HCCB TBM Design and Fabrication Plan and Cost Estimate

From Cost Guideline Planning will be for the US Reference Scenarios:

- DCLL TBM with PbLi exit temperature of 470°C and a series of TBM that occupy half a port
- HCCB submodule that has a size of 1/3 of one-half port in cooperation with the EU or Japan

Alice Ying
ITER-TBM
UCLA
Dec. 12, 2005
## HCCB Schedule

### HCCB Test Blanket Project

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Support</th>
<th>R&amp;D</th>
<th>Engineering Design</th>
<th>Prototype Fabrication and Testing</th>
<th>Ancillary Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Program Project Support

- PrS report
- 1st Concrete
- TSD/QA
- QA
- Permission to install
- DAPRE

### R&D

- Fabrication and Material Database
- Performance Predictive Capability
- Safety & Licensng Database
- Mock-up Tests (1/4 to 1/2 scale)

### Engineering Design

- Preliminary Design
- Detailed Design
- Title III

### Prototype Fabrication and Testing

- Contract Award
- Material Procurement
- Tooling Preparation
- Fabrication
- Testing

### TBM Fabrication, Assembly, and QA

- CD2
- CD3
- CD4

### Ancillary Equipment

- Assembly & Qualification Tests
- ITER Installation and System Checkout

First plasma permission to install required for interface resources.
## Summary of Engineering costs for design, prototype and EM test submodule (including fabrication, testing and QA)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Blanket Module</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>First plasma</td>
</tr>
<tr>
<td>Engineering Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preliminary Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Title III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-total Cost</td>
<td>503 k</td>
<td>597 k</td>
<td>378 k</td>
<td>430 k</td>
<td>356 k</td>
<td>232.3 k</td>
<td>308 k</td>
<td>116 k</td>
<td>119 k</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prototype Fabrication and Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract Award</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Procurement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tooling Preparation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabrication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBM Fabrication, Assembly, and QA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-total cost</td>
<td>503 k</td>
<td>597 k</td>
<td>378 k</td>
<td>531 k</td>
<td>697 k</td>
<td>742 k</td>
<td>818 k</td>
<td>496 k</td>
<td>500 k</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost for testing facility is not included. Cost basis for fabrication/testing: 0.25 FTE scientist and 0.75 FTE technician for fabrication/assembly, and 0.5 FTE scientist and 0.5 FTE technician for testing. 100 k allocated to tooling preparation.
11x1.5\textsuperscript{T} square tube

First wall

Total wall length is 2760mm

Length: >3200mm
About 2.5 times gross material needed to produce net weight of 2 tones of F82H for a half-port module structural box and internal cooling plates/tubes

<table>
<thead>
<tr>
<th></th>
<th>Net weight</th>
<th>Gross weight</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>1745.6</td>
<td>4074kg</td>
<td>\41,310,000</td>
</tr>
<tr>
<td>Tube</td>
<td>248.4</td>
<td>768kg</td>
<td>\57,660,000</td>
</tr>
<tr>
<td>Total</td>
<td>1994</td>
<td>4842kg</td>
<td>\98,970,000</td>
</tr>
</tbody>
</table>

*Cost per kg plate or tube = 899,727.27/1994= 451.2 US$/kg

* JAEA purchase cost from JFE (a JA steel company)
## Cost Estimates for Unit Cell and Submodule

