Work Authorization Document

NSTX Upgrade Project

Control Account #:	1304	**Title:**	Inner TF Bundle (Ds/Fab)
WBS	1.1.6	**Title:**	Magnet Systems
Period of Performance:	01 December 2009 through 31 March 2014		
Authorized Budget:	$2,595	**Control Account Manager:**	Chrzanowski
Revision #:	0	**Revision Date:**	July-11

Authorized Work Description:

The TF inner leg subsystem consists of the new coil sections that will make up the TF inner bore and bundle. Also included in the scope of this WBS element is the TF coil joint (flex bus assembly) and testing of the new TF coil joint design.

For the NSTX Upgrade Project a new TF Inner Leg will be fabricated. This WBS element includes the design of the TF Bundle, the TF flex bus and flex bus supports and includes all analytical and CAD design efforts for these components. It also includes the early procurement of the TF conductor [80 lengths] and procurement of the TF flex bus and supports. It does not include the procurement/fabrication of the Inner TF bundle, which is included as part of the OH procurement in WBS 1.1.3.3.2.

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		1,075	01DEC09A	01DEC09A	31MAR14	31MAR14	0	25	2,600,540.35		781,209.80	800,604.60

Job: 1304 - Inner TF Bundle (Ds/Fab)-CHRZANOWSKI

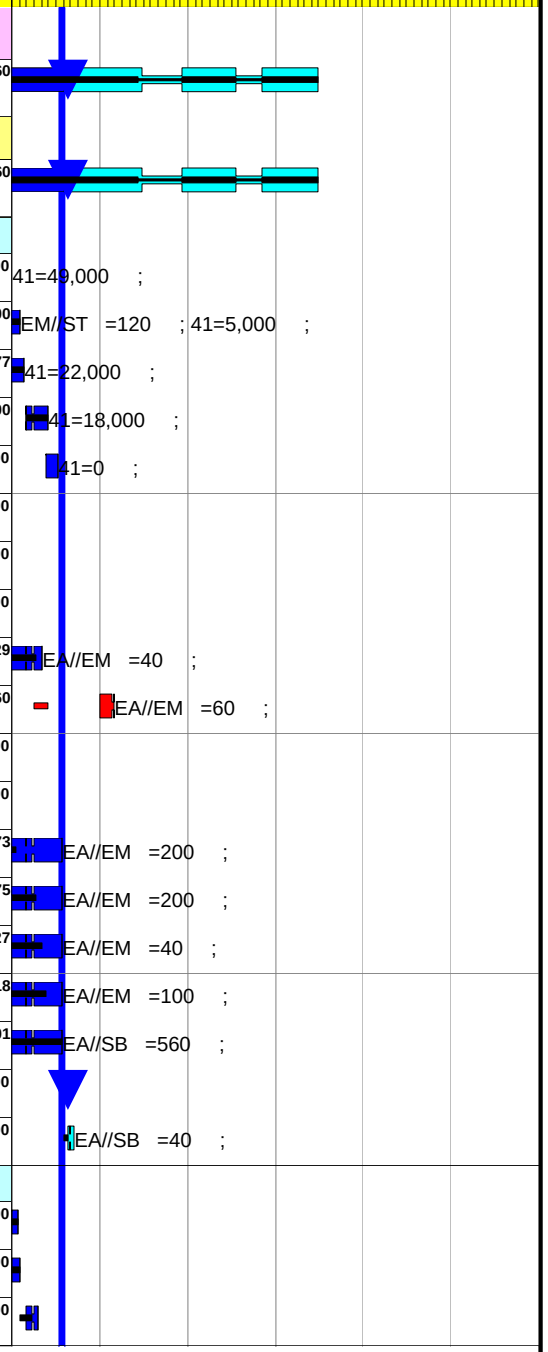
Subtotal		1,075	01DEC09A	01DEC09A	31MAR14	31MAR14	0	25	2,600,540.35		781,209.80	800,604.60

Inner TF Bundl;e Design

1304-0050	Perform Add'l Friction Stir Weld Trials-Phase II	75	01SEP10A	01SEP10A	01OCT10A	01OCT10A	0		0.00	100	0.00	0.00
1304-0060	Fabricate Flex Bus Assy's for Testing (2)	42*	01SEP10A	01SEP10A	29OCT10	29OCT10A	0		17,500.00	100	17,500.00	17,500.00
1304-0065	New Insulation Shear R&D Test	43*	16SEP10A	16SEP10A	15NOV10	15NOV10A	0		27,269.77	100	27,269.77	27,269.77
1304-0065B	Second Insulation Shear R&D Test (60k cycle tes	60*	24NOV10*	24NOV10A	25FEB11	25FEB11A	0		22,680.00	100	22,680.00	22,680.00
1304-0065C	Third Insulation Shear R&D Test (60k cycle tes	36*		21FEB11A		11APR11A	0		0.00	100	0.00	0.00
1304-0110	Design-Analyze Tension Strap	15	24JUN10A	24JUN10A	15JUL10A	15JUL10A	0		0.00	100	0.00	0.00
1304-0130	Complete Analysis if TF Flex Bus	24	26JUL10A	26JUL10A	26AUG10A	26AUG10A	0		0.00	100	0.00	0.00
1304-0140	Complete & Check Thermal Stresses	15	16JUL10A	16JUL10A	05AUG10A	05AUG10A	0		0.00	100	0.00	0.00
1304-0150	Maintain input to Willards Flex Model (LOE)	191*	24JUN10A	24JUN10A	03JAN11	31JAN11A	-20		7,312.04	100	7,250.29	7,250.29
1304-0160	Check Willards/Tooling/Fixturing Calculations	40	03JAN11*	03OCT11*	25FEB11	29NOV11	-192	-5	25,354.80		0.00	23,121.60
1304-0170	N/R Tooling/Fixturing Calculations	45	31AUG10A	31AUG10A	31AUG10A	31AUG10A	0		0.00	100	0.00	0.00
1304-0180	N/R Calculation/Write/Check Files	80	31AUG10A	31AUG10A	31AUG10A	31AUG10A	0		0.00	100	0.00	0.00
1304-0190	Analyze Pins & Crown	212*	24JUN10A	24JUN10A	15OCT10	29APR11A	-132		37,156.65	100	34,880.73	34,880.73
1304-0210	Pedestal/Lower Skirt/TF Teeth Analysis	186*	02AUG10A	02AUG10A	05JAN11	29APR11A	-82		37,556.25	100	36,783.75	36,783.75
1304-0220	Finish Torque for Upper Teeth & Covers Post Proc	182*	02AUG10A	02AUG10A	02FEB11	25APR11A	-58		7,506.94	100	7,413.27	7,413.27
1304-0230	DCPS Input	218*	24JUN10A	24JUN10A	16FEB11	29APR11A	-52		18,578.33	100	18,354.18	18,354.18
1304-0250	Complete Detail and Assembly CAD Drawings	228*	24JUN10A	24JUN10A	29APR11	29APR11A	0		68,147.01	100	68,147.01	68,147.01
1304-0255	Inner TF Bundle - Peer review	0				18MAY11*	0	128	0.00		0.00	0.00
1304-0260	Prepare for FDR	19*	02MAY11	23MAY11	20MAY11	17JUN11	-19	126	4,996.40		0.00	0.00

