



U.S. DEPARTMENT OF
ENERGY Office of
Science

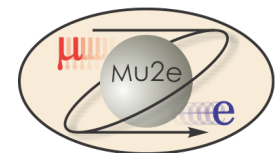
Risk Management

Mu2e Independent Cost Estimate

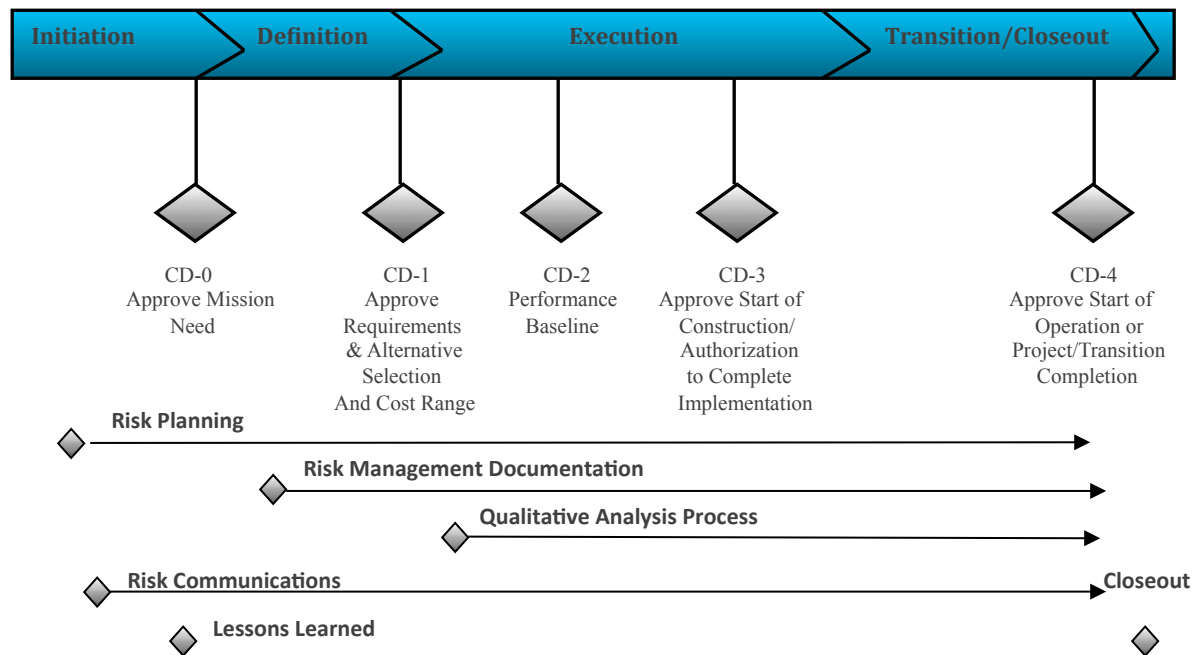
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Mu2e Risk Manager

8/26/2014



RISK MANAGEMENT DURING CD PHASES



Critical Decision Phases with continuous and iterative risk management.

Definition of Risk

Situations that have potential to cause an unwanted or undesired change in schedule, cost, scope, ES&H or technical success are described as risks. A risk is explained as a definable event with a probability of occurrence and a consequence or impact to the Project if it occurs. The event can have a positive (opportunity) or negative (threat) effect on the Project.

$$\text{Risk Severity} = \text{Probability} \times \text{Impact}$$

Outline

- Introduction
- Definition of Risk
- Key Elements of Risk Management
 1. Risk Planning
 2. Risk Identification
 3. Qualitative Risk Analysis
 4. Quantitative Risk Analysis
 5. Risk Mitigation Strategies
 6. Risk Monitoring
- Future Process
- Summary

KEY ELEMENTS OF RISK MANAGEMENT

1. Risk Planning
2. Risk Identification
3. Qualitative Risk Analysis
4. Quantitative Risk Analysis
5. Risk Handling and Mitigation Strategies
6. Risk Monitoring

Risk Planning

- Sets the process and standards to which the Project manages and documents risk
 - Create Risk Management Plan
 - Set up risk identification process
 - Identify key team members
 - Establish Risk Management Board (RMB) = Technical Board
 - Training on the risk process

