

Work Authorization Document

NSTX Upgrade Project

| | | | |
|---------------------------|-------|---------------|-----------------------------|
| Control Account #: | 1001 | Title: | CS Plasma Facing Components |
| WBS | 1.1.1 | Title: | Plasma Facing Components |

Period of Performance: 23 February 2009 to 25 November 2013

| | | | |
|---------------------------|---------|---------------------------------|----------|
| Authorized Budget: | \$2,169 | Control Account Manager: | Tresemer |
| Revision #: | 0 | Revision Date: | July-11 |

Authorized Work Description:

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 protection, divertor area strike plates, and local I&C. This element consists of the engineering design, analysis, procurement activities and component fabrication.

The NSTX Upgrade Project will require new PFCs on the new Center Stack Casing (CSC) and the new Inboard divertor (IBD). This WBS element includes the design and analysis for both the CS and IBD PFCs, design modifications to the PFC tiles to accommodate surface diagnostics, including design of the tile mounting schemes and routing plans for diagnostic wires, generation of required documentation such as checked calculations, specifications and procedures, the procurement and installation of all PFC tiles and hardware on the CSC and IBD.

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 |
|------|----------------|--------------|------------|-----------|
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| | | | | |

| Approvals | Name | Signature | Date |
|-------------------------|---------------|-----------|------|
| NSTX-U Project Manager | R. Strykowski | | |
| Control Account Manager | K. Tresemer | | |
| Functional Manager | L. Dudek | | |

| 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

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|----------|--|-------|----------|----------|---------|---------|----|-------|--------------|--|------------|------------|--|--|--|--|--|--|
| Subtotal | | 1,182 | 23FEB09A | 23FEB09A | 25NOV13 | 08NOV13 | 11 | 1,706 | 2,169,095.88 | | 607,780.69 | 670,087.66 | | | | | | |
|----------|--|-------|----------|----------|---------|---------|----|-------|--------------|--|------------|------------|--|--|--|--|--|--|

Job: 1001 - CS Plasma Facing Components-TRESEMER

| | | | | | | | | | | | | | | | | | | |
|----------|--|-------|----------|----------|---------|---------|----|-------|--------------|--|------------|------------|--|--|--|--|--|--|
| Subtotal | | 1,182 | 23FEB09A | 23FEB09A | 25NOV13 | 08NOV13 | 11 | 1,706 | 2,169,095.88 | | 607,780.69 | 670,087.66 | | | | | | |
|----------|--|-------|----------|----------|---------|---------|----|-------|--------------|--|------------|------------|--|--|--|--|--|--|

