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|  | Mu2e Project Office  **BASIS of ESTIMATE FORM (BoE)** | | **Document Number:**  Mu2e-doc-1639-v14  (Machine Protection) | | |
| **Date of Estimate:** | | |
| 10/17/2011 | | |
| **Prepared by:**  Brian Drendel | | |
| **WBS Section: 475.02.11.04**  **Activity ID:** | **Task Name:** Operations Preparations – Machine Protection - Beam Permits for Aborts. | | | | |
| **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:  **365**  Most Likely: 365  Maximum: 365 | | | | | |
| **Task M&S Cost** (FY11$)**:**  Minimum: $33K  Most Likely: $121K ($93K)  Maximum: $280K ($215K)  **Task M&S Contingency (%) for most likely cost:** 30%. *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 | | 62.5 (50) | 100 (80) |
| Controls Engineer (FN.AD.EN.EE.CS) | 480 | | 600 (480) | 1200 (960) |
| Controls Technician (FN.AD.TE.ET.EL) | 360 | | 575 (460) | 900 (720) |
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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 Pbar Beam Permit system to handle separate beam aborts for the Accumulator and Debuncher.. 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):**

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| --- | --- | --- | --- |
| Engineering Physicist (hours) | | | |
|  | Minimum/Likely/Maximum | | |
| 475.02.11.04.01.012010 Post CD-0 Conceptual Design | 5 | 10 | 20 |
| 475.02.11.04.02.013010 Post CD-1 Preliminary Design | 5 | 10 | 20 |
| 475.02.11.04.02.013020 Post CD-1 Final Design | 5 | 10 | 20 |
| 475.02.22.04.03.014010 Post CD-3 Implementation & Close-out | 5 | 10 | 20 |
| Total | 20 | 50 | 80 |

The Beam Permit system will consist of three beam permits:

* AP1/AP3/Accumulator Permit
  + Will use existing Pbar beam permit infrastructure.
    - Beam permit loop goes MCR->AP10->AP30->F27->AP0 S->F23->AP0 N->AP50->AP10->MCR
    - We may move the abort permit over to a fiber optic link. The costing for the installation of this fiber optic link is covered in the Storage Rings Controls BoE (475.02.04.06)2 and Beam Lines Controls BoE (475.02.02.03)3.
  + If we lose permit conditions, permit drops immediately and we send beam to Accumulator abort.
  + This permit will provide the single input back to the BSSB. This means a single beam switch and single beam permit, with no BSSB hardware replacement costs.
  + The Camac 201 module will need to be moved from the MCR to the location of the Accumulator abort kicker (AP50).
  + Camac 479 card will also be located at AP50 to monitor clock events and fall of the abort permit.
* Debuncher Permit:
  + A second loop will be made for the Debuncher.
  + New cabling will need to be pulled between service buildings...AP50->AP30->AP10->AP50.
    - While new cabling is being pulled a spare set should also be pulled as it won't add much to the cost.
    - We will also need to pull cable out to the new Mu2e experimental building.
    - Cable runs will need to be copper due to expected radiation levels and the fact that some of the cable runs go through the tunnel enclosures.
    - The costing for the cable pulls are covered in the Storage Rings controls BoE (475.02.04.06)2, and Beam Lines Controls BoE (475.02.02.03)3. They are not part of this cost estimate.
  + The Debuncher beam permit will provide a single input to the AP1/AP3/Accumulator beam permit.
  + When the Debuncher beam permit goes away, we immediately abort the Debuncher beam, and pull the AP1/AP3/Accumulator permit.
  + Camac 201 and 479 cards will need to be located near the abort kicker at AP50.
* P1/P2 Permit:
  + These two permits will be combined if we don't have need to send beam to the Tevatron.
  + If this permit goes away, the Accumulator beam permit is dropped.