Risk Identification

- Risk items are identified by team members and documented.
- Clearly states the risk event and impact to the Project.
- Interdependencies within the Project are noted
- Compilation is assembled and reviewed at the Subproject level then submitted to the Project Office.
- Risks are then combined and the Project decides on those risks to be included in the Project risk register.
- Currently Mu2e risk register contains 48 entries
 - 12 opportunities 36 Threats
 - \$5.1M Exposure At 90% Confidence

Qualitative Analysis

Risk scoring has two dimensions:

- impact and probability.
- Impact is the potential impact of a risk
- The highest impact score gives the impact score of the risk item.

Table 1: Impact Assessment Matrix. Impacts range from *Very Low* to *Very High*.

Impact Risk	Very Low	Low	Moderate	High	Very High
Cost	< \$50K	\$50K - \$100K	\$100K - \$250K	\$250K - \$500K	> \$500K
ES&H	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.

Qualitative Analysis

Risk scoring has two dimensions:

- impact and probability.
- Impact is the potential impact of a risk
- The highest impact score gives the impact score of the risk item.
- The probability score assigns a ranking, using the parameters in Table 2, gauged on how likely the event is to occur.
- The risk owner makes the first scoring determination which is then evaluated by the RMB and Project Manager.

Qualitative Analysis

- An overall risk score is given to each risk item by a composite of the impact and probability score.

Table 2: Risk Classification Matrix

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

Qualitative Analysis

Table 1: Impact Assessment Matrix. Impacts range from *Very Low* to *Very High*.

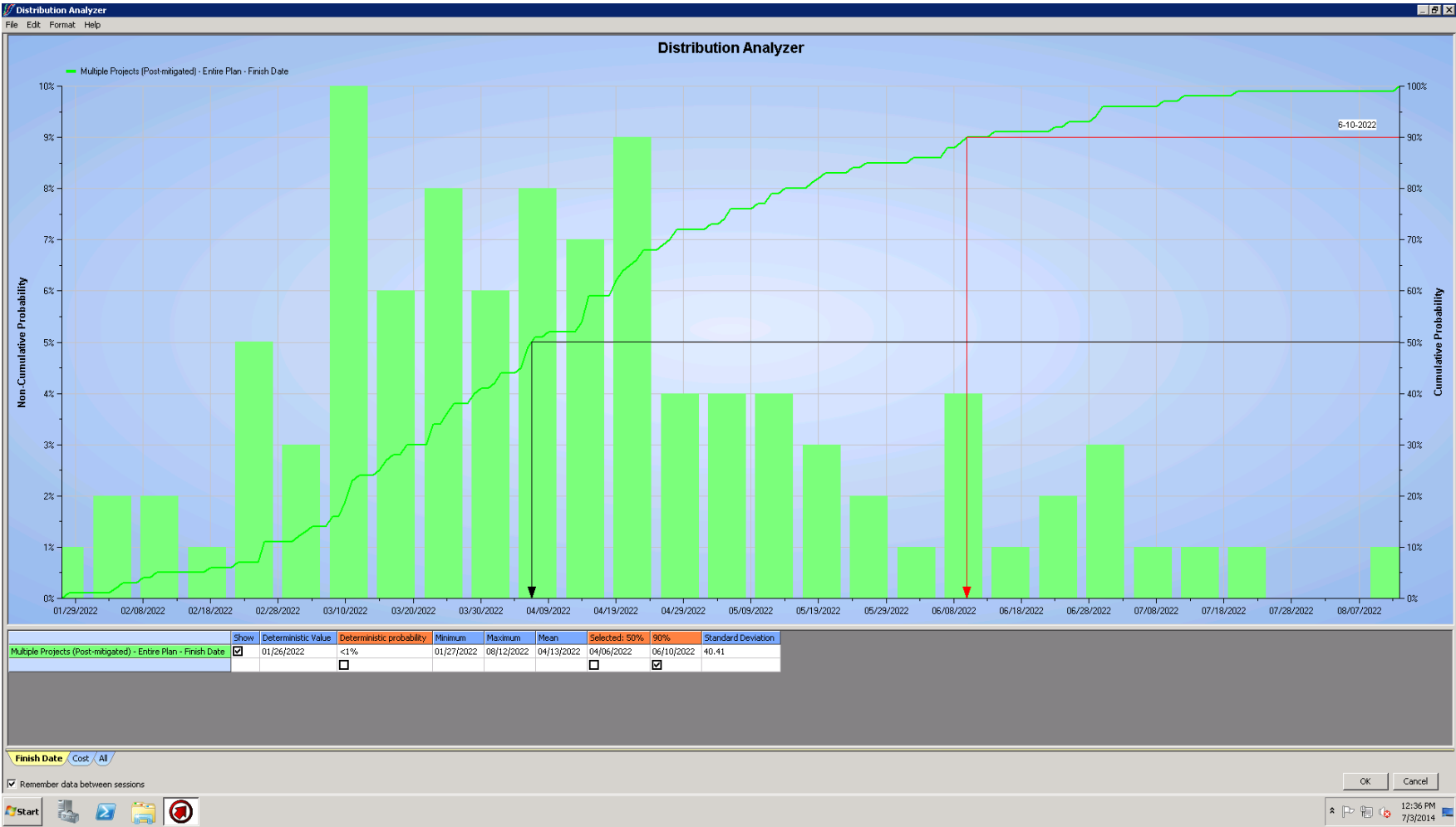
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Quantitative Analysis

