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| --- | --- | --- | --- | --- | --- |
|  | Mu2e Project Office  **BASIS of ESTIMATE FORM (BoE)** | | **Document Number:**  Mu2e-doc-1577-v19 (1A) | | |
| **Date of Estimate:** | | |
| 02/02/2012 | | |
| **Prepared by:**  Brian Drendel | | |
| **WBS Section: 475.02.03.04**  **Activity ID:** | **Task Name:** Beam Line Toroids | | | | |
| **Cost Type:**  **\_ x \_ M&S**  **\_ x \_Labor** | **Costing Method:**  \_x\_Engineering Estimate  \_\_\_Prior purchase or experience. Source:  \_\_\_Catalog Price. Source:  \_\_\_Vendor Quote (attached)  **\_\_\_** Other- Description: | | | | |
| **Attach Relevant Documents (including but not limited to):**  RFP, Responses to RFP, Technical Evaluation of RFP, Vendor Quotes, Technical Specifications, drawing numbers | | | | | |
| **Task Duration** (calendar days)  Minimum: 300  Most Likely: 312  Maximum: 320 | | | | | |
| **Task M&S Cost** (FY11$)**:**  Minimum: $12K  Most Likely: $17.3K ($13.8K)  Maximum: $62.1K ($49.7K)  **Task M&S Contingency (%) for most likely cost:** 25%. *The minimum cost is derived from the base cost minus some cost savings opportunity and does not include contingency. The most likely cost lists two numbers. The number inside of parenthesis is the base cost without contingency. The number not in parenthesis is the most likely cost, which is the base cost plus contingency. The maximum cost also has two numbers. The number inside of parenthesis is the base cost plus risks without contingency. The number outside of the parenthesis is the maximum cost, which is the base cost plus risks with contingency added.* | **Task Labor** (Functional Role & work hours, 85% efficiency assumed)**:**  **Task Labor Contingency for most likely duration** (25%)**:** *The minimum hours are derived from the base hours minus some cost savings opportunity and does not include contingency. The most likely hours lists two numbers. The number inside of parenthesis is the base hours without contingency. The number not in parenthesis is the most likely hours, which is the base hours plus contingency. The maximum numbers column also has two numbers. The number inside of parenthesis is the base hours plus risks without contingency. The number outside of the parenthesis is the maximum hours, which is base hours plus risks with contingency added.* | | | | |
| **Functional Role**  **(from docdb # XXXX)** | **Minimum Hours** | | **Most Likely Hours (\*)** | **Maximum Hours** |
| Engineering Physicist (FN.AD.TE.OT.EP) | 20 | | 50 (40) | 75 (60) |
| Electrical Engineer  (FN.AD.EN.EE) | 1538 | | 1922.5 (1538) | 2275 (1820) |
| Electrical Technician  (FN.AD.TE.ET) | 1734 | | 2197.5 (1758) | 2756.25 (2205) |
| Front End Programmer (FN.AD.EN.EE.CS) | 2080 | | 2600 (2080) | 2925 (2340) |
| Machine Shop (FN.AD.TE.ML) | 60 | | 75 (60) | 675 (540) |
| Mechanical Drafter (FN.AD.TE.DE.MF) | 43 | | 53.75 (43) | 166.25 (133) |
| Mechanical Engineer (FN..AD.EN.ME) | 43 | | 53.75 (43) | 166.25 (133) |
| Mechanical Technician (FN.AD.TE.MT) | 43 | | 53.75 (43) | 166.25 (133) |
| Vacuum/Alignment Crew (FN.PD.TE.AL) | 60 | | 75 (60) | 150 (120) |
| Continued… |  | |  |  |
| EE Support Designer (FN.AD.TE.DE.ED) | 120 | | 200 (160) | 200 (160) |
|  | EE Support Drafter (FN.AD.TE.DE.DR) | 120 | | 200 (160) | 200 (160) |

\*There are three options being considered for the “Most Likely” scenario. I have chosen to display the cost of the least expensive option. Complete costs for all options are outlined below.

Details of Estimate:

This Basis of Estimate covers the Post-CD0 design, post-CD1 preliminary and finals designs, and post CD-3 implementation & close-out tasks associated with upgrading the beam line toroids for Mu2e operation. This covers the toroids in the P1, P2, M1, Delivery Ring Abort, M2 and M3 and Line. This BoE does not cover any toroids upstream of the P1 line or in the Delivery Ring extraction line. Below is a breakdown of the most likely manpower needed to complete the project. The first tasks listed are those involving the engineering planning and oversight.

