NCSX Work Approval Form (WAF)

WBS Number: 75

WBS Title: Machine Assembly Operations

Job Numbers: 7501 and 7503

Job Title: Construction Crew Support (7501)

Job Title: Machine Assembly Operations (7503)

Job Manager: Erik Perry

Description:

This WBS element consists of those activities associated with the final assembly of the stellarator core in the NCSX Test Cell

Schedule:

See Attached

Approvals:

Erik Perry
Digitally signed by Erik Perry
DN: cn=Erik Perry, c=US, email=eperry@pppl.gov
Date: 2007.07.16 11:01:16 -04'00'

Job Manager _____ Date _____

Lawrence E. Dudek
Digitally signed by Lawrence E. Dudek
DN: cn=Lawrence E. Dudek, c=US
Date: 2007.07.16 11:57:31 -04'00'

Responsible Line Manager _____ Date _____

Hutch Neilson
Digitally signed by Hutch Neilson
DN: CN = Hutch Neilson, C = US, O = PPPL
Date: 2007.07.16 17:22:01 -04'00'

Project Manager _____ Date _____

Mike Williams
Digitally signed by Mike Williams
DN: cn=Mike Williams, o=PPPL, ou=Engineering, email=williams@pppl.gov, c=US
Date: 2007.07.17 07:18:33 -04'00'

Engineering Department Head _____ Date _____

NCSX June 2007 ETC
TABLE I - DESIGN LABOR

WBS Number: 75
WBS Title: Machine Assembly Operations
Job Numbers: 7501 and 7503
Job Title: Construction Crew Support (7501)
Job Title: Machine Assembly Operations (7503)
Job Manager: Erik Perry

Description:

None - this is an assembly operation

NCSX June 2007 ETC
TABLE II - Materials and Subconracts

Materials and Subcontracts (M&S)					**Basis of Estimate**		
Description:							
This is an assembly operation - M&S included in Table III							

NCSX June 2007 ETC
TABLE III - Fabrication/Assembly Installation

WBS Number: 75
WBS Title: Machine Assembly Operations
Job Numbers: 7501 and 7503
Job Title: Construction Crew Support (7501)
Job Title: Machine Assembly Operations (7503)
Job Manager: Erik Perry

In-house Fabrication and Assembly and Installation

Job 7501 - Construction Support Crew

Description of Task	ACT	K$ M&S	Travel	Hours EAEM	Metrology	EMEM	EMSM	EMTB	Duration in Shifts	Persons per Shift		Assumptions	Basis of Estimate
													Note: final designs not yet available - estimates based on conceptual information from others
LOE Construction Support Crew during machine assy	7501-05						.75 fte	2.0 fte		2.75		crane/fork lift operator 1.0 fte, rigger 1.0 fte, tool crib .75 fte (applies to 2 nd shifht also if used)	NSTX assembly
Total Job 7501		*$0K*		*0*	*0*	*0*	*0*	*0*					