Schedule Risk

- Analyzed all schedule risks individually as to see the effect on cost of the maximum amount of delay (risk register then adjusted)
- Modeled only schedule risks against the plan and ran a MC
- Modeled ALL risks against the plan and ran a MC
- Result shows that we fall under the Project milestone of 12-5-2022 with an analysis showing 90% confidence in 6-10-2022

Quantitative Analysis

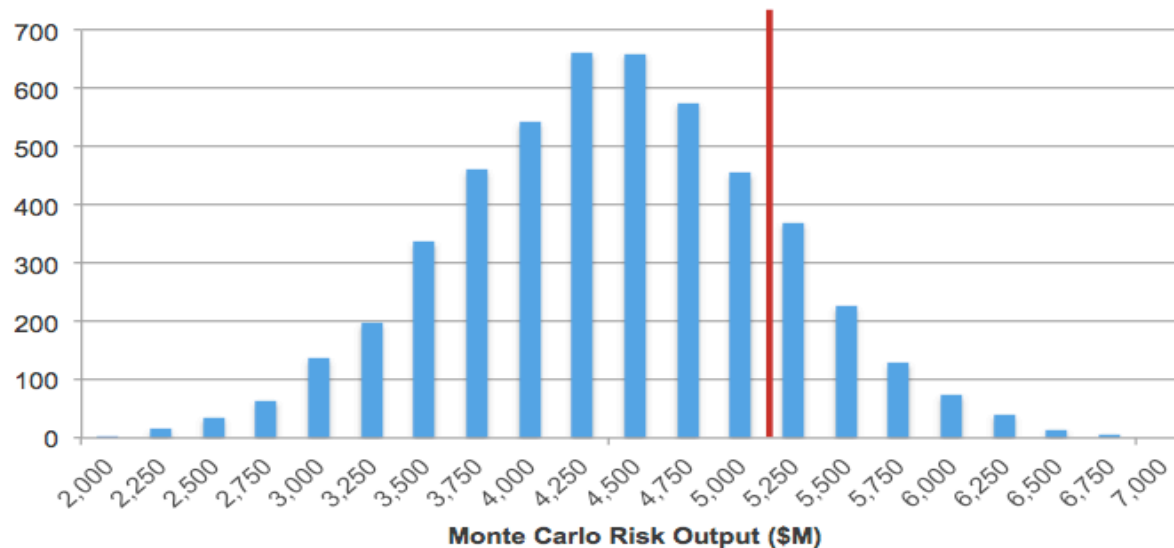


MC on Finish date shows 6-10-2022 date

Quantitative Analysis

Risk Analysis

Monte Carlo performed on Risk Register to determine cost at 90% C.L.



