)
1	Components do not arrive when required	U	If schedule critical- OT or second shift would be required to regain schedule					
2								
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=Unlikley (40%>P>10%), VU=Very Unlikely (P<10%), NC=Non-credible (P<1%)

Design Complexity

Design Maturity	Low		Medium		High	
Low	-15%	+25%	-20%	+40%	-30%	+60%
Medium	-10%	+15%	-15%	+25%	-20%	+40%
High	-5%	+10%	-10%	+15%	-15%	+25%

Design Maturity Definition

High

Final design available. All design features/requirements well known. No further design development or evolution expected that will impact estimate.

Medium

Preliminary design available. Some additional design evolution likely. Further developments can be somewhat expected or anticipated and reflected in estimate.

Low

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

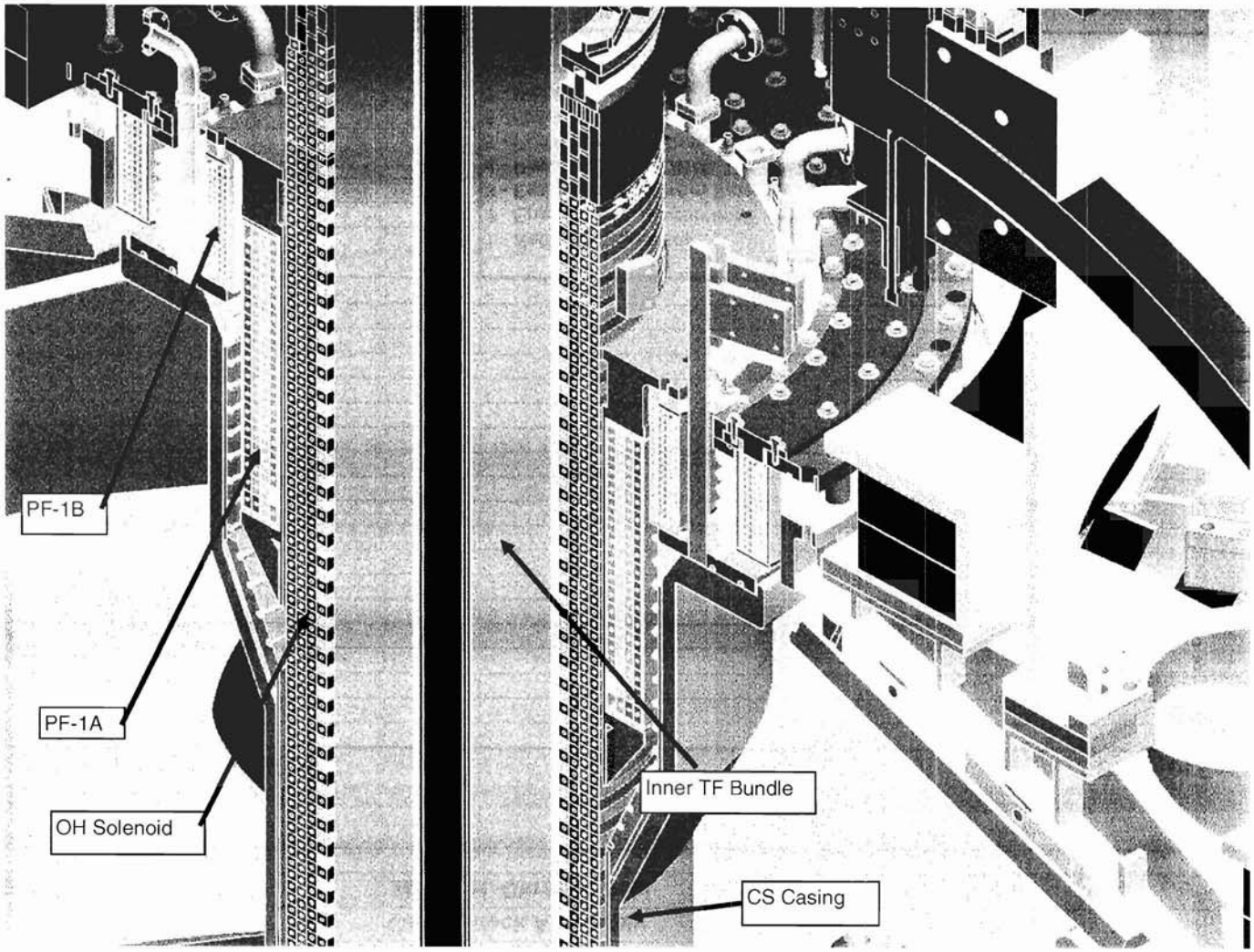
Extremely challenging tasks and/or requirements. Unique or firstof-a-kind assembly or work tasks. No good basis for estimating work exists so there is a high degree of estimate uncertainty.

Based on standard industry and DOE estimate classifications (Per AACEI Recommended

Cost Center:	**9417**		
Job Number:	**1302**		
Job Title:	**Centerstack Assembly**		
Job Manager:	**James H. Chrzanowski**		

Materials and Subcontracts (M&S)	**K$**	**Basis of Estimate**
Description:		
Material for setting up area	$10.0	2
Modify assy fixture	$10.0	2
Assemble CS- miscellaneous	$20.0	2
	TOTALS	

CATEGORIZATION CODES:	
1 - National Standards	**1**
2 - Engineering Judgement/Experience	**2**
3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.)	**3**
4 - Previous PPPL/ORNL Experieince (e.g., TFTR, NSTX, PLT, etc.)	**4**
5 - Prototype Data/Test Results	**5**
6 - Catelogue Price/Vendor Quote	**6**
7 - Placed Contracts	**7**
8 - Actual experience for NCSX Work	**8**
9 - Other	**9**


PF-1B
PF-1A
OH Solenoid
Inner TF Bundle
CS Casing