Fermilab

U.S. DEPARTMENT OF ENERGY Office of Science

Mu2e Accelerator Upgrades Procedures

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Level 2 Manager: Mu2e Accelerator Upgrades

7/8/2014

Outline

- Cost Estimating Procedures
- Mu2e BOEs
- BOE Review
- Issues
  - Review discrepancies
  - Additional External Beamline Costs

Cost Estimate Procedure

1. Project Controls (Mike Gardner) generates a BOE report that contains an entry for every activity in the schedule (example on next slide).
   - Sent to every L3 manager and selected L4 managers. Posted to Mu2e-doc-3001
   - Updated Monthly
2. L3 and L4 managers in consultation with technical experts enter the resources, estimate uncertainties, and estimate types into the BOE report and return it to project controls.
3. Mike Gardner meets face-to-face with each L3/L4 manager to transfer the resource data into the schedule along with any associated schedule logic. This is an iterative process – adjustments are made as the schedule and cost estimates evolve.
4. L3 and L4 managers generate BOE forms that contain the justification for the resources loaded for each activity.
5. The BOEs are reviewed by a BOE review team (Steve Werkema, Vladimir Nagaslaev, Mike Campbell, and Brian Drendel)

BOE Report

WBS	WBS Name	Activity ID	Activity Name	Most Likely Duration	Estimate Type Activity Level	Division / Section	Resource Name	Most Likely Units	Estimate Uncertainty Factor	Resource Note	Predecessors	BOE DocDB
475.02W.03.01.1	Transport Controls and Delivery Ring Controls	47502.03.01.1.001195	Coordinate Implementation Plan with Delivery Ring AIP	30	L3	AD	Control System Engineer	8	0.25	G Brown	47502.03.01.1.001190	3703
		47502.03.01.1.001200	Purchase Network & Communication Hardware Implementation and Closeout	30	M4		M&S Standard with Base Year FY14	5000	0.25	Repurposed / Pro Card	47502.01.02.001050, 47502.03.01.1.001195	3703
		47502.03.01.1.001220	Abort Link Implementation	60	L4	AD	Engineering Physicist	10	0.3	A Franck	47502.03.01.1.001200	3703
							Electronics Design Engineer	100	0.3	D McArthur	47502.03.01.1.001200	3703
							Control System Engineer	47	0.3	G Vogel	47502.03.01.1.001200	3703
		47502.03.01.1.001230	Camac and Timing Links Implementation and Closeout	60	L4	AD	Electronics Technician	40	0.3	TBD	47502.01.02.001050, 47502.03.01.1.001200	3703
							Control System Engineer	10	0.3	G Vogel	47502.01.02.001050, 47502.03.01.1.001200	3703
		47502.03.01.1.001240	Network Installation Implementation and Closeout	60	L4	AD	Electronics Technician	16	0.3	S Conlon	47502.03.01.1.001200	3703
							Control System Engineer	8	0.3	G Brown	47502.03.01.1.001200	3703
475.02W.03.01.2	Mu2e Experimental Hall Controls	47502.03.01.2.001090	Purchase Controls Hardware	30	M3		M&S Standard with Base Year FY14	31000	0.15		47502.01.02.001050, FY18B02	3553
		47502.03.01.2.001110	Purchase Network and Communication Hardware	30	M3		M&S Standard with Base Year FY14	45800	0.15		47502.01.02.001050, FY18B02	3553
		47502.03.01.2.001130	Pull Innerduct	4	M4		Electrician	128	0.3	Assumes 4 day pull for 4 workers	47502.03.01.2.001110, 47502.03.01.2.001120	3553
		47502.03.01.2.001140	Pull Cable CrossGallery(Xgal) to Mu2e	5	M4		Electrician	160	0.3	5 day pull for 4 workers	47502.03.01.2.001130, 47502.03.01.2.001100, 47502.03.01.2.001090	3553
		47502.03.01.2.001150	Pull Cable AP30 to Mu2e	3	M4		Electrician	96	0.3	3 day pull for 4 workers	47502.03.01.2.001140, 47502.03.01.2.001100, 47502.03.01.2.001090	3553
		47502.03.01.2.001160	Terminate Connectors	20	M4		Electrician	64	0.3	Fiber Terminations	47502.03.01.2.001150, 47502.03.01.2.001140, 47502.03.01.2.001130	3553
		47502.03.01.2.001170	Controls Infastructure	60	L3	AD	Electrical Technician	47	0.2	M Colburn (FIRIS)	47502.03.01.2.001160	3553
								94	0.2	TBD	47502.03.01.2.001160	3553
							Control System Engineer	14	0.2	G Vogel	47502.03.01.2.001160	3553
										A Franck	47502.03.01.2.001160	3553
		47502.03.01.2.001180	Network Infastructure	60	L3	AD	Electrical Technician	9	0.2	S Conlon	47502.03.01.2.001160	3553
							Control System Engineer	5	0.2	G Brown	47502.03.01.2.001160	3553
		47502.03.01.2.001190	HRM Installation	60	L3	AD	Electrical Technician	188	0.2	TBD	47502.03.01.2.001160	3553
							Control System Engineer	4	0.2	G Vogel	47502.03.01.2.001160	3553
							Computing Services Specialist	64	0.2	TBD	47502.03.01.2.001160	3553

