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|  | Mu2e Project Office **BASIS of ESTIMATE FORM (BoE)** | **Document Number:** Mu2e-doc-1572 v-12 |
| **Date of Estimate:**  |
| 10/14/2011 |
| **Prepared by:**Brian Drendel |
| **WBS Section: 2.03.03****Activity ID:**  | **Task Name:** Beam Line Controls |
| **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: 210Most Likely: 800Maximum: 910 |
| **Task M&S Cost** (FY11$)**:** Minimum: $227KMost Likely: $430K ($344K) Maximum: $846K ($677K) **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) | 80 | 200 (160) | 375 (300)  |
| Computer Professional(FN.AD.EN.EE.CS) | 390 | 1300 (1040) | 2388 (1910) |
| Electrical Engineer(FN.AD.EN.EE) | 110 | 600 (480) | 1338 (1070) |
| Electrical Technician(FN.AD.TE.ET) | 595 | 1470 (1838) | 3325 (2660)  |

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 Recycler to Accumulator beam transport lines controls for Mu2e operations. Controls for these areas span the MI-60, F0, F1, F23, F27, AP-0 and AP-30 service buildings and can be broken down into two general categories:

1. **Links and Camac**: Estimate includes inventory of existing serial links and Camac crates1 to determine if the current infrastructure can be repurposed for Mu2e operations, as well as constructing and implementing a plan to move CAMAC crates, cards and links for Mu2e operation. We have an ample supply of spare Camac cards and crates, and the current crate and link structure is believed to be adequate. A large portion of the implementation effort will involve technician time for moving crates and cards and computer professional time to update parameter database information.
2. **Hot Rack Monitor (HRM)**: A number of Camac modules have become end of life and will be upgraded to a VME platform that talks to the controls system via Ethernet. Camac 190/290 cards will be replaced by HRM installations. Installing HRMs will provide 16 bit A/D readbacks, DAQ, I/O and clock channels. The minimum estimate will include one HRM installations, the most likely estimate will include 8 HRM installations and the maximum installation will include 10 installations.
3. **Network**: Estimate includes analysis of current network infrastructure to determine if the existing network equipment1 is adequate for Mu2e operations, planning and implementing the upgrade of legacy equipment. The controls wireless networks at F23 and F27 and the shared 10MBps network at AP0 are believed to be inadequate and will need to be upgraded. The most economical solution would be to run fiber messenger cable attached to the existing struts that support the cryo pipe on the Tevatron berm. The cable would run from MI60 to AP0 and then to F23 and F27. New network switches will need to be installed in the buildings. A large portion of the implementation labor effort will involve technician time to make Ethernet connections from each end node to the central network switch in each service building.

These efforts do not include upgrades to the beam permit system, which are covered by the machine protection section of operational preparedness. These efforts include consultation with controls experts from existing systems to determine an initial conceptual design. Below is a breakdown of the most likely manpower needed for each. We will start with engineering oversight, Camac and Network work.

**Conceptual Design: Engineering Oversight (Management), Camac and Network:**

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| 475.02.03.03.01.012010 Post CD-0 Conceptual Design |
|  | Engineering Physicist (FTE)Minimum/Likely/Maximum | Computer Professional (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 5 | 10 | 20 | 5 | 10 | 20 |
| HRM Installation | 5 | 10 | 20 | 5 | 10 | 20 |
| Network | 5 | 10 | 20 | 5 | 10 | 20 |
| Totals | 15 | 30 | 60 | 15 | 30 | 60 |

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| 475.02.03.03.01.012010 Post CD-0 Conceptual Design |
|  | Engineer (FTE)Minimum/Likely/Maximum |  |
| Serial Link and Camac | 5 | 10 | 20 |  |  |  |
| HRM Installation | 5 | 10 | 20 |  |  |  |
| Network | 5 | 10 | 20 |  |  |  |
| Totals | 15 | 30 | 60 |  |  |  |

**Preliminary Design: Engineering Oversight (Management), Camac and Network:**

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| 475.02.03.03.02.013010 Post CD-1 Preliminary Design |
|  | Engineering Physicist (FTE)Minimum/Likely/Maximum | Computer Professional (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 5 | 10 | 20 | 5 | 10 | 20 |
| HRM Installation | 5 | 10 | 20 | 5 | 10 | 20 |
| Network | 5 | 10 | 20 | 5 | 10 | 20 |
| Totals | 15 | 30 | 60 | 15 | 30 | 60 |

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| 475.02.03.03.02.013010 Post CD-1 Preliminary Design |
|  | Engineer (FTE)Minimum/Likely/Maximum |  |
| Serial Link and Camac | 5 | 10 | 20 |  |  |  |
| HRM Installation | 5 | 10 | 20 |  |  |  |
| Network | 5 | 10 | 20 |  |  |  |
| Totals | 15 | 30 | 60 |  |  |  |

**Final Design: Engineering Oversight (Management), Camac and Network:**

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| 475.02.03.03.02.013020 Post CD-2 Final Design |
|  | Engineering Physicist (FTE)Minimum/Likely/Maximum | Computer Professional (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 5 | 10 | 20 | 10 | 20 | 30 |
| HRM Installation | 5 | 10 | 20 | 10 | 20 | 30 |
| Network | 5 | 10 | 20 | 10 | 20 | 30 |
| Totals | 15 | 30 | 60 | 20 | 60 | 90 |