Job 7503 - Construction Support Crew

Description of Task	ACT	K$ M&S	Travel	Hours EAEM	Metrology	EMEM	EMSM	EMTB	Duration in Shifts	Persons per Shift		Assumptions	Basis of Estimate
													Note: final designs not yet available - estimates based on conceptual information from others
Assembly of Components for Others													
Fabricate assembly structure		$80K				96	240	960	20	6	1,376	Design by WBS 1803	
Fabricate structure to go between assembly sleds & FPAs		$80K				96	240	960			1,376	EWDA - same magnitude as assembly sleds is assumed	
Assemble 3 FPA support stands						48	120	480	15	4	648		
Assemble 3 VV spool piece support stands						32	80	320	10	4	432		
Assemble machine base structure						32	80	320	10	4	432		
Assemble 3 FPA installation carts						32	80	320	10	4	432		
Fabricate 3 laser support poles		$24K						480	30	2	504		
Fabricate 3 concrete blocks for testing of assembly structure with metrology		$18K				20		192	12	2	230	Req'd for concrete block on assembly structure test T. Brown requirement	
Exercise assembly structure with concrete block and metrology before start of assembly						80	320	640	40		1,040	T. Brown requirement	
Install test cell metrology site monuments and check them					640	64	160		20	4	864	T. Brown requirement - re-doing what is done for station 5 work	
Test test cell floor deflections with concrete block placed at FPA support positions					120	48	120	480	15	4	768	T. Brown requirement	
Exercise assembly structure with FPA-1 before start of assembly		$0K			320	80	320	640	40		1,360	Review requested 8 weeks of trial runs/metrology	
Machine Assembly											-		
Install Permanent Base Plates/Columns	7503-020			60			120	480	10	6	660		TFTR and NSTX assembly
Install temp assembly structure						72	180	720	15	6	972		TFTR and NSTX assembly
Install Lower PF 4,5&6 into prelim position	7503-060						16	32	1	4	48		TFTR and NSTX assembly
Install 3 Spool Pieces on fixt & test movement	7503-070			40	80		80	320	10	4	520		TFTR and NSTX assembly
FPA-1 Installed on temp assembly sleds	7503-080										-		TFTR and NSTX assembly
FPA-2 Installed on temp assembly sleds	7503-110										-		TFTR and NSTX assembly
FPA-3 Installed on temp assembly sleds	7503-150										-		TFTR and NSTX assembly
FPA-1 installation and assembly test					320	80	320	640	20		1,360	T. Brown requirement	
FPA-2 installation and assembly test					320	80	320	640	20		1,360	T. Brown requirement	
FPA-3 installation and assembly test					320	80	320	640	20		1,360	T. Brown requirement	
Test movement of FPAs & position checks.	7503-120			20	40		40	160	5	4	260		TFTR and NSTX assembly
MC Shims		$36K		60	32	86	216	864	18	6	1,294	shims provided by others; M&S for final sizing	TFTR and NSTX assembly
Install inboard and outboard shims											-		TFTR and NSTX assembly
Move all FPAs together, check fitup, tack shims											-		TFTR and NSTX assembly
Weld inboard shims on mating flanges											-		TFTR and NSTX assembly
Install end TF coils					48		48	192	6	4	288		TFTR and NSTX assembly
Install spacer supports and spacers							16	64	2	4	80		TFTR and NSTX assembly
Move FPAs & spacers together & check fitup					32		48	192	6	4	272		TFTR and NSTX assembly
Remove spacers and machine to fit								64	4	2	64		TFTR and NSTX assembly
Re-install spacers							16	64	2	4	80		TFTR and NSTX assembly
Position all FPA's / Spool Pieces @ MC Interface	7503-160			24	48		48	192	6	4	312		TFTR and NSTX assembly
Install local Platforms around FPA-1	7503-090			0			32	128	4	4	160		TFTR and NSTX assembly
Install local Platforms around FPA-2	7503-130			0			32	128	4	4	160		TFTR and NSTX assembly

NCSX June 2007 ETC

TABLE III - Fabrication/Assembly Installation

WBS Number: 75
WBS Title: Machine Assembly Operations
Job Numbers: 7501 and 7503
Job Title: Construction Crew Support (7501)
Job Title: Machine Assembly Operations (7503)
Job Manager: Erik Perry