**Engineering Oversight (management) Labor:**

|  |  |  |  |
| --- | --- | --- | --- |
| Engineering Physicist (hours) | | | |
|  | Minimum/Likely/Maximum | | |
| 475.02.02.03.04.A.01.012010 Post CD-0 Conceptual Design | 5 | 10 | 15 |
| 475.02.02.03.04.A.02.013010 Post CD-1 Preliminary Design | 5 | 10 | 15 |
| 475.02.02.03.04.A.02.013020 Post CD-1 Final Design | 5 | 10 | 15 |
| 475.02.02.03.04.A.03.014010 Post CD-3 Implementation & Close-out | 5 | 10 | 15 |
| Total | 20 | 40 | 60 |

Toroids will be the primary beam intensity measurement device for each of the beam lines. Labor and M&S numbers are taken from our Beam Line Toroid costing spreadsheet1, and include both materials as well as contract electricians for cable pulls. M&S for the Beam Line Toroids is divided into minimum, most likely and maximum scenarios defined as follows:

* Minimum: Use existing toroids and insulators, and do not add a second toroid to the AP3 line. Except at new location for TOR109, all tunnel installations only have general maintenance performed on them. VME crate, controllers and timing cards will be repurposed from other locations.
* Most Likely:
  + (1\*) Use existing toroids and insulators, and do not add a second toroid to the AP3 line. Except at new location for TOR109, all tunnel installations only have general maintenance performed on them. VME crate, controllers and timing cards will be repurposed from other locations. New transition board for analog conditioning will be designed and procured.
  + (2) Use existing toroids and insulators. TOR109 will be moved. Install spare toroid and insulator from AP2 line to add a second toroid to the AP3 line. Only 2 tunnel installations will be replaced; all others only have general maintenance performed on them. VME crate, controllers and timing cards will be repurposed from other locations. New transition board for analog conditioning will be designed and procured.
  + (3) Use existing toroids and insulators. TOR109 will be moved. Install newly purchased toroid (3100) and insulator to add a second toroid to the AP3 line. Only 2 tunnel installations will be replaced; all others only have general maintenance performed on them. VME crate, controllers and timing cards will be repurposed from other locations. New transition board for analog conditioning will be designed and procured.
* Maximum: Use existing toroids and insulators. Install newly purchased toroid (3100) and insulator to add a second toroid to the AP3 line. All tunnel installation will be reviewed and modifited to follow standardized system model. New VME crate, controllers and timing cards will be purchased. New transition board for analog conditioning will be designed and procured.

Costing assumes that the pre-target beam transport path is identical to g-2.Mu2E estimates assumes all work on the pretarget transport was done for g-2, except for moving Mu2E. To simplify Mu2E estimates, It is assumed g-2 work included (1) installation of a 2nd toroid in the P2line, (2) procurement of a signal conditional board for all pretarget toroids, and (3) installation of VME electronics for all pre-target toroids.   
A summary of the labor costing is provided below1.

**Labor** **(EDIA and Implementation):**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Minimum | Most Likely | | | Maximum |
|  |  | (1\*) | (2) | (3) |  |
| Electrical Engineer | 1538 | 1538 | 1790 | 1804 | 1820 |
| Electrical Technician | 1734 | 1758 | 2070 | 2073 | 2205 |
| Front End Programmer | 2080 | 2080 | 2340 | 2340 | 2340 |
| Machine Shop | 60 | 60 | 180 | 240 | 540 |
| Mechanical Drafter | 43 | 43 | 87 | 87 | 133 |
| Mechanical Engineer | 43 | 43 | 87 | 87 | 133 |
| Mechanical Technician | 43 | 43 | 87 | 87 | 133 |
| Vacuum/Alignment Crew | 60 | 60 | 120 | 120 | 120 |
| EE Support Designer | 120 | 160 | 160 | 160 | 160 |
| EE Support Drafter | 120 | 160 | 160 | 160 | 160 |

M&S numbers for the implementation stage will involve the cost of materials used to upgrade the beam line toroids for Mu2e operation. A summary of the M&S costing is provided below1:

**M&S (EDIA and Implementation):**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| M&S 475.02.02.03.04.A Beam Line Toroids | | | | | |
|  | Minimum | Most Likely | | | Maximum |
|  |  | (1\*) | (2) | (3) |  |
| Totals | $12K | $13.8K | $21.2K | $26.2K | $49.7K |

References:

1. A. Ibrahim, B. Drendel, “Toroid and DCCT upgrade for Mu2e Storage Rings and Beam Lines,” Mu2e Documents Database #1180, January 2012.