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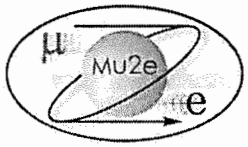


Mu2e Cost and Schedule

Ron Ray
Mu2e Project manager
Fermilab PAC Meeting
November 3-4, 2008

Outline

- Cost
- Schedule
- Director's Review
- Summary

Cost Estimate

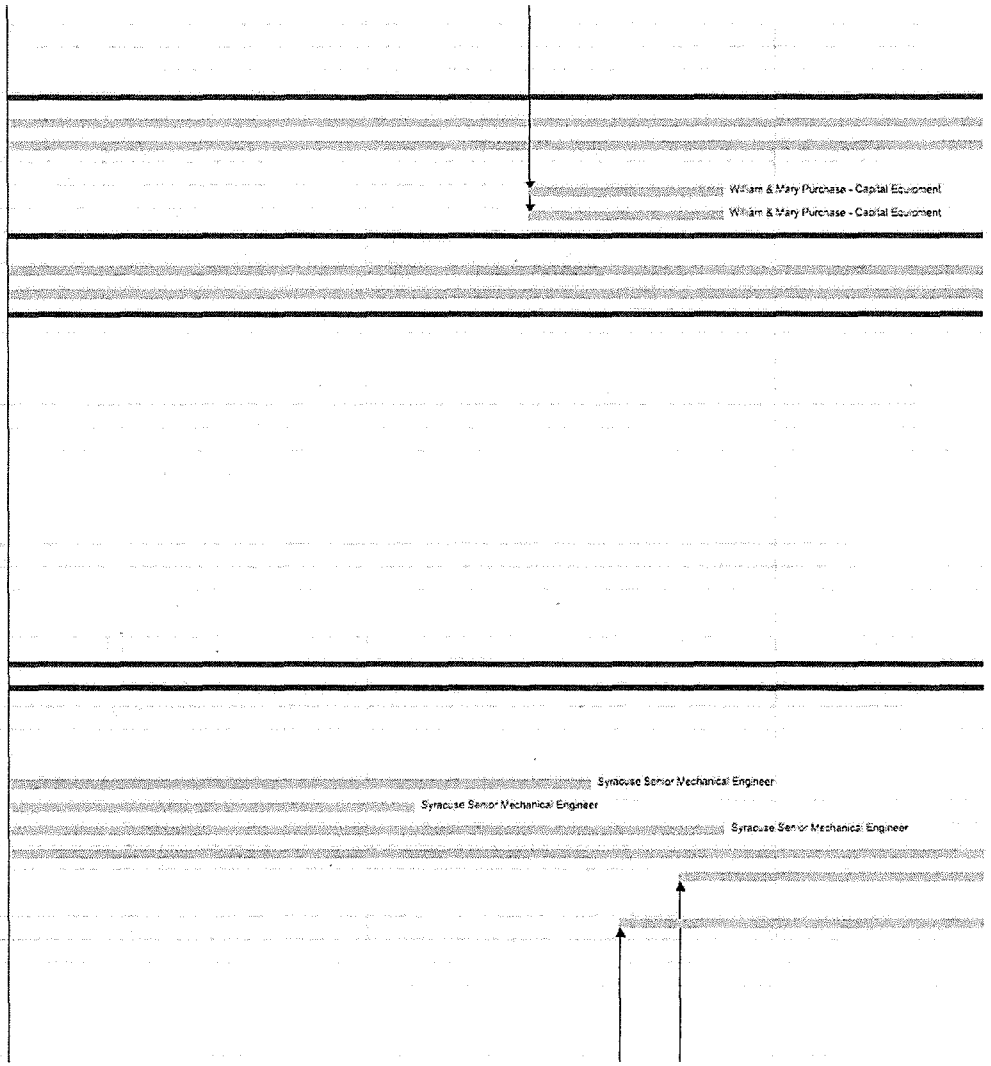
- We have seen that the actual cost of HEP projects almost always escalates from early cost estimates.
  - A reliable cost estimate requires years of effort by a large team to develop:
    - A complete basis of estimate
    - Final designs
    - Risk analysis/mitigation
  - These activities almost always increase the cost.
- MECO had a team of people who dedicated several years of effort working their way through these tasks.
  - MECO was cancelled before these tasks were completed but the legacy of their work has given us a head start in many areas, but not all.