Mean	\$4.3M
σ	\$0.78M
90% C.L.	\$5.1M

L2	90% C.L. Risk
Project Management	\$1208
Accelerator	\$982
Conventional Construction	(\$510)
Solenoids	\$1196
Muon Beamline	\$499
Tracker	\$651
Calorimeter	\$523
Cosmic Ray Veto	\$323
DAQ	\$273
Total	\$5145

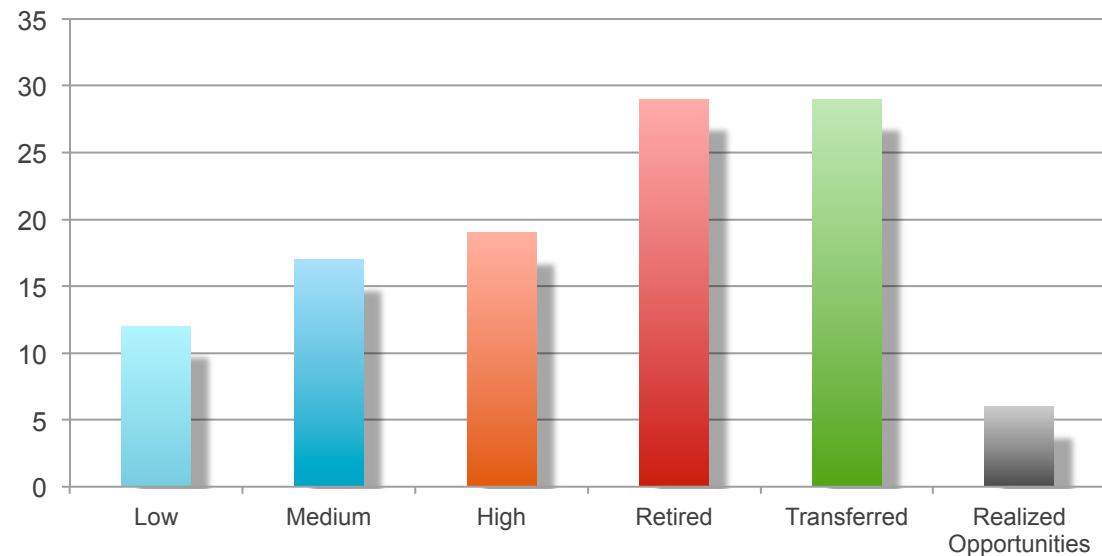
CD-2 Register

Since CD-1

- 29 Risks retired
- 6 opportunities realized at a savings of \$1.7M
- >\$6M spent to mitigate risks
- Loaded into PRA for analysis

Current

- 48 Entries
- Register - \$5.1M



Handling and Mitigations

- Mitigation plans are developed by the risk owner and implemented into the project plan
- They are reviewed by the Project Manager and L2 manager for effectiveness
- Mitigation plans have a direct impact on the post mitigated risk
 - Reduction of probability and/or impacts to threat events
 - Increase of probability and/or impacts to opportunity events

Risk Monitoring

- The risk owner has a significant role in risk monitoring.
- The risk owner will update information on the risk item's form promptly following recognition. The risk form revision is submitted to the Risk Manager who assigns the change for review. Upon approval of the change, the Risk Manager will update the Risk Register accordingly.
- After CD-2, the Risk Manager will prepare a monthly report that identifies any and all changes to the Risk Register in the previous month.

