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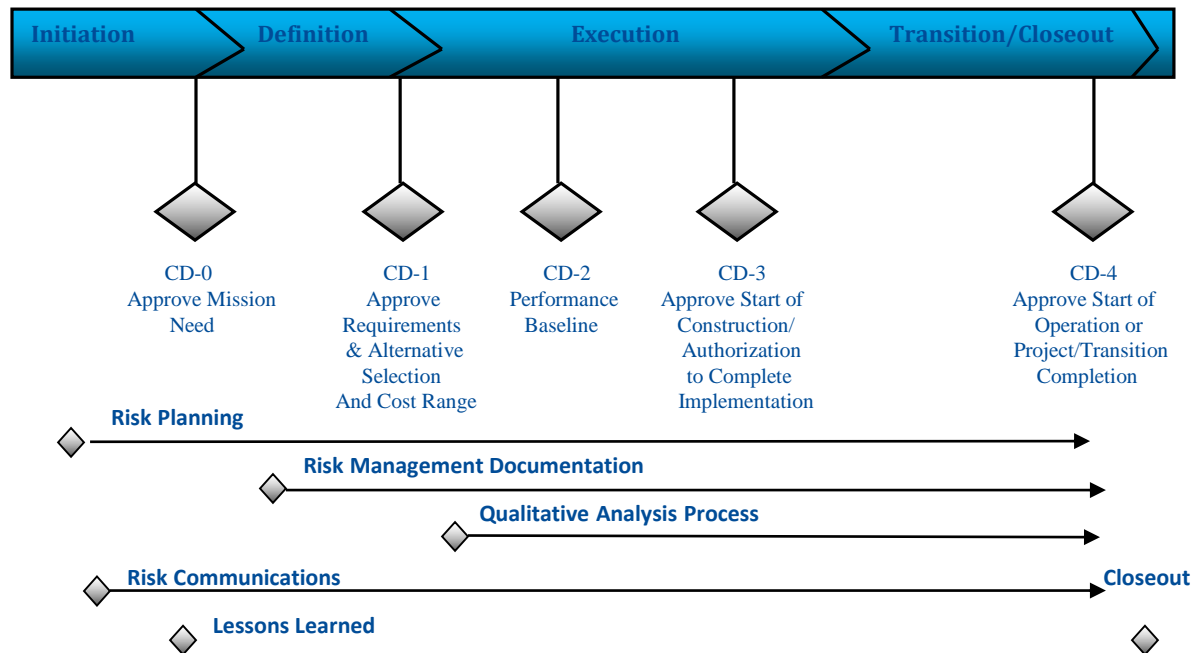
Mu2e Risk Management Update

Michael Dinnon

CD-3C Director's Review

4-19-2016

Risk Management during CD Phases



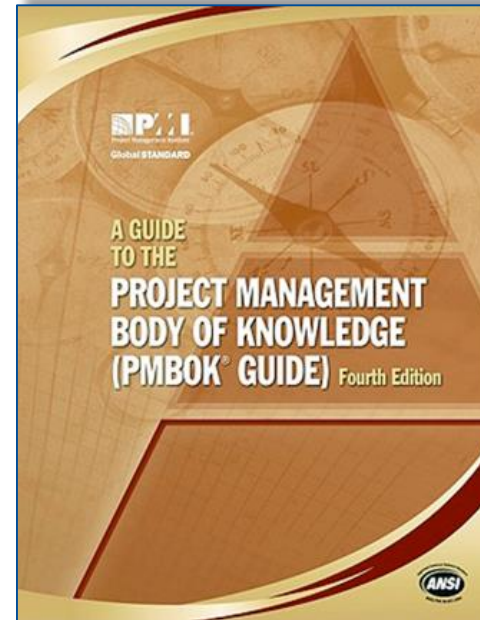
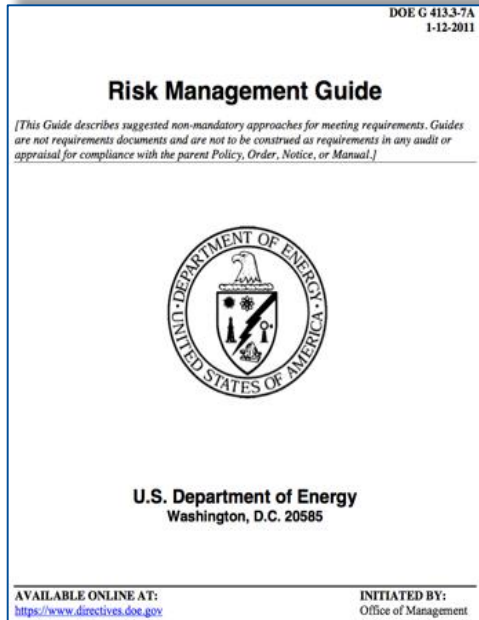
Critical Decision Phases with continuous and iterative risk management.