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit Cell</th>
<th>Submodule (TM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size, m³</td>
<td>0.188 x 0.201 x 0.6</td>
<td>0.402 x 0.71 x 0.6</td>
</tr>
<tr>
<td>Total breeding volume (0.4 m)</td>
<td>0.015115</td>
<td>0.133</td>
</tr>
<tr>
<td>Number of units</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Breeder volume per unit, m³</td>
<td>0.00589</td>
<td>0.035 (0.0028542)</td>
</tr>
<tr>
<td>Beryllium volume, m³</td>
<td>0.006167</td>
<td>0.052 (0.0071355)</td>
</tr>
<tr>
<td>Total ferritic steel volume, m³</td>
<td>0.0063648</td>
<td>0.0506</td>
</tr>
<tr>
<td>Total breeder weight, kg (Li₂TiO₃)</td>
<td>3450 x 0.94 x 0.62 x 0.00589 x 3 = 35.52</td>
<td>3450 x 0.94 x 0.62 x 0.035 = 70.37 (5.74)</td>
</tr>
<tr>
<td>Total beryllium weight, kg</td>
<td>1850 x 0.62 x 0.006167 x 3 = 21.2</td>
<td>1850 x 0.62 x 0.052 = 60 (8)</td>
</tr>
<tr>
<td>Breeder cost ¹</td>
<td>$ 352.2 k (118.4 k)</td>
<td>$ 703.7 k (57.4)</td>
</tr>
<tr>
<td>Beryllium cost²</td>
<td>$ 190.8 k (63.6 k)</td>
<td>$ 540 k (72)</td>
</tr>
<tr>
<td>Breeder + Beryllium cost</td>
<td>$ 543 K (182k)</td>
<td>$ 1243.7 (129.4)</td>
</tr>
<tr>
<td>Ferritic steel cost</td>
<td>$ 64 k (64 k)</td>
<td>$ 176 K (176 k)</td>
</tr>
<tr>
<td><strong>Total estimated net material cost</strong></td>
<td><strong>0.607 millions</strong> (203 k for 1st test article; only 1 unit cell is filled with breeding materials)</td>
<td><strong>1.4197 millions</strong> (305.4 k for 1st test submodule; only the first breeder and Be layers are filled)</td>
</tr>
</tbody>
</table>

### Table 1: Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>TD kg/m³</th>
<th>Fabricated density</th>
<th>Cost /kg</th>
<th>Ferritic Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li₂TiO₃</td>
<td>3450</td>
<td>94%</td>
<td>$ 10K¹</td>
<td>451 (plate &amp; tube cost)</td>
</tr>
<tr>
<td>Li₄SiO₄</td>
<td>2400</td>
<td>98%</td>
<td>$ 10K</td>
<td></td>
</tr>
<tr>
<td>Be</td>
<td>1850</td>
<td>100%</td>
<td>$ 9K²</td>
<td></td>
</tr>
</tbody>
</table>

1. CEA price if purchasing 1 kg. The price per kg may increase for a higher $^6$Li enrichment and decrease for a large purchase.

2. NGK beryllium pebble price. The price per kg may decrease for a large quantity.
This submodule approach shares the test space with Japan, which features designing the US blanket configurations into one of the three Japan’s submodules.

An example submodule design combines layer and edge-on configurations in one physical unit with its own first wall structural box. Each submodule measures 402 x 350 x 600 mm³.

- **Ceramic breeder:**
  - $\text{Li}_4\text{SiO}_4$ - 40% $^6\text{Li}$ enriched (single size ~0.4 mm)
  - $\text{Li}_2\text{TiO}_3$ - 70% $^6\text{Li}$ enriched (single size ~0.6 – 0.8 mm)

- **Beryllium:** (~1mm pebble)

---

**Image:**
- 2 of 3 of JA Submodules
- Helium manifold (to be designed)
Ceramic Breeder Test Submodule
Inserting “US” unit cells into the EU HCPB structural box

Electromagnetics/Neutronics unit cell design

| Neutronics Submodule Operating Conditions          |
|---------------------------------|-----|
| **Helium Coolant**              |     |
| Pressure                        | 8 MPa|
| Temperature, In/Out             | 100/250 °C|
| **Helium Purge**                |     |
| Pressure                        | 0.1 MPa|
| Temperature, average            | 225 °C|
| **Breeder**                     |     |
| Min/Max                         | 100/350 °C|
| **Beryllium**                   |     |
| Min/Max                         | 100/350 °C|
| **FS**                          |     |
| Min/Max                         | 100/300 °C|

WBS 1.8.2
Prototype versus TBM

• Prototype is a full scale of TBM but is filled with pebble materials (such as Al$_2$O$_3$) to learn filling process

• Only a fraction of breeding zone of the EM TBM will be filled with breeding materials to study the effect of “transient impulses” caused by any plasma disruptions on the pebble integrity. To run helium purge gas through the filled breeding regions to monitor their integrity

Impacts on cost:

**Prototype material cost:** 176 k US$ for F82H (HIP fabrication process will increase cost by about 268k - one full year technician)

**TBM material cost:** 305.4 k US$ for F82H and breeding materials (HIP fabrication will increase cost by about 276 k - one full year technician)
Conventional HIP process