Install local Platforms around FPA-3	7503-190			0			32	128	4	4	160		TFTR and NSTX assembly
MC Interfaces: measure holes and mark bushings for eccentric drilling							24	96	3	4	120	Field Period Assembly will fab and install all bushings except at three MC interfaces … at each of these 3 interfaces only 32 bushings will be fabricated during final assembly: 32 x 3 = 96 … 1 mh to measure and mark one bushing	TFTR and NSTX assembly
MC Interfaces: drill eccentric custom holes in bushings		$6K					24	96	3	4	126	96 bushings x 1/8 day to set up and drill each bushing with a one man crew, four crews; M&S for consumeable tools at $63 per bushing	TFTR and NSTX assembly
Measure vessel gaps to determine spool piece dimensions				288	288				18	2	576		TFTR and NSTX assembly
Spool piece installation test					320	80	320	640	20		1,360	T. Brown requirement	
Initial machining of spool pieces (complete one side)		$45K				12			45		57	Spool pieces must go outside for machining	TFTR and NSTX assembly
Final machining of spool pieces		$45K				12			45		57	Spool pieces must go outside for machining	TFTR and NSTX assembly
MC Interfaces: bolt together						29	72	288	36	6	389	all materials provided by others	TFTR and NSTX assembly
Retorque all super-nuts after 30 days						58	144	576	12	6	778	Viola requirement	
Raise permanent supports to take machine loads					180	72	180	720	15	6	1,152		TFTR and NSTX assembly
Remove temporary assembly structure							24	96	2	6	120		TFTR and NSTX assembly
Install/Level FPA's and Spool Piece supports	7503-030			120	240		240	960	30	4	1,560		TFTR and NSTX assembly
FPA Metrology Checks to Assure Alignment	7503-170			40	40			40	5	1	120		TFTR and NSTX assembly
Mate-up and weld all VV-to-Spool interfaces	7503-200				180		240	1440	30	3	1,860	Weld time doubled to account for expected significant flange mismatch .. Can only use one welder/pedalman/safety watch at a time … assume two shifts	TFTR and NSTX assembly
Weld on port 4's					60		180	720	30	3	960	6 ports	TFTR and NSTX assembly
Install e-beam mapping equipment						40	80	320	10	4	440	EWDA	TFTR and NSTX assembly
Install vacuum pumping system	7503-240						40	160	5	4	200		TFTR and NSTX assembly
Pumpdown & leak check VV	7503-260						120	480	15	4	600		TFTR and NSTX operations
Fit-up all TF coils	7503-210			40	200		200	800	25	4	1,240		TFTR and NSTX assembly
Install TF alignment and traction ring											-		TFTR and NSTX assembly
Pull TF coils radially inward & verify nose fir-up											-		TFTR and NSTX assembly
Lock TF coils at four support locations											-		TFTR and NSTX assembly
Install MC structure insulation boots	7503-240.1						80	320	10	4	400	EWDA	TFTR and NSTX assembly
Seal gaps in MC shims, cooling tubes, etc for insul pour							160	640	20	4	800		TFTR and NSTX assembly
Fill MC/VVSA annulus with pourable Aerogel insulation	7503-240.2						16	64	2	4	80		TFTR and NSTX assembly
Install LN2 manifolds							80	320	10	4	400	Fabrication by WBS 161; instl EWDA	TFTR and NSTX assembly
Complete Elect Pwr connections	7503-320						160	960	30	4	1,120	Provided by WBS 162; instl EWDA	TFTR and NSTX assembly
Install in-cryostat cabling for electric power to coils											-		TFTR and NSTX assembly
Connect cabling and I&C to MC and TF coils											-		TFTR and NSTX assembly
Complete mag diag & machine I&C	7503-321						160	320	10	4	480	Provided by WBS ?; instl EWDA	TFTR and NSTX assembly
Install PF Solenoid and PF 1a U/L into position	7503-290			16	32		32	128	4	4	208	All I&C in place on solenoid and PF 1a U/L mounted on support structure prior to arrival in Test Cell	TFTR and NSTX assembly
Align guide mechanism for solenoid installation											-		TFTR and NSTX assembly
Install solenoid support structure											-		TFTR and NSTX assembly
Install solenoid assembly											-		TFTR and NSTX assembly
Connect cabling, LN2 and I&C to solenoid							8	32	1	4	40		TFTR and NSTX assembly
Install PF4L							8	32	1	4	40		TFTR and NSTX assembly
Connect cabling, LN2 and I&C to PF4L							8	32	1	4	40		TFTR and NSTX assembly
Adjust spring compression in solenoid support structure							8	32	1	4	40		TFTR and NSTX assembly
Raise lower PF 5&6 coils into final position	7503-270			24			48	192	6	4	264		TFTR and NSTX assembly
Install Upper PF4, 5 & 6 coils	7503-280			24			48	192	6	4	264		TFTR and NSTX assembly
Install Cryostat Base, vapor barrier & port boots	7503-340						80	320	10	4	400		TFTR and NSTX assembly
Install elec pwr, LN2, & instr feedthrus thru cryo base							40	160	5	4	200	EWDA	TFTR and NSTX assembly
Integrated electrical testing						80	80	320	10	4	480		TFTR and NSTX operations
Install transition box, cabling and connect to power supplies							80	320	10	4	400	EWDA	TFTR and NSTX assembly