Risk Management on Mu2e Project

- Risk Management Plan found in Mu2e-docdb #461 and on review website
 - Risk assessments in project since CD-0
 - Contributed to cost/schedule development
- Risk Register found in Mu2e-docdb #4320
- Transitioning to Lab's new web-based risk register

Risk Management

- We follow established standard practices



- <http://science.energy.gov/opa/project-management/processes-and-procedures/>
- <http://www.pmi.org/PMBOK-Guide-and-Standards.aspx>

Risk Management on Mu2e Project

- Risk = an event with a probability to cause change in the project baseline and impact the project goals
 - **Threat**: a negative occurrence
 - **Opportunity**: a positive occurrence
- Goal of Risk Management is to reduce the project threats and capitalize on project opportunities while managing uncertainty
- Mu2e Risk Management plan
 - Based on best practices

<http://mu2e-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=461>

Roles and Responsibilities

The Mu2e Project Manager is responsible for:

- Developing the Mu2e Risk Management approach
- Executing the risk mitigation strategy
- Scheduling periodic reviews of project risks and chairing bi-monthly Risk management Board meetings
- Assuring that the risk analyses results are appropriately documented, tracked, and closed in the Mu2e Project Risk registry
- Approving, modifying, or assisting in risk abatement strategies
- Chairing the Risk Management Board

The Mu2e Level 2 managers are responsible for:

- Performing a risk analysis including identification of potential risks to the technical, cost, ES&H and schedule success of their WBS system; determining their likelihood of occurring; and estimating their potential impact on the project. This analysis is performed down to WBS level 3 or lower, as appropriate.
- Developing and executing risk mitigation strategies for their Level 2 system
- Informing the Mu2e Project Manager about the significant risks and the status of risk mitigation strategies in their WBS system

Roles and Responsibilities

The Mu2e Risk Manager is responsible for:

- Assisting L2 subprojects in developing inputs to the Risk Register.
- Organizing risks using the Primavera Risk Analysis software and other relevant tools to determine risk rankings.
- Aiding in the development of the Project Manager's top down contingency estimates for the Project.
- Generating monthly reports that determine the status of current risks, near term risks, and risks that can be retired.
- Examining project uncertainties that may impact the success of the Project.
- Identifying, analyzing and quantifying the significant risks and recommending proactive work plans or established mitigation strategies should the risk events occur.

The Mu2e Risk Management Board (RMB) (consisting of Project Managers, Level 2 Managers and Project Engineers) is responsible for:

- Reviewing and recommending approval or modification of risk analyses and risk mitigation strategies, as requested by the Project Manager
- Assisting in the development of risk abatement strategies as needed.

Risk Identification

- Risk items are identified by team members and documented.
- Compilation is assembled and reviewed at the Subproject level then submitted to the Project Office.
 - Many meetings with L2's and PM to discuss impacts
 - Solenoids broken down further - CD-2 Director's Review recommendation
- Risks are then combined and the Project decides on those risks to be included in the Project risk register.
- Currently Mu2e risk register contains 80 entries
 - 10 opportunities 70 Threats
 - \$5.7M Exposure At 80% Confidence

Qualitative Analysis

- Initial Qualitative analysis of probability and impacts is recorded on a risk form and downloaded to the docdb.

