

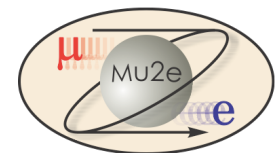


U.S. DEPARTMENT OF  
**ENERGY** Office of  
Science

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# Mu2e Cost and Schedule Development

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Deputy Project Controls Lead  
7/9/2014



# Outline

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- Project Controls Team
- Schedule Development
  - Schedule Development Process
  - Gantt Chart Information
  - Schedule Contingency
  - Critical Path
- Cost Estimate Development
  - Elements of the base estimate
  - Estimate Uncertainty Contingency
  - Escalation
  - Cost Book Information
- Earned Value Reporting
- Next Steps

# Project Controls Team

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- Nine subprojects (“L2” projects)
  - Each a separate P6 schedule and Cobra project
  - CAMs develop and update schedules
  - L2 managers have overall responsibility
- Project Controls team:
  - Fran Leavell, lead
    - Project Management
    - Trigger & DAQ
  - David Leeb, deputy
    - Solenoids
    - Calorimeter
  - Halley Brown
    - Muon Beamline
    - Tracker
  - Mike Gardner
    - Accelerator
    - Conventional Facilities
    - Cosmic Ray Veto

# Schedule Development

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- Each L2 has developed in its own way
- Typically:
  - Started with CD-1 schedule
  - Some WBS revisions, but mostly iterative refinement
  - WBS, Milestones, Tasks, Logic, Durations, Resources, Coding
  - Funds obligated via material Purchase Order tasks and university Statements of Work/PO tasks.
- Durations and resource quantities based on 85% confidence factor
- Discrete hourly task quantities have been increased by 18% to account for 85% labor efficiency.
- Level of Effort resource assignments are entered with an 88% factor, to account for Paid Time Off.
- All schedule contingency is in two years of lag between CD-4 review and Project Completion milestone.

# Data on the Gantt Chart

Activity ID, name & duration

Activity dates & predecessors

| Activity ID                         | Activity Name   | Duration - Work Days | Start      | Finish    | Predecessors     | BOE Docdb # | Cobra PMT Code | Resource Information  | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 | FY2015 |
|-------------------------------------|---|----------------------|------------|-----------|------------------|-------------|----------------|---|--------|--------|--------|--------|--------|--------|
| 47501.3.1.001260                    | Simulations Infrastructure LOE Oct13 to Apr14 (Labor)                   | 145.00               | 10/1/13 A  | 4/30/14 A | FY14S            | ACWP        | A              | Applications Development & Systems Analyst 211; Computational Physics Developer 30; Engineering Physicist 45; Computer Science Researcher 351 | F      | F      | F      | F      | F      | F      |
| 47501.3.1.001261                    | Simulations Infrastructure LOE May14 to Sep14 (Labor)                   | 106.00               | 5/1/14     | 9/30/14   | 47501.3.1.001260 | 3862        | A              | Applications Development & Systems Analyst 119; Computational Physics Developer 37; Engineering Physicist 37; Computer Science Researcher 269 |        |        |        |        |        |        |
| 47501.3.1.001265                    | Issue PO for Project Management LOE (Spokesperson Support) (Obligation) | 1.00                 | 9/3/13 A   | 9/3/13 A  | FY13S            | ACWP        | A              | M&S Pass-Thru: FY14 Base Year 65178   |        |        |        |        |        |        |
| 47501.3.1.001267                    | Project Management LOE FY14 (Spokesperson Support)                      | 164.00               | 9/4/13 A   | 4/30/14 A | 47501.3.1.001265 | ACWP        | A              | M&S Pass-Thru: FY13 Base Year 65178   |        |        |        |        |        |        |
| 47501.3.1.001270                    | LX3 - MC Beamline Enclosure GPP; Authorization to Proceed               | 0.00                 | 11/15/13 A |           |                  |             | B              |   |        |        |        |        |        |        |
| <b>DOE CD-2/3 and other Reviews</b> |   | 271.00               | 9/3/13 A   | 10/1/14   |                  |             |                |   |        |        |        |        |        |        |
| 47501.3.2.001005                    | Modify Resource Loaded Schedule   | 161.00               | 9/3/13 A   | 5/22/14   | 47501.2.2.001160 |             |                |   |        |        |        |        |        |        |