This is a small portion of the Instrumentation and Controls part of the BOE report – all of the required information is entered in this example.

Access to Mu2e BOEs

Accelerator BOE Documents

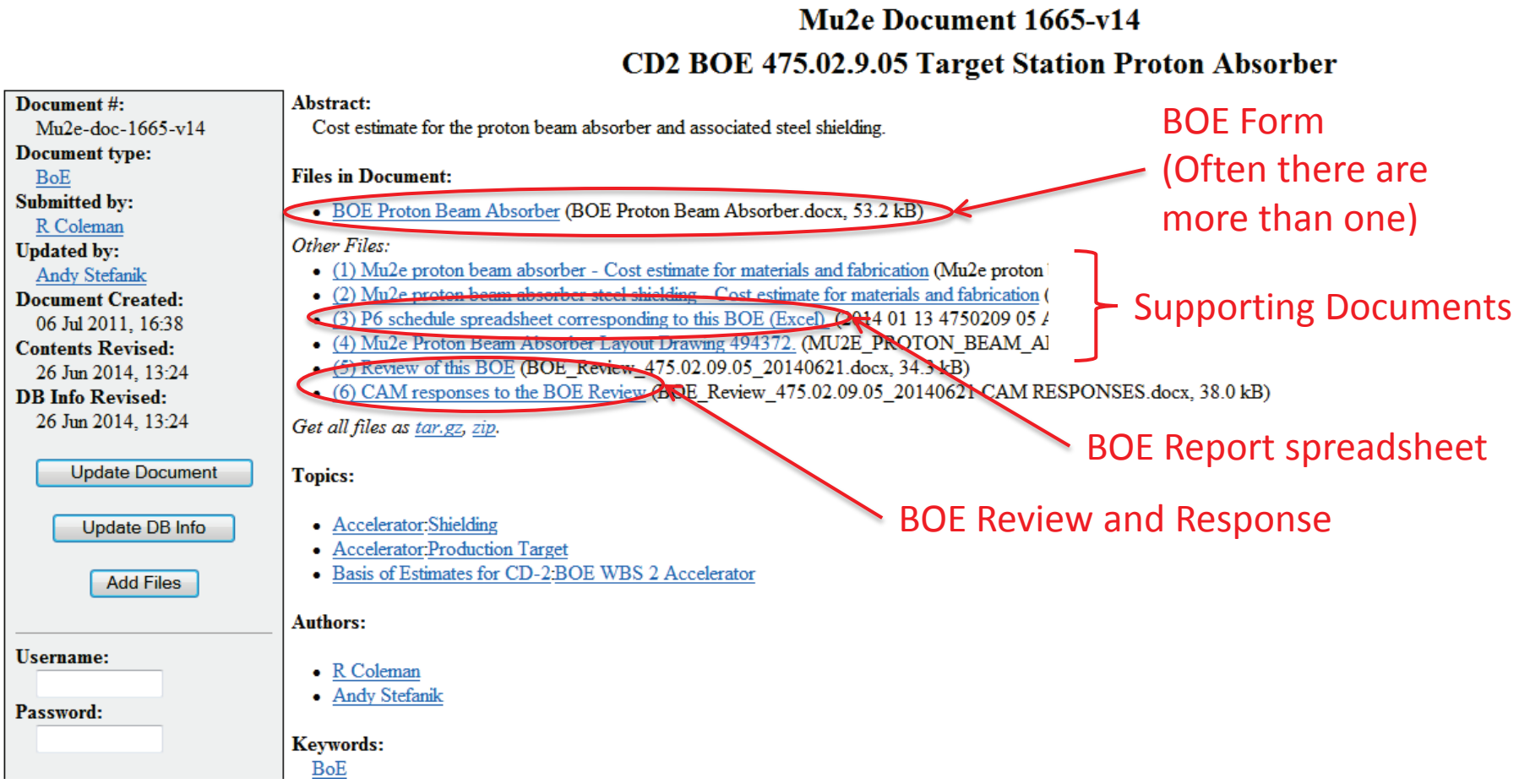
Existing supporting documentation is either bundled with its associated BOE documents or referenced within them.

