Work Authorization Document

NSTX Upgrade Project

Control Account #:	3200	**Title:**	Water Cooling System Mods
WBS	1.3.2	**Title:**	Coolant Systems
Period of Performance:	23 February 2009 through 25 July 2014		
Authorized Budget:	$195	**Control Account Manager:**	Denault
Revision #:	0	**Revision Date:**	July-11

Authorized Work Description:

The Coolant System provides cooling water to remove heat generated from NSTX systems during experimental operations. The systems include the:

- TF/PF bus and coil cooling water system;
- Center stack cooling water system;
- Component cooling water system; and the
- Ohmic heating cooling water system.

These systems will provide cooling water for normal operations and discharge cleaning of the vacuum vessel. This WBS includes engineering design, analysis, procurement activities, component fabrication and installation to the coil, bus and component cooling manifolds at the torus.

The new Center Stack on NSTX will require modifications to the existing coolant system. This WBS element will provide water cooling services to the new Center Stack and ancillary equipment in the NSTX test cell.

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.

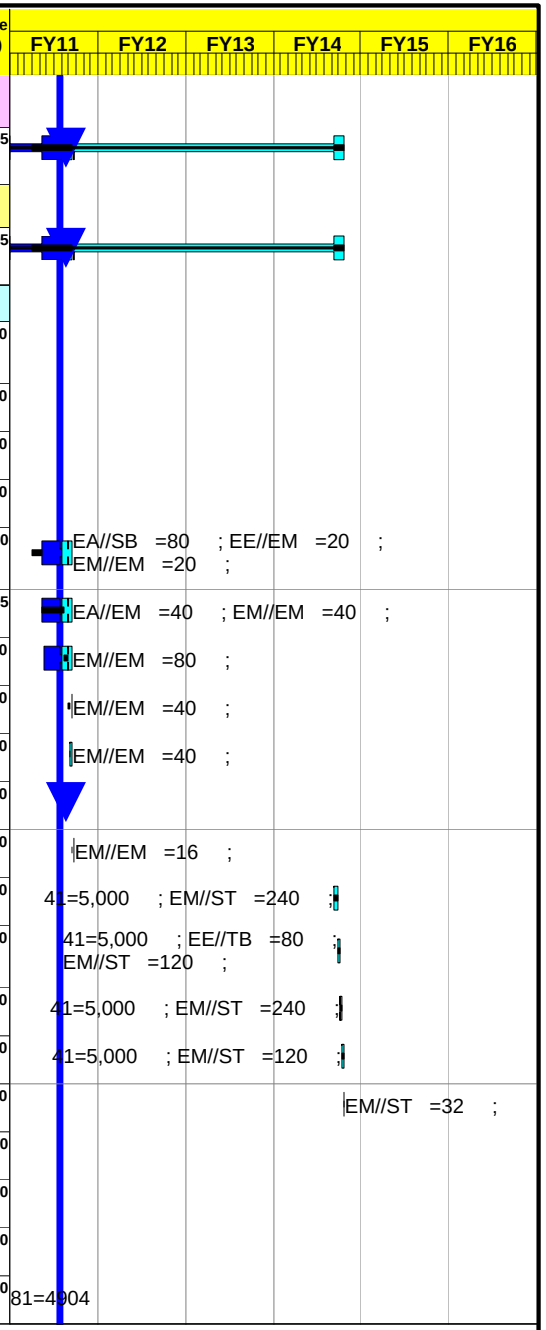
Control Account History

ECP#	Implement Date	Prior Budget	New Budget	Signature

Approvals	Name	Signature	Date
NSTX-U Project Manager	R. Strykowsky		
Control Account Manager	Denault		
Functional Manager	L. Dudek		