WBS category name

Summary duration & dates

Activity Docdb# for BOE, Cobra PMT, Resource Names and quantities

# Critical Path

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- Each L2 project, if viewed alone, has its own critical path
  - (Look for zero free float on terminal task)
- Overall Mu2e driving critical path:
  - Begins with the data date
  - Driven by constrained release of funds for FY16 for DS fabrication.
  - After DS delivery, critical path is through testing, assembly and cosmic ray test.

# Cost Estimate Development

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- Control Account Managers/Technical managers develop estimates
- Future costs estimated as quantities of resources assigned to tasks:
  - Fermilab labor and university (“non”)labor in hours
  - Materials in dollars
- Base estimate provides 85% confidence factor, but no contingency.
- Estimate Uncertainty Contingency generated via a factor on resource quantity.
- There is no risk-based contingency in the cost book.
- Process:
  - Tasks in P6 are assigned resources, quantities and an estimate uncertainty factor.
  - Cobra mines this information, with dates, from P6.
  - Cobra calculates direct costs, escalation and overheads (in that order) for both base costs and estimate uncertainty contingency.
  - Estimates are as of April 30, 2014. Actual costs are used for our budget prior to that date (i.e., “S=P=A.”)
  - The Cost Book is a pivot table of data from Cobra.

# Cost Notes

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- Escalation starts in the year after an estimate's date
  - Multiple base years possible, identified by M&S Resource ID.
  - Escalation rates are provided by the lab, by resource type (Labor, University labor, Materials, Conventional Construction)
- Escalation stops when a fixed price agreement is finalized.
- Actual costs collected at the Fermilab Project Accounting system “Chargeable Task,” to provide CAMs increased granularity for each Control Account.
- Estimate Uncertainty Factors are reduced to zero when a task is completed.
- Obligation tasks have no estimate uncertainty contingency.
- All M&S procurements are considered planning packages until the terms of the agreement are known.
- The “Cobra PMT” does not have a direct correlation to the Earned Value Technique.