WBS Number	Task Name	Mu2e doc #
475.02.01	***Project Management***	1888
475.02.03	***Instrumentation & Controls***	
475.02.03.01	*Mu2e Accelerator Controls*	
475.02.03.01.1	Transport Controls & Delivery Ring Controls	3703
475.02.03.01.2	Mu2e Experimental Hall Controls	3553
475.02.03.02	*Delivery Ring Instrumentation*	
475.02.03.02.1	Delivery Ring DC Beam Meausurement	3690
475.02.03.02.2	Delivery Ring Tune Measurement	3689
475.02.03.03	*Extraction Beamline Instrumentation*	
475.02.03.03.1	M4 Line Profile and Intensity Monitors	3675
475.02.03.03.2	M4 Line Beam Loss Monitors	3675
475.02.03.04	*Accelerator Controls and Instrumentation Project Management*	3843
475.02.04	***Radiation Safety Improvements***	
475.02.04.01	*AP1 Line to Delivery Ring Total Loss Monitoring System*	1890
475.02.04.02	*Delivery Ring Raditation Safety Upgrades*	
475.02.04.02.1	In Tunnel Shielding Over Loss Points	1872
475.02.04.02.2	Ring Safety System Total Loss Monitoring	1891

Mu2e Accelerator BOEs are accessible from the Accelerator page on the review web site: http://mu2e.fnal.gov/public/project/reviews/cd2dir-review/accel.shtml

The Mu2e doc # links take you to the Mu2e doc DB item containing the BOE and supporting documents.

BOE Doc DB contents



Mu2e Document 1665-v14

CD2 BOE 475.02.9.05 Target Station Proton Absorber

Document #: Mu2e-doc-1665-v14
Document type: BoE
Submitted by: R Coleman
Updated by: Andy Stefanik
Document Created: 06 Jul 2011, 16:38
Contents Revised: 26 Jun 2014, 13:24
DB Info Revised: 26 Jun 2014, 13:24

Update Document
Update DB Info
Add Files

Username:
Password:

Abstract:
Cost estimate for the proton beam absorber and associated steel shielding.

Files in Document:
- BOE Proton Beam Absorber (BOE Proton Beam Absorber.docx, 53.2 kB)

Other Files:
- (1) Mu2e proton beam absorber - Cost estimate for materials and fabrication (Mu2e proton
- (2) Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication (
- (3) P6 schedule spreadsheet corresponding to this BOE (Excel) (2014 01 13 4750209 05 A
- (4) Mu2e Proton Beam Absorber Layout Drawing 494372. (MU2E_PROTON_BEAM_AI
- (5) Review of this BOE (BOE_Review_475.02.09.05_20140621.docx, 34.3 kB)
- (6) CAM responses to the BOE Review (BOE_Review_475.02.09.05_20140621 CAM RESPONSES.docx, 38.0 kB)

Get all files as tar.gz, zip.