- Parts polishing (Rmax 44-4µm)
- Degassing inside can (10⁻³Pa @ 1273K)
- Assembling

Effects of pretreatment condition was studied.
<table>
<thead>
<tr>
<th>Item #</th>
<th>Activity ID</th>
<th>WBS: 1.8.2.1.3.1 Title I: Preliminary Design</th>
<th>Duration</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Project Definition (functional needs, performance matrices, design parameters)</td>
<td>30 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Establish Driving Design Considerations</td>
<td>9 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Perform Parametric Analyses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>Perform neutronics analysis to identify a technically meaningful test submodule configuration</td>
<td>15 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Perform design analysis for heat transfer, structural thermomechanics and electromagnetics</td>
<td>15 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Define fabrication route</td>
<td>15 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>Identify reference test submodule design</td>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Develop International Collaborative Agreements (Initial)</td>
<td>18 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Finalize Design to Specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td>Initial fabrication drawings</td>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>Preliminary technical specification documents</td>
<td>12 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Assess Design Issues and Risks</td>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Finalize Project Management Plan (including final international collaborative agreements)</td>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Preliminary Design Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Cost

| Total Cost | 502,920 | 596,542 | 377,420 |

Overlapping in schedule implies that an iteration process is taking place.
## 1.8.2.1.3.1-preliminary design

### FY06 cost details

**US TBM PROGRAM Cost Details and Contingency**

<table>
<thead>
<tr>
<th>WBS/Title:</th>
<th>1.8.2.1.3.1/Preliminary Design</th>
</tr>
</thead>
</table>

### COSTING BY / DATE

Alice Ying  
12/8/2005  
FY06*

<table>
<thead>
<tr>
<th>WBS #</th>
<th>Item #</th>
<th>Schedule Activity</th>
<th>DESCRIPTION</th>
<th>QTY</th>
<th>UNITS</th>
<th>$ / UNIT</th>
<th>PACKAGING &amp; SHIPPING</th>
<th>TOTAL-$</th>
<th>HRS</th>
<th>$HRS (unburdened)</th>
<th>TOTAL-$</th>
<th>SS</th>
<th>BASIS CODE</th>
<th>LABOR CODE</th>
<th>ACQUISITION CODE</th>
<th>RESOURCE CODE</th>
<th>PARTICIPANT CODE</th>
<th>UNBURDENED COST</th>
<th>COMMENTS/ASSUMPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.8.2.1.3.1 YYYY</td>
<td>1 Project definition</td>
<td>-</td>
<td>-</td>
<td>156</td>
<td>149</td>
<td>23,244</td>
<td>20,000</td>
<td>$</td>
<td>$</td>
<td>43,244</td>
<td>10% of 9 months scientist effort; 2 foreign trips + 5 peoples 3 days domestic trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Establish design driving considerations</td>
<td>-</td>
<td>-</td>
<td>156</td>
<td>149</td>
<td>23,244</td>
<td>-</td>
<td>$</td>
<td>-</td>
<td>23,244</td>
<td>10% of 9 months scientist effort, mainly focusing on the impact of fabrication on the choice of design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Perform parametric analysis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>3.1 Neutronic analysis</td>
<td>-</td>
<td>-</td>
<td>1040</td>
<td>149</td>
<td>154,960</td>
<td>-</td>
<td>$</td>
<td>-</td>
<td>154,960</td>
<td>25% of 12 months professional effort. It also includes two graduate students each one year support cost of $90k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2 Thermomechanical EM analysis</td>
<td>ANSYS/CFX/CATIA</td>
<td>5,500.00</td>
<td>$</td>
<td>16,500</td>
<td>1404</td>
<td>209,196</td>
<td>225,696</td>
<td>$</td>
<td>$</td>
<td>43,244</td>
<td>25% of 6 months professional effort. It also includes two graduate students each one year support cost of $90k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3 Define fabrication route</td>
<td>-</td>
<td>-</td>
<td>156</td>
<td>149</td>
<td>23,244</td>
<td>4,000</td>
<td>$</td>
<td>-</td>
<td>4,000</td>
<td>10% of 9 months of professional effort to engage industrial support. 2 domestic trips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Develop international collaboration agreement</td>
<td>-</td>
<td>-</td>
<td>104</td>
<td>178</td>
<td>18,512</td>
<td>10,000</td>
<td>$</td>
<td>$</td>
<td>28,512</td>
<td>5% of 12 months management effort. 2 foreign trips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal** | $ | $ | 19,500 | $ | 34,000 | $ | 502,400 | $ | 26,000 | $ | 382,400 |