Design

| | | | | | | | | | | | | | | | | | | |
|------------|---|------|----------|----------|----------|----------|-----|-----|-----------|-----|-----------|-----------|---|--|--|--|--|--|
| 1001-0021 | NDA, Export Control Issues | 146* | 03MAY10A | 03MAY10A | 29NOV10 | 29OCT10A | 19 | | 7,256.97 | 100 | 7,342.02 | 7,342.02 | EM//EM=50 | | | | | |
| 1001-0029 | PDR Prep | 36 | 03MAY10A | 03MAY10A | 22JUN10A | 22JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1001-0030 | CONDUCT PDR | 2 | 23JUN10A | 23JUN10A | 24JUN10A | 24JUN10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1001-0031 | Receipt of Material data | 110* | 23JUN10A | 23JUN10A | 29NOV10 | 29OCT10A | 19 | | 292.33 | 100 | 296.49 | 296.49 | EM//EM =02 ; | | | | | |
| 1001-0031A | Processing of Material data | 5 | 30NOV10 | 01NOV10A | 06DEC10 | 05NOV10A | 19 | | 316.42 | 100 | 316.42 | 316.42 | EM//EM =02 ; | | | | | |
| 1001-0032 | Order Samples for testing (6 wks lead) | 149* | 23JUN10A | 23JUN10A | 28FEB11 | 31JAN11A | 20 | | 19,543.06 | 100 | 19,616.75 | 19,616.75 | EM//EM =08 ; 41=15,000 ; | | | | | |
| 1001-0034 | PDR chit resolution | 60* | 25JUN10A | 25JUN10A | 20SEP10A | 20SEP10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | EM//EM =60 ; EA//ES =160 ; | | | | | |
| 1001-0035 | Update WAF for Lehman Review (prep) | 30 | 25JUN10A | 25JUN10A | 06AUG10A | 06AUG10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1001-0036 | Generic Tile Qualitfication Program | 61* | 25JUN10A | 25JUN10A | 21SEP10A | 21SEP10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | EM//EM =20 ; EA//EM =200 ; | | | | | |
| 1001-0037 | Lehman Review | 2 | 10AUG10A | 10AUG10A | 11AUG10A | 11AUG10A | 0 | | 0.00 | 100 | 0.00 | 0.00 | | | | | | |
| 1001-0038A | Fastener Mock-up | 77* | 02SEP10A | 02SEP10A | 06DEC10 | 22DEC10A | -12 | | 45,622.41 | 100 | 45,436.17 | 45,436.17 | EM//EM =08 ; 41=15,000 ; | | | | | |
| 1001-0039 | Disruption Forces - Final Tile Analysis | 75* | 12AUG10A | 12AUG10A | 29NOV10 | 29OCT10A | 19 | | 20,651.65 | 100 | 21,008.28 | 21,008.28 | EM//EM =20 ; EA//ES =40 ; EA//EM =80 ; | | | | | |
| 1001-0040 | Thermal system - Final Tile Analysis | 52* | 18OCT10* | 18OCT10A | 30NOV10 | 07JAN11A | -22 | | 26,630.60 | 100 | 26,630.60 | 26,630.60 | EM//EM =20 ; EA//Em=160 ; EA//ES=40 | | | | | |
| 1001-0041 | Fastener Scheme - Final Tile Analysis | 125* | 14JAN11* | 16DEC10A | 25FEB11 | 17JUN11 | -79 | 135 | 37,473.80 | 85 | 31,852.73 | 37,473.80 | EM//EM =20 ; EA//Em=160 ; EA//es=40 | | | | | |
| 1001-0043 | Part re-design | 61* | 28FEB11 | 24FEB11A | 25MAR11 | 19MAY11 | -39 | 135 | 21,264.00 | 60 | 12,758.40 | 21,264.00 | EM//EM =64 ; EA//es =128 ; | | | | | |
| 1001-0044 | Tile adjustments/Drawings | 41* | 28MAR11 | 24MAR11A | 15APR11 | 19MAY11 | -24 | 178 | 10,885.28 | 60 | 6,531.17 | 10,885.28 | EM//EM =16 ; EA//es =64 ; | | | | | |
| 1001-0045 | Fastener Prototype | 97* | 25MAR11* | 15FEB11A | 27MAY11 | 30JUN11 | -23 | 135 | 48,489.24 | 15 | 7,273.39 | 27,406.96 | EM//EM =44 ; EA//ES =40 ; EM//ST=320;M&S=5,000 | | | | | |
| 1001-0046 | Testing | 20 | 31MAY11 | 01JUL11 | 27JUN11 | 29JUL11 | -23 | 135 | 16,651.50 | | 0.00 | 0.00 | EM//EM =30 ; EM//ST =120 ; | | | | | |
| 1001-0048 | Mechanical - Material Testing | 59* | 01MAR11* | 20DEC10A | 28MAR11 | 18MAR11A | 6 | | 20,132.30 | 100 | 20,132.30 | 20,132.30 | EM//EM =30 ; EA//ES =40 ; EM//ST =120; | | | | | |
| 1001-0049 | Thermal - Material Testing | 53* | 01MAR11 | 20DEC10A | 21MAR11 | 10MAR11A | 7 | | 12,999.70 | 100 | 12,999.70 | 12,999.70 | EM//EM =10 ; EM//ST =80;ea//es40 | | | | | |