# Data on the Cost Book

WBS ID(s) and names

Direct Fermilab & labor hours from P6

Budgeted costs, including escalation & overhead

Mu2e Cost Book CD-2 Directors Review

| WBS   | BoE Labor Hours | BoE Non-Fermi Hours | BoE M&S   | B A C      | Estimate Uncertainty | Total      | Contingency on remaining costs |
|---|-----------------|---------------------|-----------|------------|----------------------|------------|--------------------------------|
| 475.01 Project Management   | 84,095          | 4,915               | 2,691,888 | 2,752,022  | 862,837              | 21,614,859 | 7.0%                           |
| 475.01.02 Conceptual Design (Post CD-0: OPC)  | 1,648           |                     | 1,964,015 | 4,948,107  |                      | 4,948,107  | 0.0%                           |
| 475.01.02 Conceptual Design (Post CD-0: OPC)  |                 |                     | 1,964,015 | 4,678,875  |                      | 4,678,875  |                                |
| 201404 Set Initial Baseline   |                 |                     | 1,964,015 | 4,678,875  |                      | 4,678,875  |                                |
| 475.01.02.01 CD-1 Conceptual Design/Engineering   | 1,648           |                     |           | 269,232    |                      | 269,232    | 0.0%                           |
| 47501.2.1.001276 Guest Scientist Support for Mu2e II (LOE)                                    | 1,648           |                     |           | 269,232    |                      | 269,232    | 0.0%                           |
| 475.01.03 Preliminary & Final Design Phase to CD-2/3  | 6,436           | 825                 | 553,873   | 4,725,097  | 88,110               | 4,813,206  | 9.3%                           |
| 475.01.03 Preliminary & Final Design Phase to CD-2/3  |                 |                     | 553,873   | 3,779,624  |                      | 3,779,624  |                                |
| 201404 Set Initial Baseline   |                 |                     | 553,873   | 3,779,624  |                      | 3,779,624  |                                |
| 475.01.03.01 Design Phase Management (Post CD-1 PED)  | 6,436           | 825                 | 20,000    | 945,473    | 88,110               | 1,033,582  | 9.3%                           |
| 47501.3.1.001221 Project Management LOE May14 to Sep14 (Labor)                                | 5,899           |                     |           | 745,772    | 47,423               | 793,196    | 6.4%                           |
| 47501.3.1.001231 Project Management LOE May14 to Sep14 (Labor: ES&H)                          | 75              |                     |           | 10,601     | 3,180                | 13,781     | 30.0%                          |
| 47501.3.1.001241 Project Management LOE May14 to Sep14 (M&S: Equipment & Supplies and Travel) |                 |                     | 20,000    | 23,774     | 7,436                | 31,210     | 31.3%                          |
| 47501.3.1.001251 Project Management LOE May14 to Sep14 (M&S: Controls)                        |                 | 825                 |           | 97,635     | 9,763                | 107,398    | 10.0%                          |
| 47501.3.1.001261 Simulations Infrastructure LOE May14 to Sep14 (Labor)                        | 463             |                     |           | 67,690     | 20,307               | 87,998     | 30.0%                          |
| 475.01.04 Implementation & Closeout to CD-4   | 76,011          | 4,090               | 174,000   | 11,078,819 | 774,727              | 11,853,545 | 7.0%                           |
| 475.01.04.01 Implementation   | 76,011          | 4,090               | 174,000   | 11,078,819 | 774,727              | 11,853,545 | 7.0%                           |
| 47501.4.1.001010 Project Management LOE FY15 (Labor)  | 15,824          |                     |           | 1,934,070  | 131,869              | 2,065,940  | 6.8%                           |