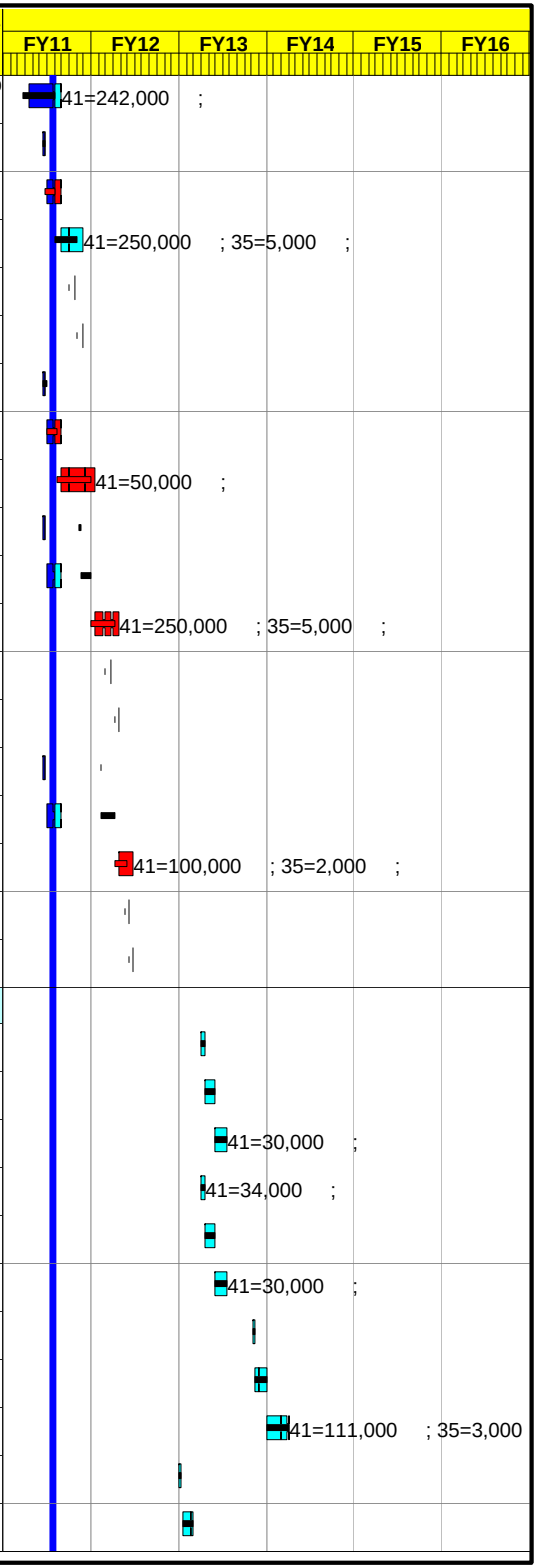
Manufacture Inner TF Conductor

1304-0460	Generate SOW for TF Conductor	20*	01OCT10A	01OCT10A	28OCT10	28OCT10A	0		0.00	100	0.00	0.00
1304-0480	Prep Req for TF Conductor & Submit to Proc	25*	01OCT10A	01OCT10A	04NOV10	29OCT10A	4		0.00	100	0.00	0.00
1304-0500	Bid & Award TF Conductor-Copper Extrusions	30*	05NOV10	01DEC10A	20DEC10	19JAN11A	-16		0.00	100	0.00	0.00