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		**1,355**	**23FEB09A**	23FEB09A	**25JUL14**	25JUL14	**0**	**31**	195,236.64		25,604.06	**44,284.65**
Job: 3200 - Water Cooling System Mods-DENAULT												
Subtotal		**1,355**	**23FEB09A**	23FEB09A	**25JUL14**	25JUL14	**0**	**31**	195,236.64		25,604.06	**44,284.65**
3200-0015	**Prelim Dsn-Design Drawings**	**30**	**03MAY10A**	03MAY10A	**14JUN10A**	14JUN10A	**0**		0.00	**100**	0.00	**0.00**
3200-0016	**Prelim Dsn-PDR Prep**	**5**	**15JUN10A**	15JUN10A	**21JUN10A**	21JUN10A	**0**		0.00	**100**	0.00	**0.00**
3200-0017	**Prelim Dsn-CONDUCT PDR**	**2**	**22JUN10A**	22JUN10A	**23JUN10A**	23JUN10A	**0**		0.00	**100**	0.00	**0.00**
3200-0021	**Final Design-Disposition PDR Chits**	**2**	**24JUN10A**	24JUN10A	**25JUN10A**	25JUN10A	**0**		0.00	**100**	0.00	**0.00**
3200-0022	**Final Design-Design Drawings**	**94***	**03JAN11***	07FEB11A	**11FEB11**	17JUN11	**-89**	**123**	16,614.80	**20**	3,322.96	**16,614.80**
3200-0023	**Final Design-Update Analyses**	**89***	**14FEB11**	14FEB11A	**12MAY11**	17JUN11	**-25**	**123**	14,035.60	**25**	3,508.90	**12,061.85**
3200-0024	**Final Design-Update Cost & Schedule Estimate**	**84***	**13MAY11**	21FEB11A	**26MAY11**	17JUN11	**-15**	**123**	12,656.80	**25**	3,164.20	**0.00**
3200-0025	**Final Design-Prep Procurement Specs**	**5**	**27MAY11**	13JUN11	**03JUN11**	17JUN11	**-10**	**123**	6,328.40		0.00	**0.00**
3200-0026	**Final Design-FDR Prep**	**10***	**06JUN11**	06JUN11*	**10JUN11**	17JUN11	**-5**	**123**	6,328.40		0.00	**0.00**
3200-0026A	**Water Cooling System - Peer review**	**0**				18MAY11*	**0**	**147**	0.00		0.00	**0.00**
3200-0027	**Final Design-CONDUCT FDR**	**3**	**13JUN11**	22JUN11*	**14JUN11**	24JUN11	**-8**	**121**	2,531.36		0.00	**0.00**
3200-0055	**Bus Work Cooling**	**10**	**11JUN14**	11JUN14	**24JUN14**	24JUN14	**0**	**31**	34,311.60		0.00	**0.00**
3200-0057	**Flow Sensors**	**5**	**25JUN14**	25JUN14	**01JUL14**	01JUL14	**0**	**31**	28,304.40		0.00	**0.00**
3200-0059	**Modify Manifold**	**10**	**02JUL14**	02JUL14	**16JUL14**	16JUL14	**0**	**31**	34,311.60		0.00	**0.00**
3200-0061	**Fab & Connect Lines**	**5**	**17JUL14***	17JUL14*	**23JUL14**	23JUL14	**0**	**31**	20,530.80		0.00	**0.00**
3200-0063	**Leak Check**	**2**	**24JUL14**	24JUL14	**25JUL14**	25JUL14	**0**	**31**	3,674.88		0.00	**0.00**
FY093000	**FY09 Actual Cost**	**22***	**23FEB09A**	23FEB09A	**30SEP09A**	30SEP09A	**0**		5,447.00	**100**	5,447.00	**5,447.00**
FY103000	**FY10 Actual Cost**	**40**	**01OCT09A**	01OCT09A	**30NOV09A**	30NOV09A	**0**		3,956.00	**100**	3,956.00	**3,956.00**
FY103200	**FY10 Actual Cost**	**22**	**01APR10A**	01APR10A	**30APR10A**	30APR10A	**0**		1,301.00	**100**	1,301.00	**1,301.00**
FY103200A	**FY10 Actual Cost**	**110**	**03MAY10A**	03MAY10A	**30SEP10A**	30SEP10A	**0**		4,904.00	**100**	4,904.00	**4,904.00**