Labor and M&S numbers are taken from our costing documentation1, and include both materials as well as contract electricians for cable pulls. Cost estimates are divided into minimum, most likely and maximum scenarios defined as follows:

* Minimum: Assumes we can split the costing for the BSSB evenly with LBNE, we can use existing multimode fiber optic cable between AP10, AP30 and AP50 for both abort links, can repurpose and refurbish Tevatron Camac 200 modules, and do not require any additional Camac 204 modules. Abort link cabling will still need to be pulled between AP30 and the Mu2e experimental hall.
* Most Likely: Assumes we can split the costing for the BSSB evenly with LBNE, we can use existing multimode fiber optic cable between AP10, AP30 and AP50 for both abort links, can repurpose and refurbish Tevatron Camac 200 modules, and require one additional Camac 204 module per beamline building. Abort link cabling will still need to be pulled between AP30 and the Mu2e experimental hall.
* Maximum: Assumes we can split the costing for the BSSB evenly with LBNE, we have to pull new multimode fiber optic cable between AP10, AP30, AP50 and the Mu2e experimental hall for both abort links, can repurpose and refurbish Tevatron Camac 200 modules, and require two additional Camac 204 module per service building.

A summary of the labor costing is provided below1:

**Beam Switch Sum Box (EDIA and Implementation)**: Labor associated with upgrading the BSSB to incorporate the Mu2e beam permit systems.

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| --- | --- | --- | --- |
| Labor 475.02.11.04.01.012010 Post CD-0 Conceptual Design  475.02.11.04.02.013010 Post CD-1 Preliminary Design  475.02.11.04.02.013020 Post CD-1 Final Design  475.02.22.04.03.014010 Post CD-3 Implementation & Close-out | | | |
|  | Minimum/Likely/Maximum (hours) | | |
| Controls Engineer | 480 | 480 | 960 |
| Controls Technician | 160 | 160 | 320 |

**CAMAC Abort Loop Hardware (EDIA and Implementation)**: Labor costs associated with refurbishing unused Tevatron Camac abort equipment hardware for Mu2e operation. This includes Camac 200, 201 and 479 modules. There are 16 hours of technician time per Camac 200 module. Overall efforts will require one (minimum), 1.5 (most likely) or 2.0 (maximum) FTE man months of technician time.

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| Labor 475.02.11.04.01.012010 Post CD-0 Conceptual Design  475.02.11.04.02.013010 Post CD-1 Preliminary Design  475.02.11.04.02.013020 Post CD-1 Final Design  475.02.22.04.03.014010 Post CD-3 Implementation & Close-out | | | |
|  | Minimum/Likely/Maximum (hours) | | |
| Controls Technician | 200 | 300 | 400 |

M&S numbers for the implementation stage will involve the cost of materials used to upgrade the beam permit system as well as the cost of contract electricians to pull cable. A summary of the M&S costing is provided below1:

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

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| --- | --- | --- | --- |
| M&S 475.01.11.04 | | | |
|  | Minimum/Likely/Maximum | | |
| BSSB Modifications | $32.5K | $32.5K | $65K |
| Camac Parts | 0 | $10K | $20K |
| Multimode Cable for abort loop | 0 | 0 | $20K |
| Terminations/Shelves for cable | 0 | 0 | $30K |
| Electricians ($1600/week/2 person team) | 0 | 0 | $35K  (10 days) |
| Yet to be determined M&S items | 0 | $50K | $100K |
| Total | $32.5K | $92.5K | $215K |

The minimum and most likely scenarios assume that the existing multimode fiber between the service buildings can be used and no BSSB modifications are needed. The Maximum scenario assumes that new cable must be pulled. Cable pulls between AP30 and the new experimental building are covered in the Controls BoE.

References:

1. B. Drendel, et el, “Mu2e Storage Rings and Beam Lines Machine Protection,” Mu2e Documents Database #1349, June 2011.
2. B. Drendel, “BoE 475.02.04.06: Mu2e Storage Rings Controls,” Mu2e Documents Database #1468, June 2011.
3. B. Drendel, “BoE 475.02.03.03: Mu2e Transport Lines to Storage Rings Controls,” Mu2e Documents Database #1572, June 2011.