Topics:
- Accelerator:Shielding
- Accelerator:Production Target
- Basis of Estimates for CD-2:BOE WBS 2 Accelerator

Authors:
- R Coleman
- Andy Stefanik

Keywords:
BoE

Mu2e BOE – Page 1

Mu2e
BASIS of ESTIMATE (BoE)

Date of Estimate: March 31, 2011
Revision Date: June 26, 2014

Prepared by: Andy Stefanik
Contributing:

Docdb #: 1665

WBS number: 475.02.09.05	**Control Account:** 475.02.09	**WBS Title:** Target Station Proton Beam Absorber

WBS Dictionary Definition: Design, fabrication, and installation of the elements required for the absorption of non-interacting proton beam and secondary particle flux downstream of the proton target.

Supporting Documents (including but not limited to):
See Electronic docdb file referenced above for supporting documentation:
(1) P6 schedule spreadsheet corresponding to this BOE (Excel).
(2) Mu2e Proton Beam Absorber Layout Drawing 494372.
(3) Mu2e proton beam absorber - Cost estimate for materials and fabrication.
(4) Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication.

Quality Control Process Applied by: Steve Werkema **date:** 7/5/2014

Assumptions:
- BOE only covers activities from the baseline date of **May 1, 2014** onward. Activities prior to the baseline date are entered into the schedule as actuals with 0% contingency.
- Costs are in 2014 dollars and do not include in-directs.
- Durations are in working days.
- 1 FTE = 1768 hours for an average year. P6 uses the actual calendar for each year with the exact number of workdays.

Supporting Documents – all available in the same doc DB item

BOE Review

BOE Baseline date = May 1, 2014

M&S in 2014 dollars

Details of the Base Estimate (explanation of the Work, Contingency and Duration)
This set of activities includes the labor and M&S necessary to (1) engineer and design the components, (2) fabricate the components, and (3) provide engineering support to Civil Construction and the Alignment Group during installation.

Currently Assigned Personnel

L2 Manager: Steve Werkema
L2 Deputy: Vladimir Nagaslaev
L3 Manager: Rick Coleman
L4 Manager: Andy Stefanik

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Task 47502.09.05.001222 **Absorber material: Prep purchase requisitions and award PO M&S.**
Purchase materials.

M&S	$16,000	Source: Mu2e proton beam absorber - Cost estimate for materials and fabrication ($16,000) and Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication ($0). Refer to the summary at the end of each estimate document.
Duration	30 days	
Estimate type	Preliminary	Contingency of 25% based on contingency rule M4.

Task 47502.09.05.001230 **Absorber: Fabricate.**
Fabricate the absorber at Fermilab.

Mechanical Design Engineer	40 hours	Fabrication support.
Mechanical Designer	40 hours	Fabrication support.
Fermi mech tech supervisor	216 hours	Sources: Mu2e proton beam absorber - Cost estimate for materials and fabrication (120 hours) and Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication (96 hours). Refer to the summary at the end of each estimate document.
Fermilab mech tech	1164 hours	Sources: Mu2e proton beam absorber - Cost estimate for materials and fabrication (588 hours) and Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication (576 hours). Refer to the summary at the end of the estimate document. Refer to the summary at the end of each estimate document.
Welder – M&S	406 hours	Sources: Mu2e proton beam absorber - Cost estimate for materials and fabrication (214 hours) and Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication (192). Refer to the summary at the end of each estimate document.
M&S	$9,000	Sources: Mu2e proton beam absorber - Cost estimate for materials and fabrication ($5,000) and Mu2e proton beam absorber steel shielding - Cost estimate for materials and fabrication ($4,000). Refer to the summary at the end of each estimate document.

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There is an entry for each Activity in the schedule

Contingency and contingency rule used are cited (Called "Estimate Uncertainty" in schedule)

Each Resource this activity is listed with quantities and justification

BOE Review

This is an excerpt from a BOE review form for the BOE shown in the preceding slides.

The BOE review checks the following:

- that all the required information is present and correct
- the information given actually supports the cost estimate given
- contingency rules are properly applied
- resources given match the Mu2e schedule in P6
- that all costs have been accounted for

Mu2e Accelerator BOE Review Check List

Instructions: save this document to a new document that is named using the following format: BOE_Review_475.02.XX.XX_YYYYMMDD.docx. Fill out the form using MS Word. Create a separate document for each BOE reviewed.