| | | | | |
|------------------------------|--------------------------------------|--|--------------|--|
| Data Date Run Date | 30APR11 1105 20MAY11 10:44 | NSTX UPGRADES RESOURCE LOADED SCHEDULE CD-2 Schedule April 2011 | Sheet 1 of 3 | <div style="display: flex; justify-content: space-between;"> <div style="width: 40%;"> <div style="background-color: #00FFFF; height: 10px; margin-bottom: 5px;"></div> <div style="background-color: #0000FF; height: 10px; margin-bottom: 5px;"></div> <div style="background-color: #FF0000; height: 10px;"></div> </div> <div style="width: 55%;"> <p>Early Bar</p> <p>Progress Bar</p> <p>Critical Activity</p> </div> </div> |
| © Primavera Systems, Inc. | | | | |

| 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 | | | | | | | | |
|------------------------------------|--|-----------|----------------|----------------|-----------------|-----------------|----------------------|-------------|---------------|------|--------------------------|---------------------------|-------------------------------|--|--|--|--|--|--|--|--|
| | | | | | | | | | | | | | | | | | | | | | |
| 1001-0050 | Review Data - Material Testing | 10 | 22MAR11 | 16MAY11* | 04APR11 | 27MAY11 | -39 | 123 | 6,328.40 | | 0.00 | 6,328.40 | | | | | | | | | |
| 1001-0053 | Make Material Choices | 10 | 05APR11* | 31MAY11 | 18APR11 | 13JUN11 | -39 | 127 | 6,328.40 | | 0.00 | 6,328.40 | | | | | | | | | |
| 1001-0054 | Finalize Designs/Drawings | 45 | 28JUN11* | 01AUG11 | 30AUG11 | 03OCT11 | -23 | 135 | 50,734.78 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0055 | Drawings (Assem/Installation) | 287* | 11OCT10* | 01NOV10A | 21DEC11 | 23DEC11 | -2 | 369 | 195,023.02 | 40 | 77,899.95 | 88,935.77 | | | | | | | | | |
| 1001-0056 | Prep Procurement Specs | 15 | 31AUG11 | 04OCT11 | 21SEP11 | 24OCT11 | -23 | 135 | 5,204.70 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0056A | CS Plasma Facing Components Peer Review | 0 | | | | 18MAY11* | 0 | 2,326 | 0.00 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0057 | FDR Prep | 24 | 13MAY11* | 16MAY11 | 10JUN11 | 17JUN11 | -5 | 123 | 34,174.08 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0058 | CONDUCT FDR | 3 | 13JUN11 | 22JUN11* | 14JUN11 | 24JUN11 | -8 | 121 | 7,612.80 | | 0.00 | 0.00 | | | | | | | | | |
| Procure, Fab & Assembly | | | | | | | | | | | | | | | | | | | | | |
| 1001-0062 | Prep Req & Proc Package - Tiles (CFC) | 9 | 03OCT11* | 25OCT11* | 13OCT11 | 04NOV11 | -16 | 135 | 6,939.60 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0063 | Submit Req. to Procurement - Tiles (CFC) | 2 | 14OCT11 | 07NOV11 | 17OCT11 | 08NOV11 | -16 | 135 | 693.96 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0064 | Bid & Award (Procurement Lead Time - Tiles (CFC) | 40 | 18OCT11 | 09NOV11 | 14DEC11 | 13JAN12 | -16 | 135 | 5,551.68 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0065 | Award - Tiles (CFC) | 1 | 14DEC11* | 13JAN12* | 14DEC11 | 13JAN12 | -16 | 135 | 0.00 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066 | Fabricate and Deliver - CFC Material | 160 | 15DEC11 | 16JAN12 | 06AUG12 | 28AUG12 | -16 | 135 | 432,818.40 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066B | Prep Req & Proc Package - Machine Tiles (CFC) | 10 | 04JUN12 | 04JUN12 | 15JUN12 | 15JUN12 | 0 | 98 | 6,049.80 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066C | Submit Req. to Procurement - Machine Tiles (CFC) | 2 | 