Cost Estimate Strategy for the Proposal

- Use base costs from MECO for the detector and solenoids
  - Add 4 years of escalation at 3.5% per year
    - Note: Many commodities and construction related items have escalated much faster than this in the past few years.
      - Global economic slowdown bringing them back down.
        - "Prediction is very difficult, especially about the future" - N. Bohr
  - Adopt a *conservative* contingency of 50%, consistent with the last few reviews of RSVP.
    - Very little scope contingency on this project. Cost and schedule contingency are the only available knobs.
    - Many of the MECO parts were understood to a level that might justify a smaller contingency than 50%, but we think this approach is adequate and appropriate for a proposal.

From the MECO MS Project File

Cable Gas & Cooling Lines	35.00	9/23/08	11/19/08	35.00	9/23/08	11/19/08
Tracker	35.00	9/23/08	11/19/08	35.00	9/23/08	11/19/08
Installation	10.00	5/8/09	5/26/09	10.00	5/8/09	5/26/09
Feed-thru Installation	10.00	5/8/09	5/26/09	10.00	5/8/09	5/26/09
Stopping Target Monitor	941.19	4/21/06	7/29/10	941.19	4/21/06	7/29/10
Preparing / Testing System	941.19	4/21/06	7/29/10	941.19	4/21/06	7/29/10
Calibration / Efficiency	941.19	4/21/06	7/29/10	941.19	4/21/06	7/29/10
Germanium Detector Spectrometer	56.88	4/21/06	7/25/06	56.88	4/21/06	7/25/06
DS Window and Transport Pipe	26.25	2/8/08	3/20/08	26.25	2/8/08	3/20/08
Magnetic Defector	26.25	2/8/08	3/20/08	26.25	2/8/08	3/20/08
Muonbeamline Conceptual Design and Physics/Engineering Interface	612.50	4/21/06	2/2/09	612.50	4/21/06	2/2/09
Engineering Interface	612.50	4/21/06	2/2/09	612.50	4/21/06	2/2/09
Physics Interface	612.50	4/21/06	2/2/09	612.50	4/21/06	2/2/09
Straw Tracker	1,111.22	4/21/06	5/3/11	1,111.22	4/21/06	5/3/11
Tracker Prototypes	179.37	4/21/06	2/13/07	179.37	4/21/06	2/13/07
T-Tracker Prototype	169.37	4/21/06	10/16/06	169.37	4/21/06	10/16/06
Design	17.50	4/21/06	5/18/06	17.50	4/21/06	5/18/06
Materials	8.75	5/18/06	6/6/06	8.75	5/18/06	6/6/06
Shop Time	17.50	6/6/06	6/30/06	17.50	6/6/06	6/30/06
Fabrication	13.12	6/30/06	7/25/06	13.12	6/30/06	7/25/06
Testing	52.50	7/25/06	10/16/06	52.50	7/25/06	10/16/06
L-Tracker Prototype	179.37	4/21/06	2/13/07	179.37	4/21/06	2/13/07
Design	17.50	4/21/06	5/18/06	17.50	4/21/06	5/18/06
Materials	87.50	5/18/06	10/10/06	87.50	5/18/06	10/10/06
Shop Time	17.50	10/10/06	11/6/06	17.50	10/10/06	11/6/06
Fabrication	13.12	11/6/06	11/30/06	13.12	11/6/06	11/30/06
Testing	43.75	11/30/06	2/13/07	43.75	11/30/06	2/13/07
ReView Of the Tracker Geometry	8.75	2/13/07	2/28/07	8.75	2/13/07	2/28/07
Transverse Tracker (T Tracker)	962.49	4/21/06	9/1/10	962.49	4/21/06	9/1/10
Mechanical Engineering Support	962.49	4/21/06	9/1/10	962.49	4/21/06	9/1/10
Feed Through	163.62	4/21/06	1/18/07	163.62	4/21/06	1/18/07
Straw Tubes	109.38	2/13/07	5/9/07	109.38	2/13/07	5/9/07
Prototype Development	175.38	4/21/06	2/13/07	175.38	4/21/06	2/13/07
Construction Fixtures/Tools	223.12	2/13/07	2/19/08	223.12	2/13/07	2/19/08
Plane Supports/Alignment	191.62	5/1/07	1/11/08	191.62	5/1/07	1/11/08
Gas Manifold/Straw End Support	175.00	5/1/07	3/20/08	175.00	5/1/07	3/20/08
Attachments to Detector Frame	237.76	5/20/07	7/21/08	237.76	5/20/07	7/21/08
Layup	236.25	3/10/08	4/6/09	236.25	3/10/08	4/6/09
Wiring	210.00	1/2/09	12/15/09	210.00	1/2/09	12/15/09
Gas Distribution	328.87	2/20/08	8/17/09	328.87	2/20/08	8/17/09
Installation	109.38	3/8/10	9/1/10	109.38	3/8/10	9/1/10
Feed Through	109.38	5/18/06	11/14/06	109.38	5/18/06	11/14/06
Design	43.75	5/18/06	9/1/06	43.75	5/18/06	9/1/06
Injection Mold	26.25	9/1/06	9/13/06	26.25	9/1/06	9/13/06
Body	35.38	9/13/06	11/14/06	35.38	9/13/06	11/14/06



Cost Estimate Strategy (cont.)

