

Work Authorization Document

NSTX Upgrade Project

| | | | |
|---------------------------|------|---------------|------------------------|
| Control Account #: | 1000 | Title: | CSU Analytical Support |
|---------------------------|------|---------------|------------------------|

| | | | |
|------------|-----|---------------|---------------|
| WBS | 1.1 | Title: | Torus Systems |
|------------|-----|---------------|---------------|

Period of Performance: 04 January 2010 to 25 September 2014

| | | | |
|---------------------------|-------|---------------------------------|-------|
| Authorized Budget: | \$385 | Control Account Manager: | Titus |
|---------------------------|-------|---------------------------------|-------|

| | | | |
|--------------------|---|-----------------------|---------|
| Revision #: | 0 | Revision Date: | July-11 |
|--------------------|---|-----------------------|---------|

Authorized Work Description:

As a result of the NSTX Upgrade Project, the NSTX global models and analyses will need to be updated. This WBS element includes analytical support for global models and analysis not presently identified. The global model will provide the basis for updating the analysis to qualify components and identify areas of the tokamak requiring further analysis. Identified plasma scenarios and power supply current limit analyses will be run in the global model and current sets that require further analysis will be identified. These analyses also serve to check the results of more detailed analyses.

- 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 | P. Titus | | |
| 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 |
|---|--|-----------|----------------|----------------|-----------------|-----------------|----------------------|-------------|---------------|------|--------------------------|---------------------------|------|------|------|------|------|------|
| NSTX Upgrade Project | | | | | | | | | | | | | | | | | | |
| Subtotal | | 1,183 | 04JAN10A | 04JAN10A | 25SEP14 | 25SEP14 | 0 | 1,490 | 385,677.44 | | 132,394.11 | 167,943.56 | | | | | | |
| Job: 1000 - CSU Analytical Support-TITUS (LOE) | | | | | | | | | | | | | | | | | | |
| Subtotal | | 1,183 | 04JAN10A | 04JAN10A | 25SEP14 | 25SEP14 | 0 | 1,490 | 385,677.44 | | 132,394.11 | 167,943.56 | | | | | | |
| 1000-0002 | Maintain Global model with updated design concep | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0003 | Maintain updated 96 Scenarios | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0004 | Generic Tile Qualification Program | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0005 | Maintain Disruption Scenarios | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0006 | Develop List of in-service Inspection Areas | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0007 | Dynamic Response to Normal Loads PF4/5/TF/TF OOP | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0008 | Fault, FMEA evaluation and analyses | 21 | 03MAY10A | 03MAY10A | 01JUN10A | 01JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0009 | PDR Documentation | 21 | 02JUN10A | 02JUN10A | 30JUN10A | 30JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1000-0011 | Maintain Global model with updated design concep | 220* | 01JUL10A | 01JUL10A | 13JUN11 | 18MAY11 | 17 | 126 | 18,651.56 | 85 | 15,891.41 | 16,329.23 | | | | | | |
| 1000-0012 | Maintain updated 96 Scenarios | 220* | 01JUL10A | 01JUL10A | 25APR11 | 18MAY11 | -17 | 147 | 18,651.56 | 85 | 15,809.95 | 18,599.94 | | | | | | |
| 1000-0013 | Generic Tile Qualification Program | 220* | 01JUL10A | 01JUL10A | 25FEB11 | 18MAY11 | -58 | 147 | 37,303.13 | 85 | 31,332.47 | 36,861.73 | | | | | | |
| 1000-0015 | Develop List of in-service Inspection Areas(LOE) | 241* | 01JUL10A | 01JUL10A | 25APR11 | 17JUN11 | -38 | 126 | 18,705.28 | 60 | 11,159.96 | 18,599.94 | | | | | | |
| 1000-0016 | Dynamic Response to Normal Loads PF4/5/TF/TF OOP | 220* | 01JUL10A | 01JUL10A | 25FEB11 | 18MAY11 | -58 | 147 | 18,651.56 | 75 | 13,823.15 | 18,430.86 | | | | | | |
| 1000-0017 | Fault, FMEA analyses (LOE) | 220* | 01JUL10A | 01JUL10A | 25FEB11 | 18MAY11 | -58 | 147 | 18,651.56 | 20 | 3,686.17 | 18,430.86 | | | | | | |
| 1000-0017A | CSU Analytical Support - Peer Review | 0 | | | | 18MAY11* | | 0 | 147 | | 0.00 | 0.00 | | | | | | |
| 1000-0018 | FDR Prep/documentation | 21* | 13MAY11 | 19MAY11* | 13JUN11 | 17JUN11 | -4 | 126 | 19,268.00 | | 0.00 | 0.00 | | | | | | |
| 1000-0019 | CONDUCT FDR | 3 | 16MAY11 | 22JUN11* | 13JUN11* | 24JUN11 | -9 | 121 | 1,926.80 | | 0.00 | 0.00 | | | | | | |
| 1000-0022 | Title 3 Analysis Support | 810* | 14JUN11 | 27JUN11 | 25SEP14 | 25SEP14 | 0 | 1,490 | 193,176.99 | | 0.00 | 0.00 | | | | | | |
| FY101000 | FY10 Actual Cost | 85* | 04JAN10A | 04JAN10A | 30APR10A | 30APR10A | 0 | | 33,760.00 | 100 | 33,760.00 | 33,760.00 | | | | | | |
| FY101000A | FY10 Actual Cost | 110 | 03MAY10A | 03MAY10A | 30SEP10A | 30SEP10A | 0 | | 6,931.00 | 100 | 6,931.00 | 6,931.00 | | | | | | |