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| 475.02.03.03.02.013020 Post CD-2 Final Design |
|  | Engineer (FTE)Minimum/Likely/Maximum | Technician (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 10 | 20 | 30 | 5 | 10 | 20 |
| HRM Installation | 10 | 20 | 30 | 5 | 10 | 20 |
| Network | 10 | 20 | 30 | 5 | 10 | 20 |
| Totals | 20 | 60 | 90 | 15 | 30 | 60 |

**Implementation and Closeout: Engineering Oversight (Management), Camac and Network:**

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| 475.02.03.03.03.014010 Post CD-3 Implementation & Close-out |
|  | Engineering Physicist (FTE)Minimum/Likely/Maximum | Computer Professional (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 5 | 10 | 20 | 100 | 200 | 300 |
| HRM Installation | 5 | 10 | 20 | \* | \* | \* |
| Network | 5 | 10 | 20 | 200 | 400 | 600 |
| Totals | 15 | 30 | 60 | 300 | 600 | 900 |

\*Covered in HRM labor estimate below.

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| 475.02.03.03.03.014010 Post CD-3 Implementation & Close-out |
|  | Engineer (FTE)Minimum/Likely/Maximum | Technician (FTE)Minimum/Likely/Maximum |
| Serial Link and Camac | 10 | 20 | 10 | 200 | 300 | 400 |
| HRM Installation | \* | \* | \* | \* | \* | \* |
| Network | 10 | 20 | 10 | 300 | 500 | 600 |
| Totals | 20 | 60 | 20 | 500 | 800 | 1000 |

\*Covered in HRM labor estimate below.

**HRM assembly, testing and installation (EDIA and Implementation).** Installation of HRMs in MI60, F0, F1, F23, F2, F27 and AP0 connected to the beam lines. Does not include storage ring buildings nor the Mu2e experimental hall. These numbers were gathered from out costing documentation2.

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| Labor Hours 475.02.03.03.01.012010 Post CD-0 Conceptual Design 475.02.03.03.02.013010 Post CD-1 Preliminary Design475.02.03.03.02.013020 Post CD-2 Final Design 475.02.04.06.03.014010 Post CD-3 Implementation & Closeout |
|  | Minimum(1 installations) | Most Likely(8 installations) | Maximum(20 installations) |
| Electrical Engineer (1 week/installation) | 40 | 320 | 800 |
| Electrical Technician (2 weeks/installation) | 80 | 640 | 1600 |
| Computer Professional (1 week/installation) | 40 | 320 | 800 |

M&S numbers divided up by category.

**Camac M&S (EDIA and Implementation):** Upgrading Camac hardware in MI60, F0, F1, F23, F2, F27 and AP0 connected to the beam lines. Does not include storage ring buildings nor the Mu2e experimental hall. These numbers were gathered from out costing documentation2.

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| M&S 475.02.04.06.03.014010 Post CD-3 Implementation & Closeout |
|  | Minimum | Most Likely | Maximum |
| Camac Equipment | $5K | $10K | $40K |
| Totals | $5K | $10K | $40K |

**HRM Installation M&S (EDIA and Implementation):** Installation of HRMs in MI60, F0, F1, F23, F2, F27 and AP0 connected to the beam lines. Does not include storage ring buildings nor the Mu2e experimental hall. These numbers were gathered from out costing documentation2.

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| M&S475.02.04.06.03.014010 Post CD-3 Implementation & Closeout |
|  | Minimum(1 installations) | Most Likely(8 installations) | Maximum(20 installations) |
| VME 7 crate slot/power supply | $4.5K | $36K | $90K |
| Processor cards | $3.0K | $24K | $60K |
| HRM (128 analog inputs/HRM) | $7.0K | $56K | $140 |
| Fan In box | $1.0K | $8K | $20K |
| Totals | $15.5K | $124K | $310K |

**Network M&S (EDIA and Implementation):** Installation of network fiber and switches in MI60, F0, F1, F23, F2, F27 and AP0 connected to the beam lines. Does not include storage ring buildings nor the Mu2e experimental hall. These numbers were gathered from out costing documentation2.

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| M&S 475.02.04.06.03.014010 Post CD-3 Implementation & Closeout |
|  | Minimum | Most Likely | Maximum |
| Messenger Fiber(5,000 feet at $3.00/foot) | $15K | $15K | $15K |
| Parts and Terminations | $15K | $15K | $15K |
| Network Switches ($2K - $3K/switch)(Use MI60 backbone switch) | $8K(4 $2K switches) | $12K(4 $3K switches) | $24K(8 $3K switches) |
| Electricians ($3500/day) | $105K(30 days) | $105K(30 days) | $210K(30 days) |
| Totals | $143K | 147K | $264K |

**Network M&S (EDIA and Implementation)**: Installation of network multimode and single mode fiber and a network switch to the Mu2e experimental hall. These numbers were gathered from out costing documentation2.

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| M&S 475.02.04.06.03.014010 Post CD-3 Implementation & Closeout |
|  | Minimum | Most Likely | Maximum |
| Fiber from Mac Room(3,000 feet) | $10K | $10K | $10K |
| Parts and Terminations | $15K | $15K | $15K |
| Network Switch  | $3K | $3K | $6K(2 $3K switches) |
| Electricians ($3500/day) | $35K(10 days) | $35K(10 days) | $35K(10 days) |
| Totals | $63K | 63K | $63K |

References:

1. B. Drendel, “Pbar Controls for Mu2e,” Mu2e Document Database #1161, November 2010.
2. B Drendel, et al, “Mu2e Storage Rings and Beam Lines Controls Costing,” Mu2e Document Database #1611, June 2011.