- FESS did cost estimate on detector hall and beamline civil work. Use their contingency.
  - The building location and design are still preliminary.
    - Value engineering and detailed integration of the building with the detector and beamline will lead to many changes over time.
- AD did cost estimate on accelerator modifications and beamline.
  - Use 100% contingency because design is at pre-conceptual stage.
- Assume Project Management costs of 8%
  - Recommended by Fermilab Office of Project Management Oversight.
    - Industry standard is 10-15%, but 8% is more typical of Projects with off-Project scientists filling majority of management slots.

Cost of Design and Construction

Updated since proposal

	M&S (k$)	Labor (k$)	Base Cost (FY05 k$)	Base Cost (FY09 k$)	Contingency	Contingency (k$)	Total (FY09 k$)
Production Target and Shield	$2,490	$219	$2,709	$3,856	50%	$1,928	$5,784
Muon Beamline	$1,209	$1,265	$2,474	$2,839	50%	$1,419	$4,258
Straw Tracker	$2,280	$998	$3,278	$3,762	50%	$1,881	$5,642
Calorimeter	$3,466	$1,177	$4,643	$5,328	50%	$2,664	$7,992
Cosmic ray veto	$1,203	$406	$1,609	$1,846	50%	$923	$2,770
Trigger and DAQ	$884	$584	$1,468	$1,685	50%	$842	$2,527
Solenoids	$37,061	$7,618	$44,679	$51,270	50%	$25,635	$76,905
Accelerator and Beamline	$5,525	$5,396		$10,921	100%	$10,921	$21,842
Civil Construction	$22,842	$6,431		$29,273	32%	$9,263	$38,536
Project Office	$1,000	$8,223		$9,223	50%	$4,612	$13,835
Total	**$77,960**	**$32,317**		**$120,003**	**50%**	**$60,088**	**$180,091**

Blue shaded boxes are costs extracted from MECO Cost & Schedule

Was $180,962 in proposal

R&D

This is money we need over the next 2 years

FNAL Labor added since proposal

	M&S (k$)	FNAL Labor (k$)	Total (k$)
Solenoids	$1,000	$1,200	$2,200
Accelerator/beamline/extinction	$100	$270	$370
Civil Construction		$2,225	$2,225
Tracker	$250	$250	$500
Calorimeter	$200		$200
CR Shield	$200	$30	$230
Electron Gun Calibration	$200		$200
Total	**$1,950**	**$3,975**	**$5,925**

Was $10,127k in proposal

Updates Since Proposal

- Some double counting has been corrected.
- Proposal borrowed Project Management cost from NOvA. We dropped that and, pulled some project management costs out of the solenoid system and applied the 8% factor.
- We added an abort system for the accumulator ring
- We added the cost of removing the stochastic cooling system from the accumulator/debuncher ring.
- We added $3M to replace the lost SSC cable.
- Several other small adjustments.

Cost - Longer Term Strategy

- We will develop a resource loaded cost and schedule from the bottom up.
  - L2, L3 managers will develop a cost and schedule that they must own and be responsible for. We will start from the MECO WBS, where relevant, and work out additional details to a level appropriate for CD process, supported by a full risk and contingency analysis and BOEs for every significant activity.
  - We will use OpenPlan, COBRA, WelcomeRisk, etc. as our basic set of scheduling, budget and reporting tools.

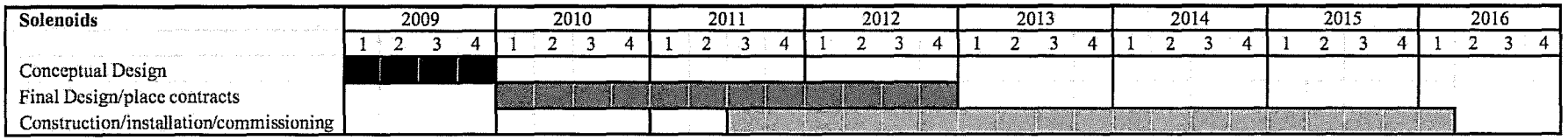
Technically Limited Schedule

Solenoids are the critical path. They drive the schedule.