Data Date 30APR11 1105
Run Date 20MAY11 10:43

**NSTX UPGRADES
RESOURCE LOADED SCHEDULE
CD-2 Schedule
April 2011**

 Early Bar
 Progress Bar
 Critical Activity

| 1000 CSU Analytical Support (Titus) | 31JAN2011 | 28FEB2011 | 31MAR2011 | 30APR2011 | 31MAY2011 | 30JUN2011 | 31JUL2011 | 31AUG2011 | 30SEP2011 | 31OCT2011 | 30NOV2011 | 31DEC2011 |
|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| BCWS | 16 | 14 | 6 | 5 | 14 | 12 | 4 | 5 | 4 | 5 | 5 | 5 |
| CUM BCWS | 142 | 157 | 163 | 168 | 182 | 194 | 198 | 203 | 207 | 212 | 217 | 222 |
| BCWP | 12 | 12 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM BCWP | 111 | 123 | 129 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 |
| ACWP | 6 | 7 | 5 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM ACWP | 87 | 94 | 99 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| CV | 24 | 28 | 30 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| SV | -31 | -34 | -34 | -37 | -50 | -63 | -67 | -72 | -76 | -81 | -86 | -91 |
| CPI | 1.27 | 1.3 | 1.3 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| SPI | .78 | .78 | .79 | .78 | .72 | .68 | .66 | .65 | .63 | .62 | .6 | .59 |

| 1000 CSU Analytical Support (Titus) | 31JAN2012 | 29FEB2012 | 31MAR2012 | 30APR2012 | 31MAY2012 | 30JUN2012 | 31JUL2012 | 31AUG2012 | 30SEP2012 | 31OCT2012 | 30NOV2012 | 31DEC2012 |
|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| BCWS | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 |
| CUM BCWS | 227 | 231 | 236 | 241 | 246 | 251 | 256 | 261 | 265 | 270 | 275 | 280 |
| BCWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM BCWP | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 |
| ACWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM ACWP | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| CV | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| SV | -96 | -100 | -105 | -110 | -115 | -119 | -124 | -129 | -134 | -139 | -144 | -149 |
| CPI | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| SPI | .58 | .57 | .56 | .54 | .53 | .52 | .51 | .5 | .5 | .49 | .48 | .47 |

| 1000 CSU Analytical Support (Titus) | 31JAN2013 | 28FEB2013 | 31MAR2013 | 30APR2013 | 31MAY2013 | 30JUN2013 | 31JUL2013 | 31AUG2013 | 30SEP2013 | 31OCT2013 | 30NOV2013 | 31DEC2013 |
|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| BCWS | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| CUM BCWS | 285 | 290 | 295 | 299 | 305 | 309 | 314 | 319 | 324 | 330 | 334 | 340 |
| BCWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM BCWP | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 |
| ACWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM ACWP | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| CV | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| SV | -154 | -159 | -163 | -168 | -173 | -178 | -183 | -188 | -193 | -198 | -203 | -208 |
| CPI | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| SPI | .46 | .45 | .45 | .44 | .43 | .42 | .42 | .41 | .4 | .4 | .39 | .39 |

| 1000 CSU Analytical Support (Titus) | 31JAN2014 | 28FEB2014 | 31MAR2014 | 30APR2014 | 31MAY2014 | 30JUN2014 | 31JUL2014 | 31AUG2014 | 30SEP2014 | 31OCT2014 | 30NOV2014 | 31DEC2014 |
|-------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| BCWS | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 0 | 0 | 0 |
| CUM BCWS | 345 | 350 | 355 | 360 | 365 | 370 | 375 | 380 | 385 | 385 | 385 | 385 |
| BCWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM BCWP | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 | 131 |
| ACWP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CUM ACWP | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| CV | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| SV | -214 | -218 | -223 | -228 | -234 | -239 | -244 | -249 | -253 | -253 | -253 | -253 |
| CPI | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| SPI | .38 | .38 | .37 | .36 | .36 | .35 | .35 | .35 | .34 | .34 | .34 | .34 |