Task (Work Package) ID and name

Direct material dollars (\$k) from P6

Estimate Uncertainty Contingency; Contingency as % of remaining costs

# Earned Value Reporting

Mu2e  
May 31, 2014  
Currency: US \$

| Work Package/WBS ID              | Current Period |              |              |              |             |             |            |               | Cumulative to Date |               |              |            |             |           |             |             | At Complete    |                |             |            |            |
|----------------------------------|----------------|--------------|--------------|--------------|-------------|-------------|------------|---------------|--------------------|---------------|--------------|------------|-------------|-----------|-------------|-------------|----------------|----------------|-------------|------------|------------|
|                                  | Budget         | Earned       | Actuals      | SV (\$)      | SV (%)      | CV (\$)     | CV (%)     | Budget        | Earned             | Actuals       | SV (\$)      | SV (%)     | CV (\$)     | CV (%)    | SPI         | CPI         | BAC            | EAC            | VAC         | % Spent    | % Complete |
| 475.01 Project Management        | 217            | 217          | 205          | 0            | 0%          | 12          | 6%         | 8,676         | 8,676              | 8,663         | 0            | 0%         | 12          | 0%        | 1.00        | 1.00        | 20,752         | 20,744         | 8           | 42%        | 42%        |
| 475.02 Accelerator               | 563            | 351          | 337          | (212)        | -38%        | 14          | 4%         | 10,608        | 10,396             | 10,382        | (212)        | -2%        | 14          | 0%        | 0.98        | 1.00        | 40,941         | 40,848         | 93          | 25%        | 25%        |
| 475.03 Conventional Construction | 97             | 68           | 38           | (29)         | -30%        | 30          | 44%        | 2,371         | 2,341              | 2,312         | (29)         | -1%        | 30          | 1%        | 0.99        | 1.01        | 20,638         | 20,598         | 30          | 11%        | 11%        |
| 475.04 Solenoids                 | 611            | 520          | 542          | (92)         | -15%        | (22)        | -4%        | 15,434        | 15,342             | 15,365        | (92)         | -1%        | (22)        | 0%        | 0.99        | 1.00        | 86,878         | 87,057         | (179)       | 18%        | 18%        |
| 475.05 Muon Beamline             | 259            | 109          | 106          | (150)        | -58%        | 3           | 3%         | 4,177         | 4,028              | 4,025         | (150)        | -4%        | 3           | 0%        | 0.96        | 1.00        | 19,715         | 19,681         | 34          | 20%        | 20%        |
| 475.06 Tracker                   | 95             | 16           | 184          | (79)         | -83%        | (168)       | -1061%     | 2,703         | 2,624              | 2,792         | (79)         | -3%        | (168)       | -6%       | 0.97        | 0.94        | 11,736         | 11,901         | (165)       | 23%        | 22%        |
| 475.07 Calorimeter               | 54             | 174          | 70           | 120          | 221%        | 104         | 60%        | 189           | 309                | 305           | 120          | 63%        | 104         | 34%       | 1.63        | 1.51        | 5,464          | 5,464          | (0)         | 4%         | 6%         |
| 475.08 Cosmic Ray Veto           | 223            | 57           | 74           | (166)        | -74%        | (17)        | -30%       | 1,457         | 1,292              | 1,309         | (166)        | -11%       | (17)        | -1%       | 0.89        | 0.99        | 6,735          | 6,635          | 99          | 20%        | 19%        |
| 475.09 Trigger & DAQ             | 95             | 76           | 76           | (19)         | -20%        | 1           | 1%         | 1,602         | 1,582              | 1,582         | (19)         | -1%        | 1           | 0%        | 0.99        | 1.00        | 4,816          | 4,796          | 20          | 33%        | 33%        |
| <b>Total</b>                     | <b>2,234</b>   | <b>1,587</b> | <b>1,631</b> | <b>(647)</b> | <b>-28%</b> | <b>(44)</b> | <b>-3%</b> | <b>47,218</b> | <b>46,591</b>      | <b>46,635</b> | <b>(627)</b> | <b>-1%</b> | <b>(44)</b> | <b>0%</b> | <b>0.99</b> | <b>1.00</b> | <b>217,645</b> | <b>217,726</b> | <b>(81)</b> | <b>21%</b> | <b>21%</b> |
| Management Reserve               |                |              |              |              |             |             |            |               |                    |               |              |            |             |           |             |             | 0              | 0              |             |            |            |
| TAB                              |                |              |              |              |             |             |            |               |                    |               |              |            |             |           |             |             | 217,645        | 217,726        |             |            |            |

CLASSIFICATION (When Filled In)  
**CONTRACT PERFORMANCE REPORT**  
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN \$K FORM APPROVED OMB No. 0704-0188