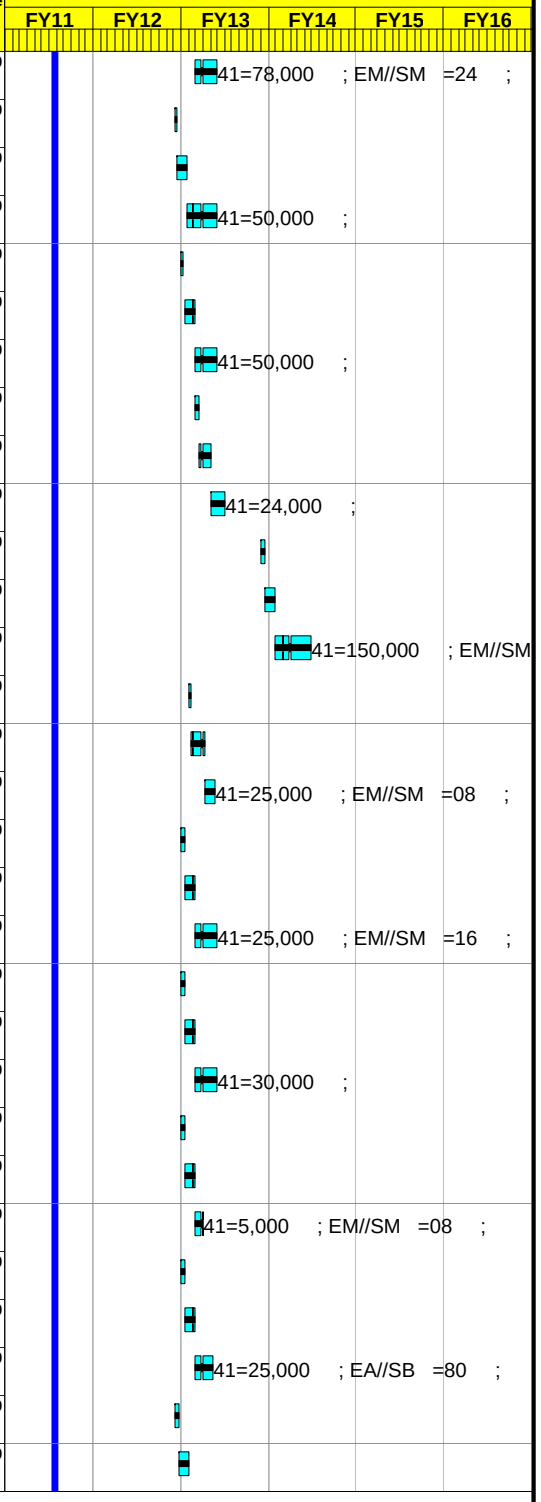


Early Bar
Progress Bar
Critical Activity

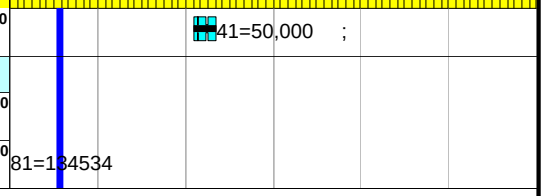
Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)
1304-0600	Manufacture TF Conductor-Copper Extrusions (56)	93*	21DEC10	20JAN11A	03MAY11	31MAY11	-19	15	304,920.00	99	301,870.80	298,144.00
1304-0730	Prep Req to Mach Conductors & Submit to Proc	5	16MAR11	16MAR11A	22MAR11	22MAR11A	0		0.00	100	0.00	0.00
1304-0740	Bid & Award Contract to Machine Conductors	43*	23MAR11	31MAR11A	03MAY11	31MAY11	-19	-19	0.00	50	0.00	0.00
1304-0750	Machine TF Conductors (Clng Grooves, Lead Areas)	65	04MAY11	01JUN11	04AUG11	31AUG11	-19	15	321,300.00		0.00	0.00
1304-0750A	Deliver 1st 25 Machined Conductors	1	30JUN11	28JUL11	30JUN11	28JUL11	-19	40	0.00		0.00	0.00
1304-0750B	Deliver 2nd 20 Machined Conductors	1	05AUG11	01SEP11	05AUG11	01SEP11	-19	15	0.00		0.00	0.00
1304-0770	Prep Req for Cu-Cr-Zr TF Lead Extensions	10	17MAR11	16MAR11A	30MAR11	22MAR11A	6		0.00	100	0.00	0.00
1304-0780	Bid & Award TF Lead Extensions	43*	31MAR11	31MAR11A	11MAY11	31MAY11	-13	-19	0.00	50	0.00	0.00
1304-0790	Fab & Del TF Lead Extensions	100	12MAY11	01JUN11	03OCT11	20OCT11	-13	-19	63,210.00		0.00	0.00
1304-0830	Prep Req for Friction Stir Welding	5	15AUG11*	16MAR11A	19AUG11	22MAR11A	106		0.00	100	0.00	0.00
1304-0840	Bid & Award Friction Stir Welding	43*	22AUG11	31MAR11A	03OCT11	31MAY11	87	81	0.00	50	0.00	0.00
1304-0850	Friction Stir-Weld Coil Leads to Conductors	60	04OCT11	21OCT11	05JAN12	24JAN12	-13	-19	328,950.00		0.00	0.00
1304-0850A	Deliver 1st 20 FSW Conductors	1	01DEC11	20DEC11	01DEC11	20DEC11	-13	1	0.00		0.00	0.00
1304-0850B	Deliver 2nd 25 FSW conductors	1	06JAN12	25JAN12	06JAN12	25JAN12	-13	-19	0.00		0.00	0.00
1304-0930	Prep Req for Final Conductor Machining	5	09NOV11	16MAR11A	15NOV11	22MAR11A	167		0.00	100	0.00	0.00
1304-0940	Bid & Award Final Conductor Machining	43*	16NOV11	31MAR11A	06JAN12	31MAY11	148	142	0.00	50	0.00	0.00
1304-0950	Machine TF Conductors (Fnl Lead Areas & Inserts)	40	09JAN12	26JAN12	02MAR12	21MAR12	-13	-19	131,580.00		0.00	0.00
1304-0950A	Receive 1st Delivery of Final Machined TF Cond	1	20FEB12	08MAR12	20FEB12	08MAR12	-13	-9	0.00		0.00	0.00
1304-0950B	Receive Balance ofFinal Machined TF Cond	1	05MAR12	22MAR12	05MAR12	22MAR12	-13	-19	0.00		0.00	0.00
Other Inner TF Bundle Hardware												
1304-1110	Prep Req for C151 (Cu-Zr) for Flex Bus	10	02JAN13*	02JAN13*	15JAN13	15JAN13	0	195	0.00		0.00	0.00
1304-1112	Bid/Award- C151 for Flex Bus	30	16JAN13	16JAN13	26FEB13	26FEB13	0	195	0.00		0.00	0.00
1304-1114	Fab & Deliver C151 for Flex Bus	40	27FEB13	27FEB13	23APR13	23APR13	0	195	39,600.00		0.00	0.00
1304-1114A	Prep Req for Flex Bus Solder Bimetal Wafers	10	02JAN13*	02JAN13*	15JAN13	15JAN13	0	195	0.00		0.00	0.00
1304-1114B	Bid/Award- for Flex Bus Solder Bimetal Wafers	30	16JAN13	16JAN13	26FEB13	26FEB13	0	195	0.00		0.00	0.00
1304-1114C	Fab & Delive- for Flex Bus Solder Bimetal Wafers	40	27FEB13	27FEB13	23APR13	23APR13	0	195	39,600.00		0.00	0.00
1304-1120	Prep Req for Flex Bus Fabrication	10	05AUG13*	05AUG13*	16AUG13	16AUG13	0	85	0.00		0.00	0.00
1304-1122	Bid/Award Flex Bus Fabrication	30	19AUG13	19AUG13	30SEP13	30SEP13	0	85	0.00		0.00	0.00
1304-1124	Fab & Deliver Flex Bus	60	01OCT13	01OCT13	06JAN14	06JAN14	0	85	153,930.00		0.00	0.00
1304-1130	Prep Req for Cu-Cr-Zr (C1815) for OTF Lead Ext	10	01OCT12*	01OCT12*	12OCT12	12OCT12	0	138	0.00		0.00	0.00
1304-1132	Bid/Award Cu-Cr-Zr for OTF Lead Ext	30	15OCT12	15OCT12	27NOV12	27NOV12	0	138	0.00		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)