31JUL12 | 31JUL12 | 01AUG12 | 01AUG12 | 0 | 113 | 693.96 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066D | Bid & Award (Proc Lead Time - Machine Tiles(CFC) | 39 | 02AUG12 | 02AUG12 | 26SEP12 | 26SEP12 | 0 | 113 | 5,551.68 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066E | Award - Machine Tiles (CFC) | 2 | 27SEP12 | 27SEP12 | 28SEP12 | 28SEP12 | 0 | 113 | 0.00 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0066F | Fabricate/Machine tiles + diagnostics | 85 | 01OCT12* | 01OCT12* | 07FEB13 | 07FEB13 | 0 | 113 | 321,316.90 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0069 | Tile Bakeout | 40 | 08FEB13 | 08FEB13 | 04APR13 | 04APR13 | 0 | 113 | 66,000.00 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0071 | Prep Req & Proc Package - hardware, other materl | 10 | 18JUN12* | 18JUN12* | 29JUN12 | 29JUN12 | 0 | 98 | 6,049.80 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0072 | Submit Req. to Procurement - hardware, other mat | 2 | 02JUL12 | 02JUL12 | 03JUL12 | 03JUL12 | 0 | 98 | 693.96 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0073 | Procurement Lead Time - hardware, other material | 40 | 05JUL12 | 05JUL12 | 29AUG12 | 29AUG12 | 0 | 98 | 5,551.68 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0074 | Award - hardware, other materials | 1 | 30AUG12 | 30AUG12 | 30AUG12 | 30AUG12 | 0 | 98 | 0.00 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0075 | Fabricate and Deliver - hardware, other material | 160 | 31AUG12 | 31AUG12 | 25APR13 | 25APR13 | 0 | 98 | 282,951.30 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0078 | Fab/Assembly Procedures | 30 | 08JUL13 | 19JUN13 | 16AUG13 | 01AUG13 | 11 | 1 | 21,256.80 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0079 | Tile Assembly with Hardware | 40 | 01OCT13* | 16SEP13* | 25NOV13 | 08NOV13 | 11 | 1 | 39,949.48 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0082 | Installation Procedure | 30 | 19AUG13 | 02AUG13 | 30SEP13 | 13SEP13 | 11 | 1 | 21,256.80 | | 0.00 | 0.00 | | | | | | | | | |
| 1001-0083 | Tile Re-fit, as needed, additional machining | 30 | 01OCT13* | 16SEP13* | 11NOV13 | 25OCT13 | 11 | 1 | 34,468.32 | | 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) | | | | | | |
|-------------|----------------------|-----------|----------------|----------------|-----------------|-----------------|----------------------|-------------|---------------|------|--------------------------|---------------------------|------|-------|------|------|------|------|
| | | | | | | | | | | | | | FY11 | FY12 | FY13 | FY14 | FY15 | FY16 |
| | | | | | | | | | | | | | | | | | | |
| FY091001 | FY09 Actual Cost | 22 | 23FEB09A | 23FEB09A | 30SEP09A | 30SEP09A | 0 | | 64,576.00 | 100 | 64,576.00 | 64,576.00 | | | | | | |
| FY101001 | FY10 Actual Cost | 100 | 01DEC09A | 01DEC09A | 30APR10A | 30APR10A | 0 | | 103,885.00 | 100 | 103,885.00 | 103,885.00 | | | | | | |
| FY101001A | FY10 Actual Cost | 130 | 01APR10A | 01APR10A | 30SEP10A | 30SEP10A | 0 | | 99,233.32 | 100 | 99,233.32 | 99,233.32 | 81= | 90477 | | | | |
| FY101110 | FY10 Actual Cost | 85 | 01OCT09A | 01OCT09A | 31JAN10A | 31JAN10A | 0 | | 49,992.00 | 100 | 49,992.00 | 49,992.00 | | | | | | |

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

protection, divertor area strike plates, and local I&C. This element consists of the engineering design, analysis, procurement activities and component fabrication.

