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| Delivery Ring Beam Position Monitors AIP  **BASIS of ESTIMATE FORM (BoE)** | **Document Number:** Mu2e-doc-2226  **Date of Estimate:** 5/3/12  **Prepared by:**  Peter Prieto, Brian Drendel |

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| WBS Category Number: MuAIP.03.05.01  WBS Category Name: Ring Beam Position Monitor  Control Account (number and name): |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |
| External Supporting Documents: B. Drendel, P. Prieto, “Beam Line and Delivery Ring BPM upgrades for Mu2e,” Mu2e Documents Database #2230, May 1, 2012 |

Update the Delivery Ring Beam Position Monitors to enable beam position measurements for Mu2e operations. Modify existing electronics, hardware and cabling to meet updated performance requirements.

**Preliminary Design:**

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| WBS Category Name: Preliminary Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The preliminary design will continue to develop requirements and specifications for improvements and upgrades to components/hardware and provide data for completing the design effort. The information will also establish data for use by project management to determine a high confidence level in the specifications. Effort will focus on providing documentation to determine if the proposed design meets project requirements.

**Preliminary Design Labor:**  Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.01.02 | Engineering design and oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 20 | 30% | 26 |
| MuAIP.03.05.01.02 | System Design (Conceptual?) | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 20.25 | 30% | 26.3 |
| MuAIP.03.05.01.02 | 2.5MHz Transition Board Design | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 9.5 | 30% | 12 |
| MuAIP.03.05.01.02 | 2.5MHz Transition Board Layouts | FNAD.ELEC.DRAFTER (Electrical Drafter) | 120 | 30% | 156 |
| MuAIP.03.05.01.02 | BPM Software design | FNAD.APDEV.SYSTMAYST (Computer Professional) | 500 | 30% | 650 |
| MuAIP.03.05.01.02 | Digital Downconverter software design | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 30 | 30% | 39 |

(labor estimates assume 85% efficiency)

**Final Design Labor:**

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| WBS Category Name: Final Design of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

The final design will provide the documents necessary to repurpose and upgrade required components/hardware. Effort will focus on finalization of documentation.

**Final Design Labor:** Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.01.03 | Engineering design and oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 20 | 30% | 26 |
| MuAIP.03.05.01.03 | System Integration and manufacture of | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 8.0 | 30% | 10 |
| MuAIP.03.05.01.03 | System Integration and manufacture | FNAD.ELTN.TECH (Electronics Technician) | 160 | 30% | 208 |

(labor estimates assume 85% efficiency)

**Implementation:**

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| WBS Category Name: Implementation of infrastructure improvements to the beam lines |
| Costing Method:  \_\_\_ Existing P.O. \_\_\_ Prior Experience (source: )  \_\_\_ Catalog Listing / Vendor Quote \_\_\_ Expert Opinion  \_\_\_ Budgetary Estimate \_\_\_ Pre-conceptual Design  \_X\_ Engineering Experience \_\_\_ Other (description: ) |

Implementation will include the installation of components and hardware necessary to support a fully functioning system. Effort will involve repurpose and refurbishing of components to meet project requirements. Included will be the installation and testing of items to ensure functionality.

**Implementation M&S and Labor:** Costing was determined via consultation Accelerator Division Instrumentation Engineers and is detailed in the supporting documentation1. Contingencies follow labor contingency rule #3. M&S contingencies were determined by M&S contingency rule #5.

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| **Activity ID** | **Description** | **Resource ID**  **(mu2e-doc-1305)** | **Base Est.**  **(hours)** | **Cont.**  **(%)** | **Base Est. + Cont.**  **(hours)** |
| MuAIP.03.05.01.04 | BPM Electronics | FN.M&S.STND | $15.92K | 40% | $22.3K |
| MuAIP.03.05.01.04 | Engineering design and oversight | FNAD.ENGNRING.PHYST (Engineering Physicist) | 25 | 30% | 33 |
| MuAIP.03.05.01.04 | Installation and commissioning | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 60 | 30% | 78 |
| MuAIP.03.05.01.04 | Refurbish and installation of components | FNAD.ELTN.TECH  (Electronics Technician) | 41.5 | 30% | 54 |
| MuAIP.03.05.01.04 | Documentation | FNAD.ELTN.DESIGN.EN (Electronics Engineer) | 80 | 30% | 104 |

(labor estimates assume 85% efficiency)

**M&S: Detailed cost breakdown**

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| Hardware Costs | | |
|  | Quantity | Total Cost |
| MVME4320 processors | 3 | 0 |
| VME64X Crates | 3 | 0 |
| Accumulator Transition Boards | 0 | 0 |
| DDC Boards (Echotek) | 12 | 0 |
| Timing PMC clock Modules | 3 | 0 |
| Bsync Decoders, Clock Decoders | 3 | 0 |
| DeBuncher Transition Boards | 12 | 0 |
| Modifications to DeBuncher transition boards | 12 | $1,020.00 |
| DownConverter Boards | 12 | 0 |
| Transition Panels from top plate to transition boards | 3 | $8,700.00 |
| Cables (N- to N connectors), Top Plate to Transition Panel | 96 | $4,800.00 |
| Cables, Transition Boards to DDCs | 96 | 0 |
| Sync Cables, Timing board to DDCs | 12 | $200.00 |
| Clock Cables from timing board to DDCs | 12 | $200.00 |
| Miscellanous Connectors (sma to smb), cables |  | 2,000.00 |
| Power supplies for Transition Board Crates | 3 | 0 |
| Transition Board Crates | 3 | 0 |
| Totals |  | $15,920.0 |

**Additional Background Information**

This Basis of Estimate covers

1. Removing old BPM electronics hardware from the Delivery Ring (Debuncher).
2. Modify Recycler analog transition boards to handle expected signal intensity produced by a 1e12 ppb (2.5 MHz) in the Delivery Ring.
3. Design a plate which transitions N-type connectors to DB-9 connectors allowing BPM signals to connect to 2.5 MHz transition board DB -9 input connectors.
4. Design and test 2.5 MHz filters in the digital down-converter boards installed in the Debuncher.
5. Install VME64X crates in Delivery Ring service building.
6. Purchase MVME5500 processor boards to be used as crate controllers or if any available from TeV BPM system use those.
7. Make # of Top Plates for the relay racks where the VME64X crates will be installed.
8. Modify transition boards to handle signal intensity in the 2.5 MHz channel which is already implemented in the existing transition boards.
9. Develop front-end software in the BPM system that can be used with Debuncher control system.
10. Develop code to process signals from the digital down converter boards and produce a beam position signal.

References:

1. B. Drendel, P. Prieto, “Beam Line and Delivery Ring BPM upgrades for Mu2e,” Mu2e Documents Database #2230, May 1, 2012