Data Date 30APR11
Run Date 20MAY11 10:58

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1105

NSTX UPGRADES
RESOURCE LOADED SCHEDULE
CD-2 Schedule
April 2011

Early Bar
Progress Bar
Critical Activity

3200 Water Cooling System Mods (Denault)	START	28FEB2009	31MAR2009	30APR2009	31MAY2009	30JUN2009	31JUL2009	31AUG2009	30SEP2009	31OCT2009	30NOV2009	31DEC2009
BCWS	0	0	1	1	1	1	1	1	1	2	2	0
CUM BCWS	0	0	1	2	2	3	4	5	5	8	9	9
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	.	.	-1.	-2.	-2.	-3.	-4.	-5.	-5.	-8.	-9.	-9.
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

3200 Water Cooling System Mods (Denault)	31JAN2010	28FEB2010	31MAR2010	30APR2010	31MAY2010	30JUN2010	31JUL2010	31AUG2010	30SEP2010	31OCT2010	30NOV2010	31DEC2010
BCWS	0	0	0	1	1	1	1	1	1	0	0	0
CUM BCWS	9	9	9	11	12	13	14	15	16	16	16	16
BCWP	0	0	0	0	0	0	0	0	0	0	0	16
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	16
ACWP	0	0	0	0	0	0	0	0	0	0	0	18
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	18
CV	0	0	0	0	0	0	0	0	0	0	0	-2
SV	-9.	-9.	-9.	-11.	-12.	-13.	-14.	-15.	-16.	-16.	-16.	.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	.89
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1

3200 Water Cooling System Mods (Denault)	31JAN2011	28FEB2011	31MAR2011	30APR2011	31MAY2011	30JUN2011	31JUL2011	31AUG2011	30SEP2011	31OCT2011	30NOV2011	31DEC2011
BCWS	12	7	5	5	17	13	0	0	0	0	0	0
CUM BCWS	27	35	40	44	61	74	74	74	74	74	74	74
BCWP	0	6	4	0	0	0	0	0	0	0	0	0
CUM BCWP	16	21	26	26	26	26	26	26	26	26	26	26
ACWP	0	1	1	0	0	0	0	0	0	0	0	0
CUM ACWP	18	18	19	19	19	19	19	19	19	19	19	19
CV	-2	3	7	7	7	7	7	7	7	7	7	7
SV	-12.	-13.	-14.	-19.	-36.	-48.	-48.	-48.	-48.	-48.	-48.	-48.
CPI	.88	1.16	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SPI	0.57	0.61	0.65	0.58	0.42	0.35	0.35	0.35	0.35	0.35	0.35	0.35

3200 Water Cooling System Mods (Denault)	31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	74	74	74	74	74	74	74	74	74	74	74	74
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	26	26	26	26	26	26	26	26	26	26	26	26
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	19	19	19	19	19	19	19	19	19	19	19	19
CV	7	7	7	7	7	7	7	7	7	7	7	7
SV	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.
CPI	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SPI	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

3200 Water Cooling System Mods (Denault)	31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	74	74	74	74	74	74	74	74	74	74	74	74
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	26	26	26	26	26	26	26	26	26	26	26	26
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	19	19	19	19	19	19	19	19	19	19	19	19
CV	7	7	7	7	7	7	7	7	7	7	7	7
SV	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.	-48.
CPI	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SPI	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