The NSTX Upgrade Project will require new PFCs on the new Center Stack Casing (CSC) and the new Inboard divertor (IBD). This WBS element includes the design and analysis for both the CS and IBD PFCs, design modifications to the PFC tiles to accommodate surface diagnostics, including design of the tile mounting schemes and routing plans for diagnostic wires, generation of required documentation such as checked calculations, specifications and procedures, the procurement and installation of all PFC tiles and hardware on the CSC and IBD.

{Center Stack Upgrade (CSU) PFCs (Job 1001)}

In addition the NSTX Upgrade will require analysis of the passive plates for disruption and thermal loads. CDR level calculations were performed that addressed one of five disruptions. The remaining identified disruptions are to be completed during Preliminary Design. During Final design, analysis updates are expected as a result of preliminary design evolution. Modest hardware upgrades are anticipated as part of this task. Additions of accelerometers or other diagnostics to benchmark calculations with actual performance in NSTX are also anticipated. This analysis effort is included in this WBS element.

{Passive Plate Analysis and Upgrade Activity (Job 1002)}

With the exception of the modifications identified above, no additional modifications to the PFCs are anticipated.

WBS Element: 1.1.2

WBS Level: 3

WBS Title: Vacuum Vessel and Support Structure

Definition: The vacuum vessel & support structure (VVSS) consists of the vacuum chamber, not including the PFCs, all ports and vacuum boundary closures and the torus support structure which provides the overall supporting mechanism for the torus components to the test cell floor. This WBS element includes the engineering design, analysis, procurement activities and component fabrication.

The NSTX Upgrade Project will require that the existing VVSS be modified to accommodate the new center stack structure, including the umbrella structure and the new center stack support structure. This WBS element includes the analytical and CAD design of the support structures associated with the Magnet upgrade activities. The scope includes; the Vacuum Vessel & Structural Support, the Outer TF Structures, the Outer PF Coil Structures, the Umbrella Structural Reinforcement, the CS Support Pedestal and miscellaneous Vacuum Vessel Structural Supports. It also includes the procurement and fabrication of these structures, but

Work Approval Form (WAF)

Cost Center: 9417

Job Number: 1001

Job Title: NSTX CS Upgrade PFCs

Job Manager: Kelsey Tresemer

Rev 5 7/13/2010

Description:

Provide adequate thermal coverage for the upgraded center stack via tiles.

1) Includes the design and analysis for both the CS and IBD plasma facing components. 2)

Includes design modifications to the tiles to accommodate surface diagnostics

3) Includes design of tile mounting schemes and routing plan for diagnostics wires 4) Includes

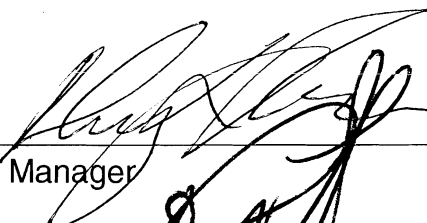
generation of required documentation such as checked calculations, specs and procedures. 5) Includes the

procurement of all PFC tiles and hardware for the CS and IBD


Schedule:

See Tab B or attached


Approvals:

 7/20/10

Job Manager

 8/3/10

Project Manager

 8/3/10

Engineering Department Head

USER INPUT TASKS AND DESCRIPTIONS

| Task | TASK DESCRIPTION | Responsible | DURATION | | SCHEDULE | | USER INPUT | | Calculated | | Start Date | Finish Date | Category |
|------|---|--------------|----------|------|----------|----------|--|----------------------------------|------------|-------------|------------|-------------|----------|
| | | | WEEKS | DAYS | ON In | WOR K | OPTIONAL: Logical Pre-requisites (one task numbers in each column may order) | User Input Start Date (optional) | START DATE | FINISH DATE | | | |
| 1 | Conceptual Design | Tresmer | 20 | | 6/29/09 | 06/29/09 | | | | | | | |
| 2 | Preliminary Planning / Fact finding | Tresmer | 15 | | 7/6/09 | 07/06/09 | | | | | | | |
| 3 | Title Layout/Preliminary Title Design | Tresmer | 10 | | 7/27/09 | 07/27/09 | | | | | | | |
| 4 | Diagnostic Layout | Tresmer | 4 | | 8/8/09 | 08/08/09 | | | | | | | |
| 5 | PPPL peer review prep | Tresmer | 1 | | 8/13/09 | 08/13/09 | | | | | | | |
| 6 | PPPL peer review | Tresmer | 40 | | 8/14/09 | 08/14/09 | | | | | | | |
| 7 | Title/Diagnostic/Hardware Reconfig, Mat Research | Tresmer | 15 | | 9/14/09 | 09/14/09 | | | | | | | |
| 8 | Initial Title Thermal Analysis | Tresmer | 5 | | 10/5/09 | 10/05/09 | | | | | | | |
| 9 | CDR prep | Tresmer | 1 | | 10/13/09 | 10/13/09 | | | | | | | |
| 10 | CONDUCT CDR | Tresmer | 10 | | 10/14/09 | 10/14/09 | | | | | | | |
| 11 | Preliminary Design | Tresmer | 160 | | 10/28/09 | 10/28/09 | | | | | | | |
| 12 | CDR chit resolution | Tres/Jari | 80 | | 10/28/09 | 10/28/09 | | | | | | | |
| 13 | Title Fit and diagnostic Fit (end re-fit, per analysis) | Tres/Jari | 100 | | 3/18/10 | 03/18/10 | | | | | | | |
| 14 | Wireway routes, diagnostic placement | Tres/Jari | | | | | | | | | | | |
| 15 | Preliminary hardware fit (end re-fit, per analysis) | Tres/Jari | | | | | | | | | | | |
| 16 | Update preliminary drawings (non-assembly) | Tres/Jari | | | | | | | | | | | |
| 17 | Material Specs | Tresmer | 80 | | 10/28/09 | 10/28/09 | | | | | | | |
| 18 | Make vendor contacts | Tresmer | 100 | | 3/18/10 | 03/18/10 | | | | | | | |
| 19 | NDA, Export Control Issues | Tresmer | | | | | | | | | | | |
| 20 | Preliminary Title Analysis | Tres/Jari | 80 | | 10/28/09 | 10/28/09 | | | | | | | |
| 21 | Thermal | Tres/Jari | 50 | | 2/17/10 | 02/17/10 | | | | | | | |
| 22 | Forces | Tresmer | 30 | 24 | 4/28/10 | 04/28/10 | | | | | | | |
| 23 | Fasteners | Tres/Jari | 5 | | 4/21/10 | 04/21/10 | | | | | | | |
| 24 | PPPL Peer Review prep | Tresmer | 1 | | 4/28/10 | 04/28/10 | | | | | | | |
| 25 | PPPL Peer Review | Tresmer | 25 | | 4/22/10 | 04/22/10 | | | | | | | |
| 26 | Update CS WAF | Tresmer | 10 | | 6/9/10 | 06/09/10 | | | | | | | |
| 27 | PDR Prep | Tresmer | 2 | 29 | 07/18/10 | 07/18/10 | | | | | | | |
| 28 | CONDUCT PDR | Tresmer | 1 | 30 | 08/05/10 | 08/05/10 | | | | | | | |
| 29 | Receipt of Material data | Tresmer | 32 | 21 | 08/05/10 | 08/16/10 | | | | | | | |
| 30 | Order Samples for testing (8 was lead) | Tresmer | 30 | 30 | 07/19/10 | 08/30/10 | | | | | | | |
| 31 | Final Design | Tresmer | 300 | 34 | 08/30/10 | 10/24/11 | | | | | | | |
| 32 | PDR chit resolution | Tresmer | 30 | 30 | 07/19/10 | 08/30/10 | | | | | | | |
| 33 | Drawings (with ongoing revisions) | Tresmer | 30 | 30 | 07/19/10 | 08/30/10 | | | | | | | |
| 34 | Update WAF for Lehman Review (prep) | Tresmer | 30 | 30 | 07/19/10 | 08/30/10 | | | | | | | |
| 35 | Generic Title Qualification Program | Bres/Tsa/Bmt | 2 | 36 | 8/10/10 | 08/10/10 | | | | | | | |
| 36 | Lehman Review | Tresmer | 40 | 37 | 08/30/10 | 10/28/10 | | | | | | | |
| 37 | Final Title Analysis | Brooks | 15 | 40 | 10/25/10 | 11/15/10 | | | | | | | |
| 38 | Disruption Forces | Brooks | 10 | 40 | 11/15/10 | 11/23/10 | | | | | | | |
| 39 | Thermal system | Tres/Jari | 20 | 42 | 11/29/10 | 12/27/10 | | | | | | | |
| 40 | Fastener Scheme | Tres/Jari | 15 | 44 | 12/27/10 | 01/17/11 | | | | | | | |
| 41 | Fastener Design | Tresmer | 20 | 44 | 12/27/10 | 01/24/11 | | | | | | | |
| 42 | Part re-design | Tresmer | 15 | 46 | 01/24/11 | 02/14/11 | | | | | | | |
| 43 | Title adjustments/drawings | Tresmer | 40 | 24 | 12/27/10 | 02/21/11 | | | | | | | |
| 44 | Fastener Mock-up | Tresmer | 20 | 49 | 02/21/11 | 03/21/11 | | | | | | | |
| 45 | Testing | Tresmer | 40 | 44 | 12/27/10 | 02/21/11 | | | | | | | |
| 46 | Material Testing | Tresmer | 20 | 44 | 12/27/10 | 02/21/11 | | | | | | | |
| 47 | Mechanical | Tresmer | 20 | 44 | 12/27/10 | 02/21/11 | | | | | | | |
| 48 | Thermal | Tresmer | 20 | 44 | 12/27/10 | 02/21/11 | | | | | | | |