NCSX June 2007 ETC

TABLE III - Fabrication/Assembly Installation

WBS Number: 75													
WBS Title: Machine Assembly Operations													
Job Numbers: 7501 and 7503													
Job Title: Construction Crew Support (7501)													
Job Title: Machine Assembly Operations (7503)													
Job Manager: Erik Perry													
Complete LN2 connections from coils to manifolds	7503-310						80	320	10	4	400		TFTR and NSTX assembly
Connect coil and VV instrumentation							80	320	10	4	400	EWDA	TFTR and NSTX assembly
Connect 150C bakeout							40	160	5	4	200	EWDA	NSTX operations
Prepare for and perform warm coil testing											-	***covered in other WBS***	
Install cryostat cooling system and instrumentation							320	1280	20	8	1,600	EWDA	TFTR and NSTX assembly
Install Cryostat											-		TFTR and NSTX assembly
Install Cryostat upper section and port boots	7503-350						80	320	10	4	400		TFTR and NSTX assembly
Install Midplane Cryostat sections and port boots	7503-360						120	480	15	4	600		TFTR and NSTX assembly
Install Cryostat Circulation Duct	7503-370						40	160	5	4	200	Cryo cooling system instl in WBS 623	TFTR and NSTX assembly
PTP and Cooldown	730.8200					80	80	480			640		TFTR and NSTX operations
Total Job 7503		***$334K***	-	756	3,860	1,489	7,468	26,776					

NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 75
WBS Title: Machine Assembly Operations
Job Numbers: 7501 and 7503
Job Title: Construction Crew Support (7501)
Job Title: Machine Assembly Operations (7503)
Job Manager: Erik Perry

Uncertainty of the Estimate

		High	Medium	Low	Uncertainty Range (%)	s/Other Considerations
Job 7501					-20%/+40%	
	Design Maturity			X		Estimated without detailed drawings. Significant uncertainty that current concept will stay the same - see Residual Risks below.
	Design Complexity		X			Follows tasks in Job 7503 - but most are LOE activities
Job 7503					-20%/+40%	
	Design Maturity			X		Estimated without detailed drawings. Significant uncertainty that current concept will stay the same - see Residual Risks below.
	Design Complexity		X			Experienced in assembly fusion devices, but tolerances exceed anything done before.
	Other Comments:					Major source of uncertainty is in the machine assembly concepts which are still evolving. See Residual Risks below.

Residual Impacts

Job	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact Low	Cost Impact High	Schedule Impact Low	Schedule Impact High
7501 - NONE								
7503	Additional trim coils may be required to suppress field errors from n>1 modes	U	Analysis being performed to firm up requirements	Costs could more than double the present estimate	+ $200	+ $400	+ 0.00	+ 0.00
	"Back office" support for FPA and final assembly becomes a chronic bottleneck, stretching out the time required to complete assembly operations	VU	Additional support budgeted for Brown, Brooks, and Ellis providing "2 deep" back office support. Should be available to mitigate peak demands once training in key skills is completed.	Estimated impact is <2 months on the critical path. Cost impact covers up to 2 months of FPA/final assembly.	+ $0	+ $600	+ 0.00	+ 2.00

NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 75														
WBS Title: Machine Assembly Operations														
Job Numbers: 7501 and 7503														
Job Title: Construction Crew Support (7501)														
Job Title: Machine Assembly Operations (7503)														
Job Manager: Erik Perry														
	Insulation on TF/PF coil fails during initial cooldown and testing requiring in situ repair				**VU**	**Ist of each kind will be tested at cryogenic temperature at elevated (50% higher) voltage for faults to ground. All coils will be tested at RT at elevated (50% higher) voltage for faults to ground. Ring tests are performed to reveal low resistance turn-to-turn shorts at RT.**			**Repair in situ is assumed recovery scenario taking 2-3 months. 1 month to warmup and cooldown the stellrator core. 3 techs/1 engr for duration of active repair)1-2 months).**			**+ $50**	**+ $150**	**+ 1.00**	**+ 2.00**
	Insulation on TF/PF coil fails during initial cooldown and testing requiring dismantling stellarator core				**VU**	**Ist of each kind will be tested at cryogenic temperature at elevated (50% higher) voltage for faults to ground. All coils will be tested at RT at elevated (50% higher) voltage for faults to ground. Ring tests are performed to reveal low resistance turn-to-turn shorts at RT.**			***Crisis event not covered by contingency***						
	Insulation on modular coil fails during initial cooldown and testing requiring in situ repair				**VU**	**C1 tested at full current at cryogenic temeprature. All modular coils will be tested at RT at elevated (50% higher) voltage for faults to ground.**			**Repair in situ is assumed recovery scenario taking 2-3 months. 1 month to warmup and cooldown the stellrator core. 3 techs/1 engr for duration of active repair)1-2 months).**			**+ $50**	**+ $150**	**+ 1.00**	**+ 2.00**
	Insulation on modular coil fails during initial cooldown and testing requiring stellarator core disassembly				**VU**	**C1 tested at full current at cryogenic temeprature. All modular coils will be tested at RT at elevated (50% higher) voltage for faults to ground.**			***Crisis event not covered by contingency***						

NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 75														
WBS Title: Machine Assembly Operations														
Job Numbers: 7501 and 7503														
Job Title: Construction Crew Support (7501)														
Job Title: Machine Assembly Operations (7503)														
Job Manager: Erik Perry														
	Unanticipated problems with cryostat penetrations (icing, excessive condensation). May require warming up the stellarator core to effect repair with consequent impacts to critical path activities.				U	Rapid repair materials will be on hand.			Nominally repaired with a 4-man crew in 1 week with 3 weeks for warmup/cooldown (if required)			+ $15	+ $30	+ 0.25	+ 1.00
	Assembly sled for final assembly is not adequately stiff or does not provide repeatable motion				U	Functionality of sled will be determined first with concrete blocks and later with first FP. Ample time to make design modifications between arrival of the first and third FPs.			Nominal cost impact is 1 man-month of engineering design and up to half the fabrication cost of the sled			+ $25	+ $75	+ 0.00	+ 0.00
	TC floor is not adequately rigid for present metrology plan				VU	Copper sheet and spongy surface removed from TC floor. Fiducials will be placed. Concrete blocks will be placed to see if floor is adequately stiff.			Nominal cost impact is 2 man-months of engineering design and $50-150K for local reinforcement of building structures			+ $50	+ $200	+ 0.00	+ 0.00
	Modular coils are shorted across toroidal break between field periods				NC	Need very low impedence, multiple shorts to get into trouble									
	Metrology equipment and general purpose tooling/ lifting equipment (e.g.cranes) not available to support the schedule				U	Maintenance contract mitigates impact of metrology equipment. Additional $200K budgeted for a 3rd laser tracker and/or spare metrology equipment. Should result in improved efficiency.			Up to 2 week impact on FPA and critical path. FPA cost impact assumed to be $300k/mo.			+ $0	+ $150	+ 0.00	+ 0.50

NCSX June 2007 ETC
TABLE IV - Uncertainty of Estimate and Residual Risk Assessment

WBS Number: 75
WBS Title: Machine Assembly Operations
Job Numbers: 7501 and 7503
Job Title: Construction Crew Support (7501)
Job Title: Machine Assembly Operations (7503)
Job Manager: Erik Perry

Notes:

[1]	Low cost and schedule impacts are considered the minimum (0-percentile) impacts should the event occur.
	High cost and schedule impacts are considered the maximum (100-percentile) impacts should the event occur
[2]	Cost impacts should be entered as man-hours (by demographic) and M&S direct cost under basis of estimate.
	Cost impacts should NOT include standing army costs which are separately calculated from the schedule impact
	Project control is reponsible for quantifying the low and high cost impacts based on the labor hours and M&S identified
[3]	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.
[4]	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%)