|                                    |                    |   |                          |   |                                       |   |                               |  |  |  |  |
|------------------------------------|--------------------|---|--------------------------|---|---------------------------------------|---|-------------------------------|--|--|--|--|
| 1. CONTRACTOR<br>a. NAME           |                    | 2. CONTRACT<br>b. NAME                        |                          | 3. PROGRAM<br>a. NAME<br>Mu2e           |                                       |   |                               | 4. REPORT PERIOD<br>a. FROM (YYYYMMDD)<br>2014 / 05 / 01<br>b. TO (YYYYMMDD)<br>2014 / 05 / 31 |  |  |  |
| b. LOCATION (Address and ZIP Code) |                    | d. NUMBER                                     |                          | b. PHASE                                |                                       | c. EVMS ACCEPTANCE<br>NO <input type="checkbox"/> X <input checked="" type="checkbox"/> YES (YYYYMMDD) 2010 / 01 / 28 |                               |  |  |  |  |
| 5. CONTRACT DATA                   |                    |   |                          |   |                                       |   |                               |  |  |  |  |
| a. QUANTITY                        | b. NEGOTIATED COST | c. ESTIMATED COST OF AUTHORIZED UNPRICED WORK | d. TARGET PROFIT/FEE     | e. TARGET PRICE                         | f. ESTIMATED PRICE                    | g. CONTRACT CEILING   | h. ESTIMATED CONTRACT CEILING | i. DATE OF OTB/OTS (YYYYMMDD)  |  |  |  |
| 1                                  | 0                  | 0   | 0                        | 0                                       | 0                                     | 0   | 0                             |  |  |  |  |
| 6. ESTIMATED COST AT COMPLETION    |                    |   |                          | 7. AUTHORIZED CONTRACTOR REPRESENTATIVE |                                       |   |                               |  |  |  |  |
|                                    |                    | MANAGEMENT ESTIMATE AT COMPLETION (1)         | CONTRACT BUDGET BASE (2) | VARIANCE (3)                            | a. NAME (Last, First, Middle Initial) |   |                               | b. TITLE   |  |  |  |
| a. BEST CASE                       |                    | 0   |                          |   | c. SIGNATURE                          |   |                               | d. DATE SIGNED (YYYYMMDD)  |  |  |  |
| b. WORST CASE                      |                    | 0   |                          |   |                                       |   |                               |  |  |  |  |
| c. MOST LIKELY                     |                    | 0   | 0                        | 0                                       |                                       |   |                               |  |  |  |  |