1304-1134	Fab & Del Cu-Cr-Zr for OTF Lead Ext	60	28NOV12	28NOV12	28FEB13	28FEB13	0	138	107,197.92		0.00	0.00
1304-1140	Prep Req for OTF Lead Ext (OTF to Flex)	10	04SEP12*	04SEP12*	17SEP12	17SEP12	0	137	0.00		0.00	0.00
1304-1142	Bid/Award OTF Lead Ext (OTF to Flex)	30	18SEP12	18SEP12	29OCT12	29OCT12	0	137	0.00		0.00	0.00
1304-1144	Fab & Del OTF Lead Ext (OTF to Flex)	80	30OCT12	30OCT12	01MAR13	01MAR13	0	137	66,000.00		0.00	0.00
1304-1150	Prep ReqPrep Req for Supports for OTF Jumpers	10	01OCT12*	01OCT12*	12OCT12	12OCT12	0	138	0.00		0.00	0.00
1304-1152	Bid/Award Supports for OTF Jumpers	30	15OCT12	15OCT12	27NOV12	27NOV12	0	138	0.00		0.00	0.00
1304-1154	Fab/Deliver Supports for OTF Jumpers	60	28NOV12	28NOV12	28FEB13	28FEB13	0	138	66,000.00		0.00	0.00
1304-1160	Prep Req Lower TF Coil to Bus Jump & Supp	10	03DEC12*	03DEC12*	14DEC12	14DEC12	0	115	0.00		0.00	0.00
1304-1162	Bid/Award Lower TF Coil to Bus Jump & Supp	30	17DEC12	17DEC12	05FEB13	05FEB13	0	115	0.00		0.00	0.00
1304-1164	Fab & Deliver Lower TF Coil to Bus Jump & Supp	40	06FEB13	06FEB13	02APR13	02APR13	0	115	31,680.00		0.00	0.00
1304-1170	Prep Spec for Super Bolts	10	03SEP13*	03SEP13*	16SEP13	16SEP13	0	25	0.00		0.00	0.00
1304-1172	Bid/Award Super Bolts	30	17SEP13	17SEP13	28OCT13	28OCT13	0	25	0.00		0.00	0.00
1304-1174	Fab & Deliver Super Nuts	100	29OCT13	29OCT13	31MAR14	31MAR14	0	25	205,414.88		0.00	0.00
1304-1180	Prep Req Joint Hardware	10	02NOV12*	02NOV12*	15NOV12	15NOV12	0	144	0.00		0.00	0.00
1304-1182	Bid/Award Joint Hardware	30	16NOV12	16NOV12	09JAN13	09JAN13	0	144	0.00		0.00	0.00
1304-1184	Fab & Deliver Joint Hardware	30	10JAN13	10JAN13	20FEB13	20FEB13	0	144	34,412.64		0.00	0.00
1304-1190	Prep Spec Copper for Lead Ext for Upper ITF	10	02OCT12*	02OCT12*	15OCT12	15OCT12	0	137	0.00		0.00	0.00
1304-1192	Bid/Award - Copper Lead Ext for Upper ITF	30	16OCT12	16OCT12	28NOV12	28NOV12	0	137	0.00		0.00	0.00
1304-1194	Fab & Deliver Copper Lead Ext for Upper ITF	60	29NOV12	29NOV12	01MAR13	01MAR13	0	137	35,825.28		0.00	0.00
1304-1210	Prep Req for Up/Lwr OF to TF Supp Struct	10	02OCT12*	02OCT12*	15OCT12	15OCT12	0	137	0.00		0.00	0.00
1304-1212	Bid/Award Up/Lwr OH to TF Supp Struct	30	16OCT12	16OCT12	28NOV12	28NOV12	0	137	0.00		0.00	0.00
1304-1214	Fab & Del Up/Lwr OH to TF Supp Struct	60	29NOV12	29NOV12	01MAR13	01MAR13	0	137	39,600.00		0.00	0.00
1304-1220	Pre Req for Cooling Fittings	10	02OCT12*	02OCT12*	15OCT12	15OCT12	0	177	0.00		0.00	0.00
1304-1222	Bid/Award Cooling Fittings	30	16OCT12	16OCT12	28NOV12	28NOV12	0	177	0.00		0.00	0.00
1304-1224	Fab & Deliver Cooling Fittings	20	29NOV12	29NOV12	04JAN13	04JAN13	0	177	8,012.64		0.00	0.00
1304-1230	Prep Req for Tooling for Inst Flex Bus Segments	10	02OCT12*	02OCT12*	15OCT12	15OCT12	0	147	0.00		0.00	0.00
1304-1232	Bid/Award-Tooling for Inst Flex Bus segments	30	16OCT12	16OCT12	28NOV12	28NOV12	0	147	0.00		0.00	0.00
1304-1234	Fab/Del Tooling for Inst Flex Bus Segments	50	29NOV12	29NOV12	15FEB13	15FEB13	0	147	44,188.80		0.00	0.00
1304-1240	Prep req for Up/Lwr Teeth Interf Struct	10	10SEP12*	10SEP12*	21SEP12	21SEP12	0	153	0.00		0.00	0.00
1304-1242	Bid/Award Up/Lwr Teeth Interf Struct	30	24SEP12	24SEP12	02NOV12	02NOV12	0	153	0.00		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)
1304-1244	**Fab & Deliver Up/Lwr Teeth Interf Struct**	**60**	**05NOV12**	05NOV12	**07FEB13**	07FEB13	**0**	**153**	66,000.00		0.00	**0.00**
FY101304	**FY10 Actual Cost**	**100**	**01DEC09A**	01DEC09A	**30APR10A**	30APR10A	**0**		104,348.00	**100**	104,348.00	**104,348.00**
FY101304A	**FY10 Actual Cost**	**110**	**03MAY10A**	03MAY10A	**30SEP10A**	30SEP10A	**0**		134,712.00	**100**	134,712.00	**134,712.00**