Mu2e Risk Form

Risk Identifier: Ron Ray Risk Owner: Ron Ray
 Risk ID: PM-010 Risk Type: THREAT
 Date: 9/20/2013 Date revised: 8/15/14

Risk Title: Increase in Fermilab overhead rates
Risk Description: Fermilab overhead rates have been increasing in recent years. We will use this data to estimate increases in future years. If the increases are greater than our estimates we will have a shortfall. We are particularly vulnerable to this because of our large percentage of Fermilab labor.
Detailed Risk Cause: Base support for Fermilab decreases causing overhead rates to increase faster than our estimates.
Detailed Risk Effect: Cost increase
WBS Affected: all labor activities
Other WBS Affected:

Actual Start Date (when available from schedule)	Actual Finish Date (when available from schedule)
FY16	FY20

Initial Risk Analysis – (description of selection of impacts and probability, text length commensurate with risk complexity): All Fermilab labor has overheads applied. The overhead varies depending on the organization where the work is done. Overheads have been going up in recent years and there is a risk that they will continue to rise.

Initial Risk Probability and Impact scores selected from Mu2e Risk Management Plan (Mu2e-doc-461) Tables 1 and 2

Initial Probability (VH,H,M,L,VL)	Initial Schedule Impact (Delays Level 3 milestone or project critical path by) in days (VH,H,M,L,VL)	IF HIGH SCHEDULE IMPACT, Upper Bound of Current Schedule Impact (Days)	Initial Cost Impact (VH,H,M,V,VL)	IF HIGH COST IMPACT, Upper Bound of Current Cost impact (\$)	Initial Scope Impact (VH,H,M,L,VL)	Initial ES&H and Quality Impact (VH,H,M,L,VL)
H	N		VH	Unbounded	N	N

Exposure (What the risk will cost when it occurs): Overhead rates are adjusted at the beginning and end of each fiscal year. Changes at the end of the FY are retroactive to the beginning of the year. The risk continues until Project completion and can happen over-and-over again but the financial impact diminishes each year as less Project labor remains into the future that could be subject to increased overheads.

Initial Risk Mitigation Plan considered in the Initial Risk Analysis and included in the Base Plan Cost and Schedule: Add contingency specifically to cover higher overheads. Make sure adequate contingency exists year-by-year to cover retroactive changes.

Base Plan Mitigation Cost (\$)	Base Plan Mitigation Cost Uncertainty (\$)	Start and Finish Dates or Description of Current Mitigation Plan Duration
0	0	Accept Risk

New Mitigation Plan or Additional Risk Mitigation Measures Description:

Response Type (Accept, Reduce, Avoid, Transfer)	New or Additional Mitigation Cost Range (\$)		Schedule impact of undertaking the mitigation plan – delays Level 3 milestone or project critical path (Days)		Probability of plan failing to achieve expected mitigation (H,MH,ML,L)
	Low Bound	Upper Bound	Lower Bound	Upper Bound	
Accept	0	0	None	None	

Residual/Current Risk Probability and Impact Scores:

Residual/ Current Probability (VH,H,M,L,VL)	Residual Schedule Impact (Delays Level 3 milestone or project critical path (Days) (VH,H,M,L,VL)	IF HIGH SCHEDULE IMPACT, Upper Bound of Residual Schedule Impact (Days)	Residual Cost Impact (VH,H,M,L,VL)	IF HIGH COST IMPACT, Upper Bound of Residual Cost impact (\$)	Residual Scope Impact (VH,H,M,L,VL)	Residual ES&H and Quality Impact (VH,H,M,L,VL)
M	N		VH	Unbounded	N	N

Additional Notes: Analysis of historical data in spreadsheet posted with this form on docdb results in a 90% C.L. cost of \$1447k. Round up to \$1500k. Analysis is summarized below.