| | | | | | | | | | | | | | | | |
|--|---|--------------------------------|--|---|------------------|-------------------|------------------------------------|-------------------------------------|--------------------------------------|------|--|--|--|--|---|
| Cost Center: | cost center 1170 | | | | | | | | | | | | | | |
| Job Number: | Job Number 1101 | | | | | | | | | | | | | | |
| Job Title: | Title: CS Plasma Facing Components | | | | | | | | | | | | | | |
| Job Manager: | Job Manager: Kelsey Tresemer | | | | | | | | | | | | | | |
| Uncertainty of the Estimate | | | | | | | | | | | | | | | |
| | <u>High</u> | <u>Medium</u> | <u>Low</u> | <u>Uncertainty Range (%)</u> | | | | | | | | | | | |
| Design Maturity | | X | | -10%, 15% | | | | | | | | | | | |
| Design Complexity | | X | | -15%, +25% | | | | | | | | | | | |
| Residual Impacts | | | | | | | | | | | | | | | |
| | Risk Description | Likelihood of Occurring | Mitigation Plan | Basis of estimate | Low (\$K) | High (\$K) | Schedule Impact Low (weeks) | Schedule Impact High (Weeks) | <u>Comments/Other Considerations</u> | | | | | | |
| 1 | Tiles not delivered on time | U | If schedule critical, install tiles in vessel | Conservative vendor quote, engineering experience | | X | | X | | | | | | | |
| 2 | Special diagnostics for tiles not received on time | U | If schedule critical, install tiles in vessel | Engineering experience | | X | | X | | | | | | | |
| 3 | Tiles requiring unforeseen machining | L | If schedule critical, and in-house machining will not suffice, seek external machining sources. Additional machining time added to WAF | Engineering experience | | X | | X | | | | | | | |
| 4 | Passive Plate hardware needs upgrading: Approx 2050 tiles | U | | Hardware ONLY | | | | | 436 | | | | | | X |
| 5 | Outboard Divertor tile and hardware replacement, approx 1300 tiles, 26000 in ³ of material | L | | Material and Hardware ONLY | | | | | | 2200 | | | | | X |
| 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 | | Design Maturity Definition | | | |
|------------------------------|--------|----------------------------|------|----------------------------|------|------|---|
| 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 | | Design Maturity 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 |