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 | | | 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 |

Annex I – WBS Dictionary

WBS Element: 1

WBS Level: 1

WBS Title: NSTX Upgrade Project

Definition: The replacement of the entire Center Stack Assembly (CSA) and installation of a second Neutral Beam Injection (NBI) system on NSTX is planned to allow an improved understanding of the Spherical Torus (ST) magnetic confinement configuration which is needed to establish the physics basis for next-step ST facilities, broaden the scientific understanding of plasma confinement for ITER, and maintain U.S. world leadership in ST research capabilities. In particular, operation at higher magnetic field with reduced plasma collisionality is needed to extend the plasma physics understanding of the ST toward next-step ST facilities and ITER. Controllable fully-non-inductive current-drive will also contribute to assessing the ST as a potentially cost-effective path to fusion energy.

WBS Element: 1.1

WBS Level: 2

WBS Title: Torus Systems

Definition: The torus systems include all the systems and related elements within the boundary of the NSTX support structure. This WBS element includes the Plasma Facing Components (WBS 1.1), Vacuum Vessel & Support Structure (WBS 1.2), and Magnet Systems (WBS 1.3). The scope of the work contains engineering design, R&D, mockups, procurement activities, and component fabrication. Assembly of the Torus System is included in WBS 1.8.

WBS Element: 1.1.0

WBS Level: 3

WBS Title: Project Integrated Model

Definition: This WBS element includes development of a project integrated model and the associated analysis support of the overall NSTX Upgrade Project.

As a result of the NSTX Upgrade Project, the NSTX global models and analyses will need to be updated. This WBS element includes analytical support for global models and analysis not presently identified. The global model will provide the basis for updating the analysis to qualify components and identify areas of the tokamak requiring further analysis. Identified plasma scenarios and power supply current limit analyses will be run in the global model and current sets that require further analysis will be identified. These analyses also serve to check the results of more detailed analyses.

{Center Stack Upgrade (CSU) analytical Support (Job 1000)}

WBS Element: 1.1.1

WBS Level: 3

WBS Title: Plasma Facing Components

Definition: The plasma facing components (PFCs) include all the systems and related elements that serve to protect the vacuum vessel from the charged particles and radiation flux from the plasma. These include the plasma facing tiles and mounting components, passive stabilizers, inner wall

Work Approval Form (WAF)

Cost Center: cost center 9417
Job Number: Job Number 1000
Job Title: Title: CSU Analytical Support
Job Manager: Job Manager: Peter Titus

Description:

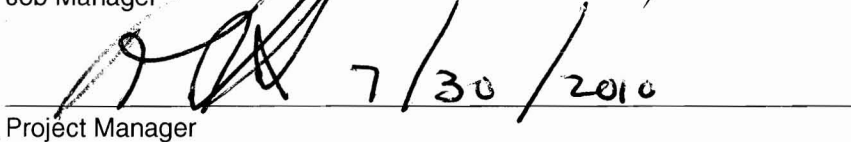
This job provides analytical support for global models and more general analyses not identified in component or task specific WAFs. The global model analysis will be used to qualify components and identify areas of the tokamak requiring further analysis. Identified plasma scenarios and power supply current limit analyses will be run in the global model and current sets that require further analysis will be identified. These analyses also serve to check the results of more detailed analyses.

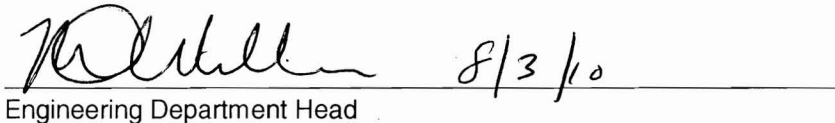
Schedule:

See Tab B and attached

Approvals:

 July 21 2010
Job Manager

 7/30/2010
Project Manager

 8/3/10
Engineering Department Head

| | | | | | | | | | | | | | | | | | | | | |
|---------------------|-------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Cost Center: | cost center 9417 | | | | | | | | | | | | | | | | | | | |
| Job Number: | Job Number 1000 | | | | | | | | | | | | | | | | | | | |
| Job Title: | Title: CSU Analytical Support | | | | | | | | | | | | | | | | | | | |
| Job Manager: | Job Manager: Peter Titus | | | | | | | | | | | | | | | | | | | |