- We assume CD-0 in Feb. 2009
- Finish Solenoid conceptual design in 1 year.
- Final design takes 3 years. Overlaps with construction (tooling) - MECO WBS
- Construction, installation, integration, testing takes almost 5 years - MECO WBS

- Our model for executing the Solenoid subproject will be different than the MECO model. We are looking for ways to advance the schedule.

- Technically limited schedule where $ and resources are available when we need them get us to Project completion in calendar 2016.



Director's Review

- We had a Director's Review on September 26. The interaction with the Committee was very constructive.
- Charge to the Review Committee:
  - In preparation of the upcoming proposal of the mu2e experiment to the PAC on November 3 – 5 and in preparation for CD-0, we are appointing a team of Fermilab scientists and engineers to help us with this process. In particular we would like you to review the draft proposal to the PAC on the physics case, the proton source and beamline concept and the detector design to make a better proposal, and help identify critical R&D areas, and provide your recommendations.

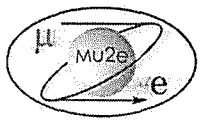
Director's Review Committee

Name (Organization)	Name (Organization)
Rick Coleman (AD)	Rich Stanek (Directorate)
Keith Gollwitzer (AD)	Brendan Casey (PPD)
Sergei Nagaitsev (AD)	David Christian (PPD)
Vaia Papadimitriou (AD)	Doug Glenzinski (PPD)
Jim Amundson (CD)	Aseet Mukherjee (PPD)
Rob Kutschke (CD)	Vadim Rusu (PPD)
Paul Lebrun (CD)	Jim Kerby (TD)
Bob Tschirhart (CD) – Chair	Peter Limon (TD)

Director's Review Agenda

Mu2e Review – **Hornet's Nest on 8th Floor Crossover**

- 08:00 Executive Session
- 08:30 Physics Overview –Bob Bernstein (30'+15')
- 09:15 Project Overview – Ron Ray (30'+15')
- 10:00 Proton source, beam extraction and targeting – M. Syphers (20'+10')
- 10:30 Coffee Break (30')
- 11:00 Muon beam transport – Jim Miller (20'+10')
- 11:30 Solenoid designs and procurement – Mike Lamm (20'+10')
- 12:00 Detector – Craig Dukes (20'+10')
- 12:30 Working Lunch (60')
- 13:30 Review Team – Writing (75')
- 14:45 Closeout / Discussion (45')

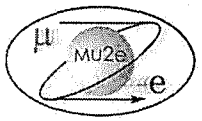


Significant Quotes

- Space charge effects not modeled! This is a huge increase in beam [flux] (x300,000, debuncher) needed for mu2e.
- Get started on magnet conceptual designs ASAP!
- Need to develop a comprehensive MC platform that is the design tool for the experiment to determine issues such as the L vs T tracker, significance of high resolution calorimetry.
- Get Project Office staffed!

Summary

- We have a conservative cost estimate that uses the MECO WBS as an initial basis of estimate. This is well in excess of the cost analysis that is typically available at the proposal stage.
  - We don't expect significant cost escalation!
- We have a technically limited schedule driven by the solenoid system.
  - In reality, our schedule will be driven by funding and Lab/DOE priorities on resource allocation.
- **We can use a strong endorsement from you to argue for more funds and resources sooner rather than later and progress more quickly.**



Backup slides

Comparison of Mu2e and MECO Costs

- Total MECO cost in FY05$ - $85.3M
- Inflate by 15% to go from FY05$ to FY09$ (3.5%/yr)
  - Adds $12.6M
- Increase contingency to 50%
  - Adds $18.2M
  - MECO overall contingency was 23.7%.
    - Too low by DOE standards. Does not adequately reflect risks or level of design.
- Add Civil Construction - New. Cost not included as part of MECO
  - Add $38.5M
- Add accelerator modifications and beamline - New. Cost not included as part of MECO
  - Add $21.8M
- Updated Project Management cost to DOE standards
  - Add $3.6M

Comparison of Mu2e and NOνA Buildings

Simple scaling exercise using round numbers. Buildings are very different.

- NOνA
  - ~$49.5M for building
  - ~34,765 sq. ft.
  - $\rightarrow$ $1424/ft^2
- Mu2e
  - Detector enclosure is $25.6M
  - ~16,500 sq. ft.
  - $\rightarrow$ $1551/ft^2