3200 Water Cooling System Mods (Denault)	31JAN2014	28FEB2014	31MAR2014	30APR2014	31MAY2014	30JUN2014	31JUL2014	31AUG2014	30SEP2014	31OCT2014	30NOV2014	31DEC2014
BCWS	0	0	0	0	0	57	64	0	0	0	0	0
CUM BCWS	74	74	74	74	74	131	195	195	195	195	195	195
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	26	26	26	26	26	26	26	26	26	26	26	26
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	19	19	19	19	19	19	19	19	19	19	19	19
CV	7	7	7	7	7	7	7	7	7	7	7	7
SV	-48.	-48.	-48.	-48.	-48.	-105.	-170.	-170.	-170.	-170.	-170.	-170.
CPI	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SPI	0.35	0.35	0.35	0.35	0.35	0.2	0.13	0.13	0.13	0.13	0.13	0.13

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

- Evacuate the spent plasma constituents at the end of each pulse prior to the next plasma pulse;
- Remove impurities liberated during bakeout and/or discharge cleaning of the vacuum vessel interior; and
- Provide instrumentation and a Residual Gas Analyzer.

This WBS element also includes the controllers for all pumps and any baffles for backstreaming.

In order to accommodate the installation of the 2nd NBI on NSTX the existing Vacuum Pumping System will be modified. This WBS element includes the design, fabrication, and installation of a new vessel pumping system and includes new pump ducts off of the Neutral Beamline 2 duct, mechanical and electrical isolation of the system, vacuum diagnostic relocation, magnetic shielding and support of TVPS TMPs, and TMP service connections.
{NSTX NB2 TVPS (Job 2485)}

WBS Element: 1.3.2 **WBS Level: 3**
WBS Title: Coolant Systems
Definition: The Coolant System provides cooling water to remove heat generated from NSTX systems during experimental operations. The systems include the:

- TF/PF bus and coil cooling water system;
- Center stack cooling water system;
- Component cooling water system; and the
- Ohmic heating cooling water system.

These systems will provide cooling water for normal operations and discharge cleaning of the vacuum vessel. This WBS includes engineering design, analysis, procurement activities, component fabrication and installation to the coil, bus and component cooling manifolds at the torus.

The new Center Stack on NSTX will require modifications to the existing coolant system. This WBS element will provide water cooling services to the new Center Stack and ancillary equipment in the NSTX test cell.
{Water System Coolant Modifications for CSU (Job 3200)}

WBS Element: 1.3.3 **WBS Level: 3**
WBS Title: Bakeout Heating System
Definition: The Bakeout Heating System provides a heating system to bake out the vacuum vessel. It includes a heating blanket system for the vacuum vessel and the insulation for that system. It includes a supplementary heating system for the center stack coil subsystems. The controls and interlocks for safe operation of this system is included. This WBS element includes the engineering design, analysis, procurement activities and component fabrication.

Work Approval Form (WAF)

Cost Center: 9417
Job Number: 3200
Job Title: Water Coolant Systems Modifications for CSU
Job Manager: Martin Denault

Description:

The new Center Stack on NSTX will require modifications to the existing coolant system. This job will provide water cooling services to the new Center Stack and ancillary equipment in the NSTX test cell

Schedule:

Refer to Primavera Data-Base

Approvals:

7-20-10
Job Manager

8/3/10
Project Manager

8/3/10
Engineering Department Head

Cost Ce	9417	
Job Number:	3200	
Job Title:	Water Coolant Systems Modifications for CSU	
Job Manager:	Martin Denault	