Point estimate (cost k\$)	Point Estimate (schedule-days)	Point estimate (probability)	EXPECTATION VALUE IN k\$	EXPECTATION VALUE IN Days
\$1500k	0	50%	\$750	0

Analysis of Risk

The Fermilab Financial Section has provided historical data for overhead rates, going back to 2007. The individual components, plotted in Figure 1a are:

- PS - Program Support for AD, CD, PPD and TD
- CS - Common Site Support
- TSCS - Technical and Scientific Common Support
- G&A - General and Administrative.

Overhead rates for AD, CD, PPD and TD are obtained by combining the Divisional Program Support rate with CSS, TSCS and G&A. For example:

$$AD \text{ Overhead rate} = (1+PS)*(1+CSS)*(1+TSCS)*(1+G\&A) - 1.$$

Overhead rates for other organizations are obtained in the same way, but without the Program Support component. The historical overall rates for the various Divisions and Sections are shown in Figure 1b.

To evaluate the risk to the Mu2e project from potential increases in overhead rates, we have evaluated low, medium and high scenarios as follows:

Accelerator Division Program Support (AD PS) – Steadily decreasing from FY08 to FY13, but a significant jump in FY14. In a band between 28% and 35% for the last 6 years. Currently at 34%. Assume:

- Low: 28%
- Medium: 30%
- High: 35%

Computing Division Program Support (CD PS) – Steadily decreasing over the past 4 years. In a band between 9% and 13% for the last 5 years. Currently at 11.3%. Assume:

- Low: 9%
- Medium: 11%
- High: 13%

Particle Physics Division Program Support (PPD PS) – In a band between 12% and 18% for the past 8 years. Currently at 17.5%. Assume:



Risk Scoring

- Determining the risk impact and probability
 - Impact relates to the potential consequence of the threat on cost, ES&H, schedule, and/or the technical baselines.
 - Probability is assessed qualitatively

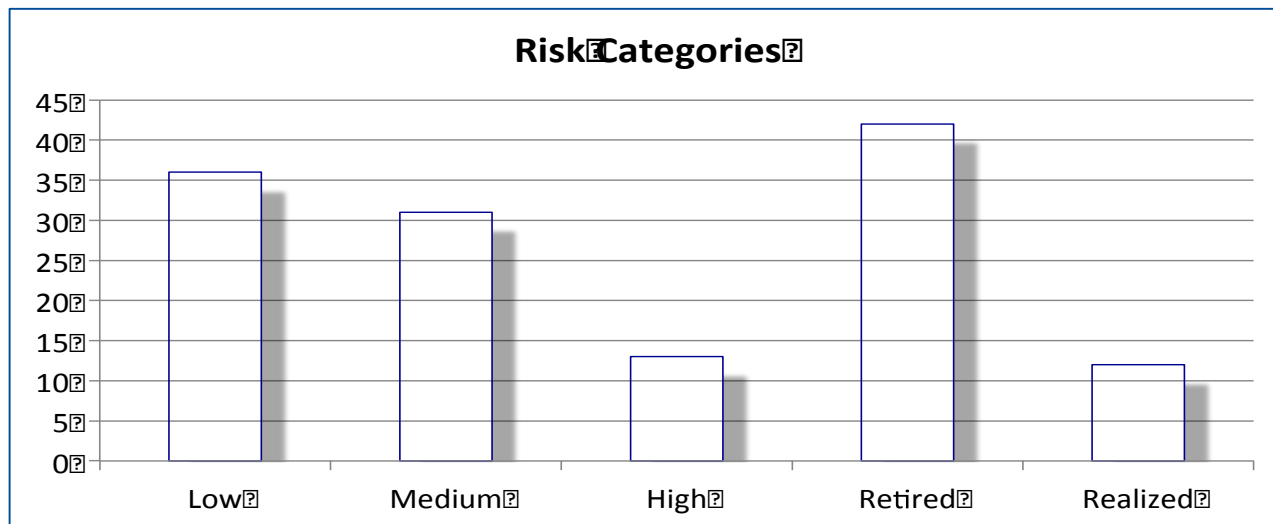
Impact	Very Low	Low	Moderate	High	Very High
Risk					
Cost	< \$50K	\$50K - \$100K	\$100K - \$250K	\$250K - \$500K	> \$500K
ES&H	Negligible	Minimal	Concern	Significant risk	High risk
Quality	Negligible	Minimal	Concern	Significant risk	High risk
Schedule	Delays Level 3 milestone or Project critical path by < 1 month	Delays Level 3 milestone or Project critical path by 1 - 3 months	Delays Level 3 milestone or Project critical path by 3 - 6 months	Delays level 3 milestone or Project critical path by 6 – 9 months	Delays Level 3 milestone or Project critical path by > 9 months
Technical	Negligible	Negligible, if any, degradation.	Significant technical degradation.	Technical performance effectively useless for attaining physics objectives.	Technical performance useless for attaining physics objectives.