Reviewer: Steve Werkema

Date of Review: 21 June 2014

BOE examined in this review: CD2 BOE 475.02.9.05 Target Station Proton Absorber

Mu2e doc DB number and version number: Mu2e-doc-1665-v10

Individual BOE Checks

1. Is the title of the doc DB item correct (i.e. does the title contain the correct WBS number, have a format similar to other BOEs)? Yes: ☒ No: ☐
   If not, what should the title be?

2. Checks that basic information is present and correct.
   - Yes: ☐ No: ☒ Date of Estimate
   - Yes: ☐ No: ☒ Revision Date (if applicable)
   - Yes: ☒ No: ☐ Doc db #
   - Yes: ☒ No: ☐ WBS number (Remove the "W" from the WBS number)
   - Yes: ☐ No: ☒ Control Account (The control account is 475.02.09)
   - Yes: ☒ No: ☐ WBS Title (Does it match the WBS name in the schedule?)
   - Yes: ☐ No: ☒ WBS Dictionary Definition (Does it match the WBS Dictionary (Mu2e-doc-2185?)

   WBS Dictionary definition is "Design, fabrication, and installation of the elements required for the absorption of non-interacting proton beam and secondary particle flux downstream of the proton target"

   Yes: ☐ No: ☒ Are the supporting documents available in the Doc db item?
   It's not clear which file corresponds to (3) Cost estimate for absorber materials and fabrication.

   Yes: ☒ No: ☐ Is the P6 schedule spreadsheet for this BOE available in the Doc db item?

   Do the assumptions listed contain the following?

   Yes: ☐ No: ☒ BOE only covers activities from the baseline date of **May 1, 2014** onward. Activities prior to the baseline date are entered into the schedule as actuals with 0% contingency.

Issues – Review Discrepancies

The BOE reviews have uncovered many discrepancies.

- Differences in cost , contingency, or duration between the BOE and the P6 schedule are:
  - Recorded in the BOE Review form
  - Communicated to Project Controls (Mike Gardner) who is keeping a list of schedule changes to be made after this review
  - These discrepancies *should* be flagged and explained in the BOE. This has not always been done.
- With the exception of the External Beamline BOEs, the discrepancies that have been found are small.
- In many cases, follow-up reviews have not yet been completed to verify that the required corrections have been made.

Issues – Additional External Beamline Costs

- During the process of BOE reviews it was discovered that the cost estimates for the External Beamline failed to completely account for all the required costs.
- There are several indications of this error that have recently come to light:
  - External beamline total costs rolled up to less than the CD-1 cost estimate by ~$1M (CD-1 estimate: $8.20M, Present estimate: $7.18M). Costs were expected to go up rather than down. Note: this *could have been* discovered as early as February (when we first started integrating costs) but was not spotted until much later.
  - BOE reviews and examination of the schedule uncovered activities without resources and large differences between the BOEs and the P6 schedule. Subsequent investigation by experts revealed several areas of substantial cost underestimation. In particular, costs were significantly underestimated for magnet power supplies (475.02.07.02).
  - The cost estimate for the g-2 portion of the M4 and M5 lines presented at the g-2 Director's review last month was $6.5M. Since this beamline is very similar to the portion of the M4 line Mu2e is building, our cost should scale from that of g-2 by the ratio of magnet counts. Such scaling gives an estimated Mu2e total external beamline cost of ~$9M, which is $1.8M more than the present estimate.
- An effort to update and correct the External Beamline BOEs has been undertaken. Consequently, there are some significant mismatches between the External Beamline BOEs and the present versions of the Mu2e schedule and cost book.

Issues – Additional External Beamline Costs (Continued)

Corrective Actions:

- We (Mike Gardner and I) have begun to build a P6 “Sandbox” schedule that will include the changes that have been identified.
- We will conduct another thorough review of external beamline costs when our experts are available (these experts are presently preoccupied by the upcoming g-2 DOE review).
- The increased external beamline costs will need to be compensated by reducing costs elsewhere in a way that has yet to be determined.