Estimate (user input)

task numb	P3 cross ref (optinal)	TASK DESCRIPTION (USER INPUT TASKS AND DESCRIPTIONS)	Resp.	SCHEDULE USER INPUT: Duration in WORK DAYS	Logical Pre-requisites (one task numbers in each column ,any order)		User Input Start Date (optional)	actual= A	FY10$K: M&S (41)	CREDIT CARD (43)	OTHER (39)	TRAVEL (35)	OVERTIME (31)	HOURS (priced at FY10 rates): EA** EM (analysis engr)	EA** (Designer)	EE** EM (Elctr Engr)	EE** TB (Electr Tech)	EM** EM (FO&M Engr)	EM** SM Senior Tech)	EM** SB (FO&M Tech)	EM** TB (FO&M Tech)	FC** AM (P&C Officer)	Contingency	Names of req'd skills if known	Basis of Estimate Category
8																									
9		**Preliminary Design**	Denault																						
16		PDR Prep		5	17													40					10%		4
17		CONDUCT PDR		2	18													16					10%		4
18		Layman Review		5			12/15/10											40					10%		4
19																									
20		**Final Design**	Denault																						
21		Disposition PDR Chits		2	21		1/28/11											16					10%		4
22		Design Drawings		10	22										80	20		20					10%		4
23		Update Analyses		5	23									40				40					10%		4
24		Update Cost & Schedule Estimate		5	24													40				40	10%		4
25		Prep Procurement Specs		5	25													40					10%		4
26		FDR Prep		5	26													40					10%		4
27		CONDUCT FDR		2	27													16					10%		4
28																									
47																									
48		**Installation**	Denault																						
49		Installation Procedure																							
50		Machine Installation																							
51		PTP Testing																							
52																									
53																									
54																									
55		[redacted]		[redacted]		42	7/24/12		[redacted]												[redacted]		10%		2
57		[redacted]		[redacted]	57	42			[redacted]								[redacted]				[redacted]		10%		2
59		[redacted]		[redacted]	59	42			[redacted]												[redacted]		10%		2
61		[redacted]		[redacted]	61	42	11/21/12		[redacted]												[redacted]		10%		2
62																									
63		[redacted]		[redacted]	63	42															[redacted]		10%		2
		TOTALS		[redacted]				[redacted]	$20	$0	$0	$0	$0	40	80	20	80	308	0	0	752	40			
		TOTAL Preliminary Cost Estimate ($k)=		$170					$24	$0	$0	$0	$0	$7	$10	$3	$7	$46	$0	$0	$67	$6			
		Notes:									**CATEGORIZATION CODES:**														

Cost Center:	9417
Job Number:	3200
Job Title:	Water Coolant Systems Modifications for CSU
Job Manager:	Martin Denault

			SCHEDULE					Estimate (user input)																	
	USER INPUT TASKS AND DESCRIPTIONS		USER INPUT					FY10$K					HOURS (priced at FY10 rates)												
task	TASK DESCRIPTION	Resp.	Duration in WORK DAYS	*Logical Pre-requisites (one task numbers in each column ,any order)*			User Input Start Date (optional)	actual= A	M&S (41)	CREDIT CARD (43)	OTHER (39)	TRAVEL (35)	OVERTIME (31)	EA** EM (analysis engr)	EA** (Designer)	EE** EM (Electr Engr)	EE** TB (Electr Tech)	EM** EM (FO&M Engr)	EM** SM Senior Tech)	EM** SB (FO&M Tech)	EM** TB (FO&M Tech)	FC** AM (P&C Officer)	Contingency	Names of req'd skills if known	Basis of Estimate Category
	(1) Procurement lead time:		Weeks																						
	Purchase orders-Commercial, off-the-shelf items		3																						
	Purchase orders-Noncommercial items		5																						
	Subcontracts (non construction)		8																						
	Construction subcontracts		9																						

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

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 Recommende

Cost Center:	9417
Job Number:	3200
Job Title:	Water Coolant Systems Modifications for CSU
Job Manager:	Martin Denault

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								
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%)

Cost Center:	**9417**		
Job Number:	**3200**		
Job Title:	**Water Coolant Systems Modifications for CSU**		
Job Manager:	**Martin Denault**		

Materials and Subcontracts (M&S)		**Basis of Estimate**
Description:		
Pipe		Vendor Pricing
Parts		Vendor Pricing
MISC		Experience

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

TOTALS