1304 Inner TF Bundle (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	17
CUM BCWS	0	0	0	0	0	0	0	0	0	0	0	17
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	.	.	.	.	.	.	.	.	.	.	.	-17.
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

1304 Inner TF Bundle (Chrzanowski)		31JAN2010	28FEB2010	31MAR2010	30APR2010	31MAY2010	30JUN2010	31JUL2010	31AUG2010	30SEP2010	31OCT2010	30NOV2010	31DEC2010
	BCWS	20	20	24	23	25	32	45	56	69	48	27	33
	CUM BCWS	38	58	82	104	130	162	208	264	332	380	407	440
	BCWP	0	0	0	0	0	0	0	0	0	0	0	416
	CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	416
	ACWP	0	0	0	0	0	0	0	0	0	0	0	427
	CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	427
	CV	0	0	0	0	0	0	0	0	0	0	0	-10
	SV	-38.	-58.	-82.	-104.	-130.	-162.	-208.	-264.	-332.	-380.	-407.	-24.
	CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	.98
	SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95

1304 Inner TF Bundle (Chrzanowski)		31JAN2011	28FEB2011	31MAR2011	30APR2011	31MAY2011	30JUN2011	31JUL2011	31AUG2011	30SEP2011	31OCT2011	30NOV2011	31DEC2011
	BCWS	103	94	86	78	112	121	115	34	14	97	106	106
	CUM BCWS	543	637	723	801	913	1,034	1,149	1,182	1,196	1,293	1,400	1,506
	BCWP	29	42	219	75	0	0	0	0	0	0	0	0
	CUM BCWP	445	487	706	781	781	781	781	781	781	781	781	781
	ACWP	14	12	21	14	0	0	0	0	0	0	0	0
	CUM ACWP	440	452	473	487	487	487	487	487	487	487	487	487
	CV	5	35	233	294	294	294	294	294	294	294	294	294
	SV	-98.	-150.	-16.	-19.	-132.	-252.	-368.	-401.	-415.	-512.	-619.	-725.
	CPI	1.01	1.08	1.49	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	SPI	0.82	0.76	0.98	0.98	0.86	0.76	0.68	0.66	0.65	0.6	0.56	0.52

1304 Inner TF Bundle (Chrzanowski)		31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
	BCWS	75	69	7	0	0	0	0	0	0	1	48	136
	CUM BCWS	1,582	1,651	1,657	1,657	1,657	1,657	1,657	1,657	1,657	1,659	1,706	1,842
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	781	781	781	781	781	781	781	781	781	781	781	781
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	487	487	487	487	487	487	487	487	487	487	487	487
	CV	294	294	294	294	294	294	294	294	294	294	294	294
	SV	-800.	-869.	-876.	-876.	-876.	-876.	-876.	-876.	-876.	-877.	-925.	-1061.
	CPI	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	SPI	0.49	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.42