Probability	Impact				
	Very Low	Low	Moderate	High	Very High
Very High (> 90%)	Low	Moderate	High	High	High
High (75% – 90%)	Low	Moderate	Moderate	High	High
Moderate (25% - 75%)	Low	Low	Moderate	High	High
Low (10% - 25%)	Low	Low	Moderate	Moderate	High
Very Low (< 10%)	Low	Low	Low	Low	Moderate

Risk Register Status

The Project is actively managing 80 risk events (docdb 4320)

- It contains 70 Threat events
- 10 Opportunity events
- 42 Risks have been retired
- And 9 new risk events have been added since CD-2



Highest Remaining Risk Events

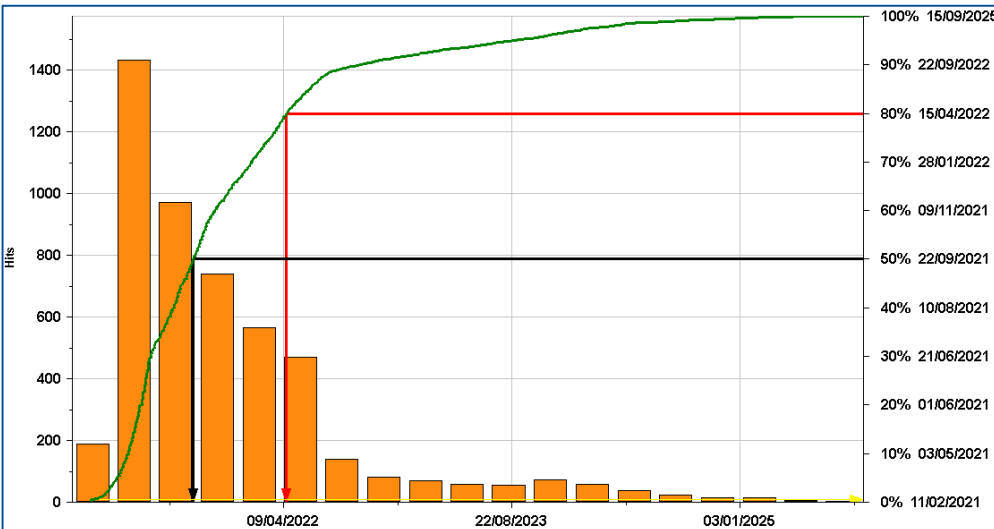
Risk							Post-mitigation						
Risk ID	Risk Form DocDb#	Type	Risk	Date of Risk	Mitigation Cost (Included in baseline)	Category	Probability	Schedule-Delays Level Milestone or Project Critical Path by Days	Cost	Technical	ESH&Q	Score	Owner
ACCEL-215	7069	Opportunity	No longer require movable magnets in the final focus beamline section.	FY16-FY17		Current Risk	H	VL	M	N	N	H	D. Still
ACCEL-015	3331	Threat	Injection tamper required for Delivery Ring	FY17-FY19		Current Risk	L	N	N	VH	N	H	S. Werkema
PM-154	3845	Threat	Commodity prices escalate faster than inflation	FY16-FY19		Current Risk	L	N	VH	N	N	H	Ron Ray
SOL-070	3368	Threat	Interface problems with the solenoids.	FY17-FY20		Current Risk	L	H	VH	N	N	H	M. Lamm
ACCEL-200	4589	Threat	Need to add new power supplies to the beamline.	FY16	\$7,000,000	Current Risk	M	VL	H	VL	N	H	D. Still
MUON-138	3360	Threat	Detector installation takes longer than expected.	FY19-FY20		Current Risk	M	N	H	N	N	H	G. Ginther
PM-010	3366	Threat	Increase in Fermilab overhead rates	FY16-FY20		Current Risk	M	N	VH	N	N	H	Ron Ray
SOL-148	3837	Threat	Production solenoid must be installed through PS hatch using a large oriented crane.	FY19-20		Current Risk	M	N	H	N	N	H	M. Lamm
SOL-183	4568	Threat	TS Magnet fabrication failure due to supplied process component	FY18-19	\$7,000,000	Current Risk	M	L	M	N	N	H	M. Lamm
TRACK-169	4444	Threat	Background levels > 4x expectation necessitate	FY16-FY17		Current Risk	M	N	VH	M	N	H	A. Mukherjee
TRIG-128	3393	Threat	Insufficient manpower for DAQ software.	FY17-FY20		Current Risk	M	N	H	N	N	H	Ryan Rivera
ACCEL-151	3833	Threat	Redesign the Remote Handling System for Water Cooled Target	FY16-FY18	\$7,000,000	Current Risk	VL	N	VH	M	N	H	M. Campbell, R. Coleman