| ITEM (1)                         | CURRENT PERIOD     |                    |                              |              |          |                    |                    |                              |                  |           | CUMULATIVE TO DATE |   |                     |                         | REPROGRAMMING ADJUSTMENTS |               |                | AT COMPLETION |  |  |
|----------------------------------|--------------------|--------------------|------------------------------|--------------|----------|--------------------|--------------------|------------------------------|------------------|-----------|--------------------|---|---------------------|-------------------------|---------------------------|---------------|----------------|---------------|--|--|
|                                  | BUDGETED COST      |                    | ACTUAL COST WORK             |              | VARIANCE |                    | BUDGETED COST      |                              | ACTUAL COST WORK |           | VARIANCE           |   | COST VARIANCE (12a) | SCHEDULE VARIANCE (12b) | BUDGET (13)               | BUDGETED (14) | ESTIMATED (15) | VARIANCE (16) |  |  |
|                                  | WORK SCHEDULED (2) | WORK PERFORMED (3) | WORK COST WORK PERFORMED (4) | SCHEDULE (5) | COST (6) | WORK SCHEDULED (7) | WORK PERFORMED (8) | WORK COST WORK PERFORMED (9) | SCHEDULE (10)    | COST (11) |                    |   |                     |                         |                           |               |                |               |  |  |
| 475.01.02 Conceptual Design (Po  | 30                 | 30                 | -2                           | 0            | 32       | 4,709              | 4,709              | 4,677                        | 0                | 32        | 0                  | 0 | 0                   | 0                       | 0                         | 4,948         | 4,917          | 31            |  |  |
| 475.01.03 Design Development     | 187                | 187                | 207                          | 0            | -20      | 3,967              | 3,967              | 3,967                        | 0                | -20       | 0                  | 0 | 0                   | 0                       | 0                         | 4,725         | 4,749          | -24           |  |  |
| 475.01.04 Implementation & Clo   | 0                  | 0                  | 0                            | 0            | 0        | 0                  | 0                  | 0                            | 0                | 0         | 0                  | 0 | 0                   | 0                       | 0                         | 11,079        | 11,079         | 0             |  |  |
| 475.02.01 Project Management     | 38                 | 38                 | 44                           | 0            | -6       | 1,002              | 1,002              | 1,008                        | 0                | -6        | 0                  | 0 | 0                   | 0                       | 0                         | 3,454         | 3,460          | -6            |  |  |
| 475.02.03 Instruments and Contr  | 8                  | 10                 | 9                            | 3            | 1        | 325                | 328                | 327                          | 3                | 1         | 0                  | 0 | 0                   | 0                       | 0                         | 2,295         | 2,296          | -1            |  |  |
| 475.02.04 Radiation Safety and I | 87                 | 4                  | 20                           | -83          | -16      | 367                | 285                | 300                          | -83              | -16       | 0                  | 0 | 0                   | 0                       | 0                         | 2,182         | 2,192          | -10           |  |  |
| 475.02.05 Resonant Extraction S  | 73                 | 60                 | 38                           | -13          | 22       | 735                | 723                | 701                          | -13              | 22        | 0                  | 0 | 0                   | 0                       | 0                         | 5,516         | 5,462          | 54            |  |  |
| 475.02.06 Rings RF               | 4                  | 7                  | 8                            | 3            | -1       | 274                | 277                | 277                          | 3                | -1        | 0                  | 0 | 0                   | 0                       | 0                         | 2,709         | 2,712          | -4            |  |  |
| 475.02.07 External Beamline      | 108                | 79                 | 32                           | -29          | 47       | 772                | 743                | 695                          | -29              | 47        | 0                  | 0 | 0                   | 0                       | 0                         | 5,740         | 5,684          | 56            |  |  |
| 475.02.08 Extinction Systems     | 65                 | 52                 | 19                           | -13          | 33       | 622                | 608                | 575                          | -13              | 33        | 0                  | 0 | 0                   | 0                       | 0                         | 3,134         | 3,104          | 31            |  |  |
| 475.02.09 Target Station         | 180                | 101                | 167                          | -80          | -66      | 1,466              | 1,386              | 1,453                        | -80              | -66       | 0                  | 0 | 0                   | 0                       | 0                         | 10,866        | 10,893         | -27           |  |  |
| 475.02.10 Accelerator Conceptua  | 0                  | 0                  | 0                            | 0            | 0        | 5,045              | 5,045              | 5,045                        | 0                | 0         | 0                  | 0 | 0                   | 0                       | 0                         | 5,045         | 5,045          | 0             |  |  |
| 475.03.01.02 Management & Ad     | 0                  | 0                  | 0                            | 0            | 0        | 537                | 537                | 537                          | 0                | 0         | 0                  | 0 | 0                   | 0                       | 0                         | 537           | 537            | 0             |  |  |
| 475.03.02 Preliminary/Final Desi | 97                 | 68                 | 38                           | -29          | 30       | 1,834              | 1,804              | 1,775                        | -29              | 30        | 0                  | 0 | 0                   | 0                       | 0                         | 2,260         | 2,231          | 30            |  |  |
| 475.03.03 Construction Phase Ov  | 0                  | 0                  | 0                            | 0            | 0        | 0                  | 0                  | 0                            | 0                | 0         | 0                  | 0 | 0                   | 0                       | 0                         | 2,486         | 2,486          | 0             |  |  |
| 475.03.04.01 Mu2e Detector Sen   | 0                  | 0                  | 0                            | 0            | 0        | 0                  | 0                  | 0                            | 0                | 0         | 0                  | 0 | 0                   | 0                       | 0                         | 12,776        | 12,776         | 0             |  |  |

# Next Steps

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- Process Change Order 1
  - Errata
  - Responses to CD-2 Director’s Review Comments
- Perform resource levelling
- Perform cost leveling (upon receipt of funding profile)
- Use lag to reduce total float, to avoid setting the baseline on early dates (NOvA lesson-learned)
- Create “Earned Value Technique” column on Gantt chart, and report this in lieu of Cobra PMT.
- Commence variance reporting
- Establish preliminary DOE CD-2 Review baseline.

# Summary

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