1304 Inner TF Bundle (Chrzanowski)		31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
	BCWS	162	136	60	35	0	0	0	0	0	56	85	89
	CUM BCWS	2,004	2,140	2,200	2,235	2,235	2,235	2,235	2,235	2,235	2,292	2,377	2,466
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	781	781	781	781	781	781	781	781	781	781	781	781
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	487	487	487	487	487	487	487	487	487	487	487	487
	CV	294	294	294	294	294	294	294	294	294	294	294	294
	SV	-1223.	-1359.	-1419.	-1454.	-1454.	-1454.	-1454.	-1454.	-1454.	-1510.	-1596.	-1685.
	CPI	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	SPI	0.39	0.37	0.36	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.33	0.32

1304 Inner TF Bundle (Chrzanowski)		31JAN2014	28FEB2014	31MAR2014	30APR2014	31MAY2014	30JUN2014	31JUL2014	31AUG2014	30SEP2014	31OCT2014	30NOV2014	31DEC2014
	BCWS	52	37	39	0	0	0	0	0	0	0	0	0
	CUM BCWS	2,518	2,555	2,595	2,595	2,595	2,595	2,595	2,595	2,595	2,595	2,595	2,595
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	781	781	781	781	781	781	781	781	781	781	781	781
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	487	487	487	487	487	487	487	487	487	487	487	487
	CV	294	294	294	294	294	294	294	294	294	294	294	294
	SV	-1737.	-1774.	-1813.	-1813.	-1813.	-1813.	-1813.	-1813.	-1813.	-1813.	-1813.	-1813.
	CPI	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	SPI	0.31	0.31	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

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

WBS Element: 1.1.3.3 **WBS Level: 4**
WBS Title: Center Stack Assembly (CSA)

Definition: The CSA consists of the inner TF coil legs, the OH solenoid, the shaping coils, and the center stack casing. Also included in this WBS element are the TF coil joint (flex bus assembly) and the ceramic break assembly. The scope of this WBS element includes the design, analysis, prototypes (as required), procurement activities, fabrication and assembly of the Center Stack.

WBS Element: 1.1.3.3.1 **WBS Level: 5**
WBS Title: Center Stack - TF Inner Legs/Bundle

Definition: The TF inner leg subsystem consists of the new coil sections that will make up the TF inner bore and bundle. Also included in the scope of this WBS element is the TF coil joint (flex bus assembly) and testing of the new TF coil joint design.

For the NSTX Upgrade Project a new TF Inner Leg will be fabricated. This WBS element includes the design of the TF Bundle, the TF flex bus and flex bus supports and includes all analytical and CAD design efforts for these components. It also includes the early procurement of the TF conductor [80 lengths] and procurement of the TF flex bus and supports. It does not include the procurement/fabrication of the Inner TF bundle, which is included as part of the OH procurement in WBS 1.1.3.3.2.
{Inner Toroidal Field Bundle (Job 1304)}

. For the NSTX Upgrade Project a test stand to measure the required performance parameters on the new NSTX TF joint design will be designed and fabricated. Test parameter measurements and cyclic lifetime tests of the new TF joint will be performed and testing data will be compiled. The test stand will be modified for revised design configurations as needed and tests repeated with a final comprehensive test report generated that includes all test data.
{TF Joint Stand & Performance Test (Job 1303)}

WBS Element: 1.1.3.3.2 **WBS Level: 5**
WBS Title: Ohmic Heating Solenoid

Definition: The ohmic heating solenoid subsystem consists of the new coils that will make up the center solenoid. This WBS element includes the design, analysis, prototypes (as required), procurement activities and fabrication.

For the NSTX Upgrade a new OH Solenoid will be fabricated. This WBS element includes the design & fabrication of a new OH solenoid and associated components including a belleville washer spring assembly and support structures for the NSTX upgrades. It also includes all analytical & CAD design efforts. Includes advance procurement of the copper conductor and co-wound [glass/Kapton] insulation. Also includes the procurement of the Micro-therm insulation, conductive paint.
Includes the procurement and engineering oversight for the combined OH

Work Approval Form (WAF)

Cost Center: 9417
Job Number: 1304
Job Title: Inner Toroidal Field Bundle
Job Manager: James H. Chrzanowski
Rev 1 7/6/2010

Description:

Includes the design of the TF bundle, TF flex bus and flex bus supports. Includes all analytical & CAD design efforts for these components. Includes the early procurement of the TF conductor [80 lengths]. Also the procurement of the TF flex bus and supports. Does not include the manufacturing of the Inner TF bundle, *which is included as part of the OH fabrication in Job 1305.*

Schedule:

Refer to Primavera Data-Base

Approvals:

James H Chrzanowski 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.)	EAEM2 mhrs (Titus)	EAEM3 mhrs (Zhang)	EMEM3 mhrs (Willard)	EMEM5 mhrs Ali	EASB1 mhrs (Paul)	EMSM mhrs Meighan	EMTB mhrs	M&S K$	OS k$	Travel k$	Stkrm. k$	Subtotal M&S k$	Basis of Estimate	Category	Contingency %
9417	1***	1304		Chrzanowski			See Job 1300															
			R&D Activities																			
			Perform additional Friction Stir Weld Trials- Phase II		15	22-Apr-10										$49.0			**$49.0**		7	10%
			Fabricate Flex bus assy's for testing [2]											120		$5.0			**$5.0**		2	30%
			New insulation primer R&D tests			**16-Aug-10**										**$15.0**			**$15.0**		**4**	**20%**
			See job 9417-1-1303 for R&D jobs and costs***																			
			Final Design Activities																			
			Design-analyze tension strap			24-Jun-10			60												4	20%
			Analyze TF bus bar			24-Jun-10				100											4	20%
			Complete analysis of TF Flex bus			24-Jun-10				144												
			Complete and check thermal stresses			24-Jun-10			60												4	20%
			Maintain input to Willard's Flex model- displacements Temper			24-Jun-10		40													4	20%
			Check Willard's calculations			24-Jun-10					60										4	20%
			Tooling/Fixturing calculations			24-Jun-10					60										4	20%
			Calculation/Write/check files			24-Jun-10		60													4	20%
			Analyze double row of teeth			24-Jun-10					200										4	20%
			Pedestal/Lower skirt/ TF Teeth Analysis			24-Jun-10					200										4	20%
			Finish torque for upper teeth and covers post processing			24-Jun-10		40													4	20%
			DCPS Input			24-Jun-10		100														
			Complete detail and assembly Cad drawings [TF bundle, joint and components]		39	24-Jun-10						560									2	25%
			Prepare for FDR		2	11-Mar-11						40									2	10%
			HOLD TF CONDUCTOR PEER REVIEW [to allow early procurement]		1	13-Aug-10																
			Purchase & Fabrication																			
			TF Conductor																			
			Extrusion: Prep requisition/SOW & submit to procurement		1	20-Aug-10															4	10%
			Bid & Award conductor extrusion order [80 pcs]		5	27-Aug-10															4	10%
			Manufacture Copper extrusions [80]		18	1-Oct-10									$242.0				**$242.0**		6	35%
			Receive TF conductors from extruder			**4-Feb-11**																
			Machining #1: Prep requisition & submit to procurement		1	7-Jan-11															4	10%
			Bid & Award conductor machining [40 pcs]		4	14-Jan-11															4	10%
			Machine conductors [finish machine, cooling grooves, lead area]- 40		13	11-Feb-11										$250.0	$5.0		**$255.0**		6	35%
			Receive first delivery of TF conductors from machinist			**8-Apr-11**																
			Receive balance of TF conductors from machinist			**13-May-11**																
			Procure Cu-Cr-Zr ITF lead extensions for FSW]		20	17-Dec-10										$50.0			**$50.0**		2	25%
			FSW: Prep requisition & submit to procurement		1	11-Mar-11															4	10%
			Bid & award lead welding [40 pcs]		4	18-Mar-11															4	10%
			Friction Stir-Weld coil leads to conductors- 40		12	15-Apr-11										$250.0	$3.0		**$253.0**		6	35%
			Receive First delivery of TF conductors from FSW			**3-Jun-11**																
			Receive balance of TF conductors from FSW			**8-Jul-11**																
			Post FSW Machining #2: Prep requisition & submit to procurement		1	8-Jul-11																10%
			Bid & Award conductor machining [40 pcs]		4	15-Jul-11																10%
			Machine conductors [Final lead area & Inserts]- 40 pcs		8	10-Jun-11										$50.0	$2.0		**$52.0**		2	35%
			Receive First Delivery of TF conductors from Machinist			**15-Jul-11**																
			Receive balance of TF conductors from machinist			**19-Aug-11**																
			Flex Bus [Inner to Outer TF]																			
			Procure C151 [Cu-Cr] copper material for flex bus		8	7-Sep-12										$25.0			**$25.0**		6	25%
			Flex bus- Prep requisition & submit to procurement		1	5-Oct-12															4	10%
			Bid & award flex bus order [80 assy's]		4	12-Oct-12															4	10%
			Fabricate Flex bus		12	9-Nov-12										$65.0	$3.0		**$68.0**		2	35%
			Receive Flex bus			**1-Feb-13**																
			Procure Cu-Cr-Zr [C1815] for OTF lead extensions		12	20-Jul-12							24			$78.0			**$78.0**		6	25%
			Procure OTF lead extensions [OTF to flex]		16	12-Oct-12										$50.0			**$50.0**		2	30%
			Procure supports for OTF jumpers		12	9-Nov-12										$50.0			**$50.0**		2	30%
			Procure lower TF coil to bus jumpers & supports		8	12-Oct-12										$24.0			**$24.0**		2	30%
			Miscellaneous parts																			
			Procure super nuts [600]		**20**	**14-Sep-12**							**16**		**$150.0**				**$150.0**		**2**	**25%**

NSTX CENTERSTACK- UPGRADE

Cost Center	Work Package	Job #	Activity Name	Responsible Cog Engr	Duration (Weeks)	Start Date	EAEM1 mhrs (Chrzan.)	EAEM2 mhrs (Titus)	EAEM3 mhrs (Zhang)	EMEM3 mhrs (Willard)	EMEM5 mhrs Ali	EASB1 mhrs (Paul)	EMSM mhrs Meighan	EMTB mhrs	M&S K$	OS k$	Travel k$	Stkrm. k$	Subtotal M&S k$	Basis of Estimate	Category	Contingency %
			Procure joint hardware [belleville & flat washers, bolts, nuts]		6	21-Dec-12							8		$25.0				**$25.0**		6	25%
			Procure Copper lead extensions for upper ITF [OFHC]		12	7-Dec-12							16			$25.0			**$25.0**		2	25%
			Procure upper/lower OH to TF support structures		12	15-Jul-11										$30.0			**$30.0**		2	30%
			Procure cooling fittings		4	3-Jun-11							8		$5.0				**$5.0**		6	15%
			Tooling for installing flex bus segments		10	5-Oct-12						80			$25.0				**$25.0**			25%
			Procure Upper/Lower teeth interface structues		12	15-Jul-11										$50.0			**$50.0**		2	35%
								240	**120**	**244**	**520**	**680**	**72**	**120**					**$1,526.0**			
			Fabrication of the ITF bundle is costed in job 9417-1***-1305																			

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:	1304
Job Title:	Inner Toroidal Field Bundle
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	Copper extrusion vendor has difficulty making full length conductors	U	FSW shorter conductors together			100		XX
2								XX
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 Maturity	Design Complexity					
	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