Risk Analysis

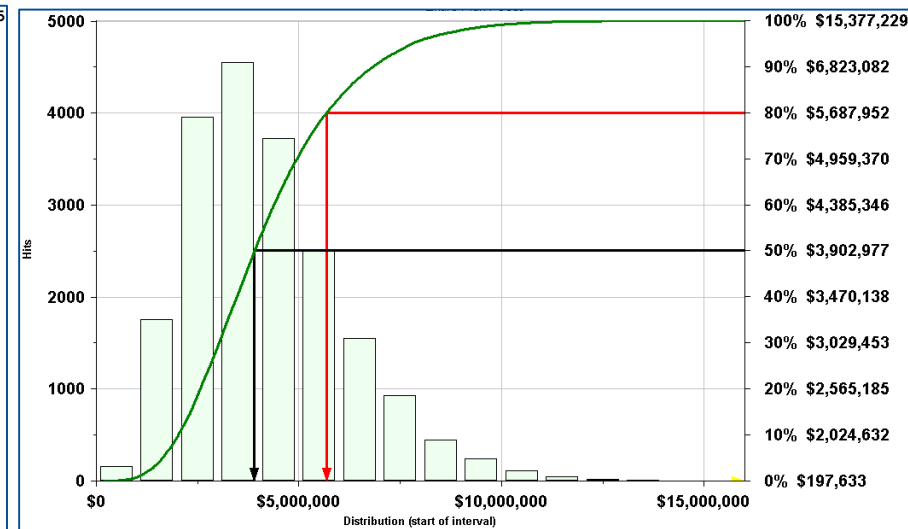
Monte Carlo performed on Risk Register using PRA

- Schedule risks included and costed in analysis
 - Uses schedule logic, correlations and costs associated with delays
 - Total Project Risk is \$5.7M (80% C.L.)
 - Project will finish by April 15, 2022 (80% C.L.)
 - Tier 0 CD-4 milestone (with 24 months of float) is Dec 2022

Schedule



Cost



M. Elrafih

Summary

- Mu2e has a well developed Risk Management System in place
- Mu2e has a risk register to capture risks on the project
- Risks are monitored and reviewed as the project progresses
- New risks are created as necessary
- High risks have mitigation plans documented on Mu2e risk forms
- Risk management is integrated into the project