Uncertainty of the Estimate

| | <u>High</u> | <u>Medium</u> | <u>Low</u> | <u>Uncertainty Range (%)</u> | <u>Comments/Other Considerations</u> |
|-------------------|-------------|---------------|------------|------------------------------|--------------------------------------|
| Design Maturity | | x | | | LOE as required |
| Design Complexity | x | | | | |

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 | Analysis indicates a significant component needs upgrade that previously hasn't been identified | low | Maintain upgrades of the model and keep ahead of the scenario changes. | ~2 Man-Months of Analysis Only | 10 | 40 | 0 | 8 * |
| 2 | Analysis indicates a minor component needs upgrade that previously hasn't been identified - weld details, details that are inconsistent with the ProE model | High | Identify these areas early with site surveys and as-builts | ~2 man-months of Analysis Only | 10 | 40 | 0 | 4 * |
| 3 | | | | | | | | |
| 4 | | | | | * These are guesses | based on identifying | Hardware that needs | Upgrade |
| 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%)

| Design Complexity | | | | | | | Design Maturity Definition | | | | | | | |
|-------------------|--------|------|--------|------|------|------|------------------------------|--|--|--|--|--|--|--|
| Design Maturity | Low | | Medium | | High | | 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 | | | | | | |

Cost Center:
Job Number:
Job Title:
Job Manager:

cost center 9417
Job Number 1000
Title: CSU Analytical Support
Job Manager: Peter Titus

Materials and Subcontracts (M&S)

Basis of Estimate

Description:

[Empty rectangular box]

| CATEGORIZATION CODES: | | | |
|---|---|----|-----------|
| 1 - National Standards | 1 | \$ | - #DIV/0! |
| 2 - Engineering Judgement/Experience | 2 | \$ | - #DIV/0! |
| 3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.) | 3 | \$ | - #DIV/0! |
| 4 - Previous PPPL/ORNL Experience (e.g., TFTR, NSTX, PLT, etc.) | 4 | \$ | - #DIV/0! |
| 5 - Prototype Data/Test Results | 5 | \$ | - #DIV/0! |
| 6 - Catalogue Price/Vendor Quote | 6 | \$ | - #DIV/0! |
| 7 - Placed Contracts | 7 | \$ | - #DIV/0! |
| 8 - Actual experience for NCSX Work | 8 | \$ | - #DIV/0! |
| 9 - Other | 9 | \$ | - #DIV/0! |
| TOTALS | | \$ | - #DIV/0! |

| | | | | | | | |
|--------------|--------------------|----------------------|--------------------|-------------------|----------------|-------------------|-----|
| OH solenoid | 1997 \$ \$136.3 | Inflator % 1.2992 | 2009 \$ \$177.1 | x4 k\$ \$708.3 | # Orig 2340 | # Upgrade 6400 | 3.0 |
| Conductor | \$7.50 | | \$48,000.00 | 2.2 | \$105,600.0 | \$105.6 | |
| OH conductor | \$40.0 | 1.2992 | \$52.0 | \$155.90 | 6400 | 2.2 | 5 |
| | FY97 cost | Escal | | | 12800 | \$92.2 | |

TF bundle \$83.0 1.2992 \$107.8 \$431.3
 \$1,139.66
 \$1,481.56 30% difficulty

OTF Conductor 2 x 3 23 #/ft 3450# 25 ft/length 6

Rotable flanges \$13.2 1.2992 \$17.1
 Inconel Forgings \$30.9 1.2992 \$40.1 1.5 \$60.2

6,400.0

| PF Conductors | width in | Height in | Hole Dia in | Hole Area in2 | Area in2 | Coil R in | Turn | length/Tur in | Length/Coil in | Length/Coil ft | x 2 | Wt/coil lb | x 2 | | |
|---------------|-------------|--------------|----------------|------------------|-------------|--------------|------|------------------|-------------------|-------------------|--------|---------------|--------|--------|----------|
| PF1a | 0.591 | 0.591 | 0.217 | 0.1180 | 0.231 | 12.571 | 120 | 78.946 | 9473.5 | 789.5 | 1578.9 | 701.1 | 1402.3 | | |
| PF1b | 0.220 | 0.220 | 0.098 | 0.0024 | 0.046 | 15.763 | 180 | 98.992 | 17818.5 | 1484.9 | 2969.7 | 262.3 | 524.6 | | |
| PF1c | 0.220 | 0.220 | 0.098 | 0.0024 | 0.046 | 21.674 | 162 | 136.113 | 22050.3 | 1837.5 | 3675.0 | 324.6 | 649.2 | | |
| | | | | | | | | | | | | | 2576.0 | x 2.2 | \$7.50 |
| | | | | | | | | | | | | | | 5667.2 | \$42.5 k |

Pi 3.14
 0.32 #/Cu in