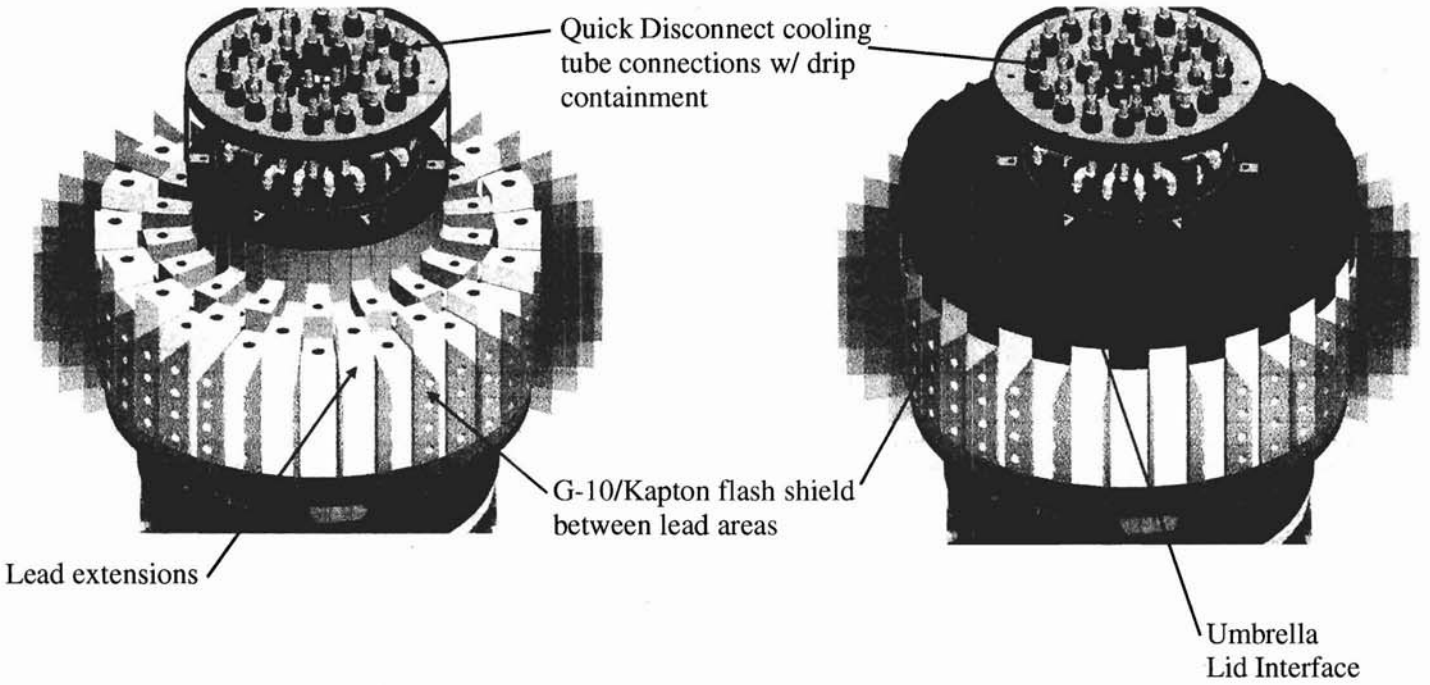
High	
	Final design available. All design features/requirements well known. No further design development or evolution expected that will impact estimate.
Medium	
	Preliminary design available. Some additional design evolution likely. Further developments can be somewhat expected or anticipated and reflected 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.

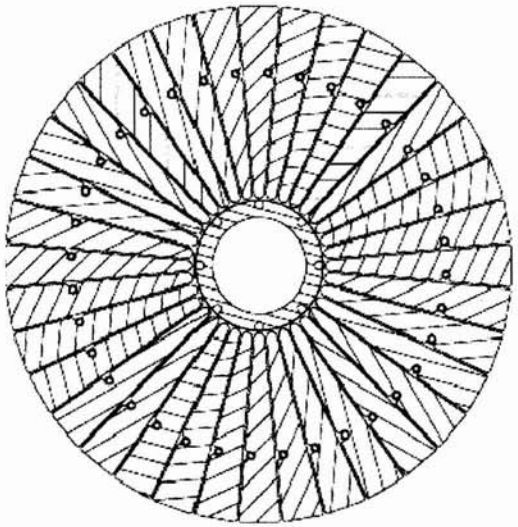
Design Complexity Definition

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:	1304						
Job Title:	Inner Toroidal Field Bundle						
Job Manager:	James H. Chrzanowski						
Materials and Subcontracts (M&S)			**K$**	**Basis of Estimate**			
Description:							
ITF copper extrusions			$242.0	6			
Machine conductors			$250.0	6			
Friction Stir Weld coil leads to conductor			$250.0	6			
Final Machine leads- Post FSW			$50.0	2			
C1815 copper material for OTF lead extensions			$78.0	6			
OTF copper lead extensions			$50.0	2			
C151 copper material for Flex bus			$25.0	6			
TF flex bus fabrication			$65.0	2			
Supports for TF jumpers			$30.0	2			
Lower TF power bus jumpers & supports			$12.0	2			
CU-Cr-Zr lead extensions [FSW]			$50.0	2			
Super bolts			$310.0	2			
Upper lead copper spacers			$25.0	2			
OH to TF lead support structures			$30.0	2			
Misc joint hardware			$25.0				
				2			
Tooling for installing TF flexes			$20.0				
			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**	
				TOTALS			

UPP TF BUNDLE





Upgraded TF Bundle 15.7 inch diameter