M & S Breakdown

TILES

Approx. 600 tiles

| | No. of tiles | Avg Dimensions | Volume (in ³) | Spare Parts | | Handling Loss | |
|---------------|--------------|--------------------|---------------------------|--------------------|---------------------------|--------------------|---------------------------|
| | | | | No. of tiles, +20% | Volume (in ³) | No. of tiles, +10% | Volume (in ³) |
| Upper | | | | | | | |
| Row 1 | | 24 2"x7"x7" | 2352 | 30 | 2940 | 33 | 3234 |
| Row 2 - 4 | | 72 1"x4.5"x4" | 1296 | 87 | 1566 | 95.7 | 1722.6 |
| Row 5 | | 24 1"x10"x3.7" | 888 | 30 | 1110 | 33 | 1221 |
| Center | | | | | | | |
| Row 6 - 20 | | 360 .75"x3.4"x5.8" | 5324.4 | 430 | 6359.7 | 473 | 6995.67 |
| Lower | | | | | | | |
| Row 1 | | 24 2"x7"x7" | 2352 | 30 | 2940 | 33 | 3234 |
| Row 2 - 4 | | 72 1"x4.5"x4" | 1296 | 87 | 1566 | 95.7 | 1722.6 |
| Row 5 | | 24 1"x10"x3.7" | 888 | 30 | 1110 | 33 | 1221 |
| Total | 600 | | 14396.4 | 724 | 17591.7 | 796.4 | 19350.87 |

| | Vol/section (in ³) | Vol/section (cm ³) | Density(g/cm ³) | Lbs |
|----------------------|--------------------------------|--------------------------------|-----------------------------|---------|
| Rows 1-5: high-k CFC | 7900.2 | 129461.083 | 1.9 | 542,284 |
| Rows 6-20: low-k CFC | 11450.67 | 187642.8621 | 1.75 | 723,943 |

high-k CFC Costs: \$1000/lb (avg)
@ \$1000 \$542,284.38

low-k CFC Costs: \$400/lb (avg)
@ 400 \$289,577.19

Subtotal:
\$831,861.57

Billets for spare parts (not finished tiles):
\$50,000

TOTAL
\$881,861.57 **-\$900,000.00**

TILE MACHINING (not diagnostics)

Rate of machining 3 tiles/day
Avg cost of machining \$72.5/hr
800 tiles @ \$193.00/tile

total \$150,000.00

DIAGNOSTIC MACHINING

Rate of machining 6 tiles/day
Avg cost of machining \$72.5/hr
235 tiles @ \$96.67/tile

total \$22,216.67

HARDWARE

(nuts, bolts, weld studs, Grafoil, locating pins, rails)

| | | |
|-----------------|----------------------|-------------|
| Bolts | \$2,000.00 | |
| Nuts | \$20,000.00 new tech | \$50,000.00 |
| Rail | \$20,000.00 | |
| T-bar | \$20,000.00 | |
| Pins | \$5,000.00 | |
| Studs | \$10,000.00 | |
| Grafoil | \$5,000.00 | |
| Locating pins | \$1,000.00 | |
| Betville washer | \$3,000.00 | |
| | \$86,000.00 | |

Compared M&S data from old Job Cost Reports (circa 1997 - 2001)

| | Inflation adjusted | |
|--------------|--------------------|---------------------|
| 1997 | \$0.00 | 0 |
| 1998 | \$59,720.00 | \$76,823.81 |
| 1999 | \$7,070.00 | \$8,959.81 |
| 2000 | \$0 | 0 |
| 2001 | \$28,974.00 | \$34,977.41 |
| TOTAL | \$95,764.00 | \$120,761.03 |

Reflect a 25% increase due to increase in amount of material (larger surface area)

TOTAL Reflect a 25% increase due to increase in amount of material (larger surface area)
\$136,000.00 \$170,000.00

TOTAL
\$150,951.29 **-\$160,000.00**

USE \$170,000.00