Indirects: Industry markups  
Overhead: DOE laboratory markups  

| BURDENED, UNESCALATED COST | $ | $ | $ | $ | $ |

*NOTE: Based on FY05*

**Contingency Technical Risk 0-15**  
**Contingency Cost Risk 0-15**  
**Contingency Schedule Risk**  
**Unknown Unknowns __%**
<table>
<thead>
<tr>
<th>Item #</th>
<th>Activity ID</th>
<th>Description</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Complete Design and Design Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Complete Technical Specification Documents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Develop Contract Agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Establish Material Specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Develop Fabrication Drawings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Establish Qualification Criteria and Non-Destructive Testing Methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Develop Instrumentation Specifics and Wiring Diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Detailed Design Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>TBM Design modification based on prototype testing if necessary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>CD3B Design review</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>429,680</td>
<td>355,280</td>
<td>116,460</td>
<td>119,060</td>
</tr>
</tbody>
</table>

**WBS: 1.8.2.1.3.2 Title III**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Activity ID</th>
<th>Description</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Fabrication support/supervision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>109,000</td>
<td>112,640</td>
<td>115,760</td>
<td>118,880</td>
</tr>
<tr>
<td>Item #</td>
<td>Activity ID</td>
<td>Activity Description</td>
<td>Duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>----------------------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Project Definition (functional needs, performance matrices, design parameters)</td>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Perform Parametric Analyses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>Develop reference test submodule design</td>
<td>12 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Perform neutronics analysis including insertion tubes design</td>
<td>15 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Perform design analysis for heat transfer, structural thermomechanics and electromagnetics</td>
<td>12 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Define fabrication route</td>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Finalize Design to Specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1</td>
<td>Initial fabrication drawings</td>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Preliminary technical specification documents</td>
<td>9 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Assess Design Issues and Risks</td>
<td>9 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Finalize Project Management Plan (including final Preliminary Design Review)</td>
<td>3 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Preliminary Design Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Design Total Cost**

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>76.2 K</td>
<td>540.1K</td>
<td>484.9K</td>
</tr>
</tbody>
</table>

Overlapping in schedule implies that an iteration process is taking place.
Major Deliverables for HCCB
US Responsible
• Test Submodule
• Ancillary Equipments (primary helium flow conditioners, measuring systems for helium, tritium, and test submodule)

Shared responsible Items: Interface Components

<table>
<thead>
<tr>
<th>Port 16</th>
<th>Test Module Configuration</th>
<th>Test Module R&amp;D, Engineering, Mock-up Tests</th>
<th>Prototype and TBM structural box fabrication, testing, QA</th>
<th>TBM material procurement</th>
<th>Helium primary loop and systems</th>
<th>Tritium processing systems</th>
<th>Interface and system integration</th>
<th>Measuring systems</th>
<th>Operating Conditioners for Coolant and for purge</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Half Port</td>
<td>One large module with 2 x 3 unit cells open for parties</td>
<td>68%</td>
<td>60%</td>
<td>68%</td>
<td>17%</td>
<td>100%</td>
<td>16%</td>
<td>100%</td>
<td>100%</td>
<td>US lower cost range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16%</td>
<td>20%</td>
<td>16%</td>
<td>16%</td>
<td>0%</td>
<td>17%</td>
<td>100%</td>
<td>100%</td>
<td>US upper cost range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16%</td>
<td>20%</td>
<td>16%</td>
<td>17%</td>
<td>0%</td>
<td>17%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Lower Half Port</td>
<td>3 submodules</td>
<td>33%</td>
<td>40%</td>
<td>33%</td>
<td>17%</td>
<td>0%</td>
<td>17%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>33%</td>
<td>40%</td>
<td>33%</td>
<td>16%</td>
<td>50%</td>
<td>17%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>34%</td>
<td>20% (Host)</td>
<td>34%</td>
<td>17%</td>
<td>50%</td>
<td>16%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

ITER Test Plan Assumptions
6 parties participation scheme, one helium cooling loop
Space sharing approach
Cost sharing allocation is being used for the US costing activity