Future Process

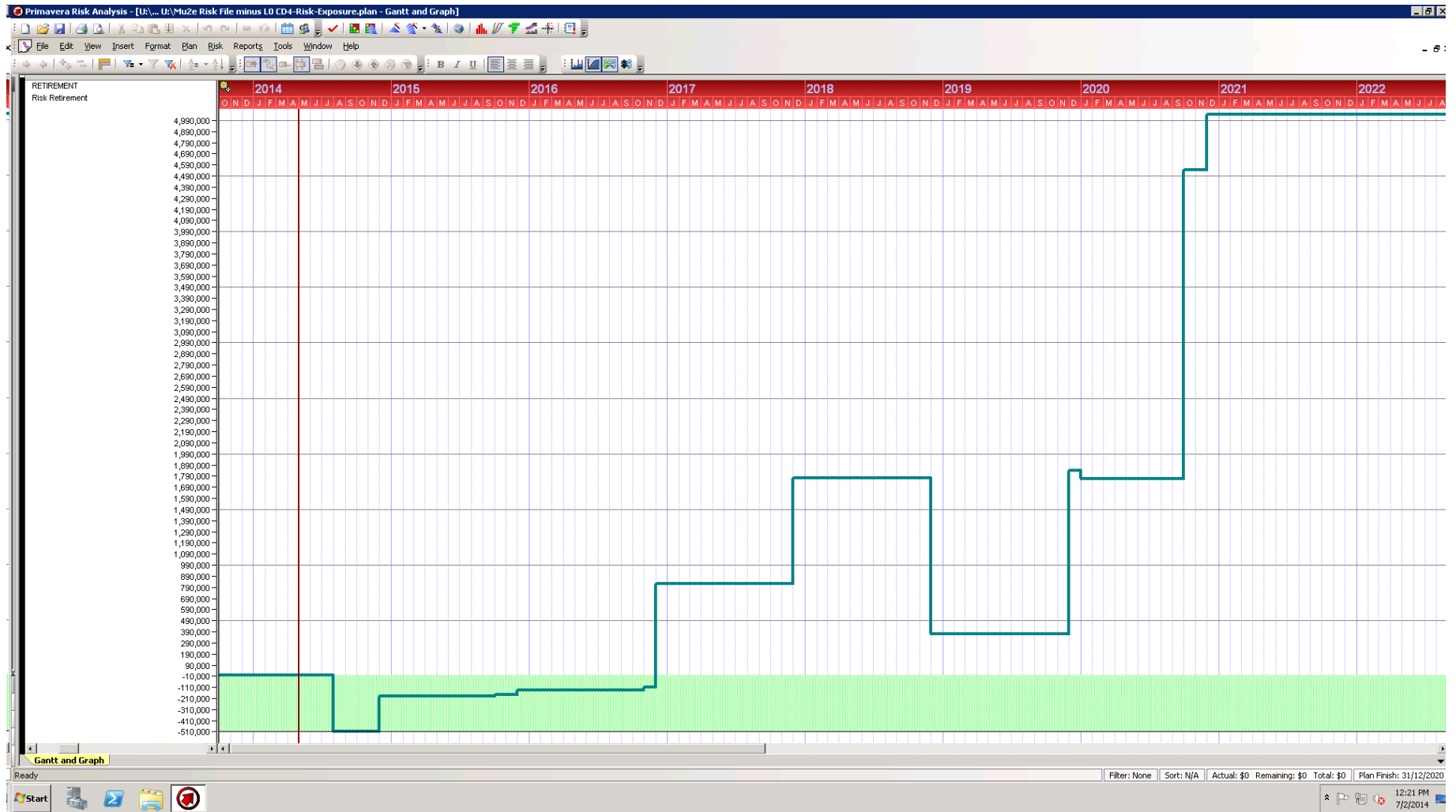
- Continue to iterate on current risk events and track
- Provide risk reports to the project
- Further develop the MC analysis parameters
- Map a risk spend down plan against the funding profile
- Identify new risks as they appear

Summary

- Mu2e has a solid foundation of risk entries that all members have agreed on.
- A Risk Management Plan has been developed by the project.
- Mu2e feels that the Project's Risk Program is acceptable and ready for a CD-2 approval.
- Iterative process will continue throughout the life cycle of the Project.

Thank You

Backup slides



Largest Remaining Risks

DocDb#-4320

Risk														Post-mitigation				
Risk ID	Risk Form DocDb #	Type	Title	Date of Risk	Mitigation Cost (Included in baseline)	Category	Probability	Schedule-Delays Level 3 Milestone or Project Critical Path by X Days	Cost	Technical	ES&H	Score	Owner	Point estimate (cost k\$)	Point Estimate (sched-days)	Point estimate (prob)	EXPECTATION VALUE IN k\$	EXPECTATION VALUE IN Days
CAL-108	3347	Threat	INFN cannot deliver full in-kind scope.	FY14-FY19		Current Risk	L	N	VH	H	N	40	R. Ray	\$ 1,000		10%	\$ 100	0
CONST-049	3351	Opportunity	Conventional construction bids are lower than estimated cost.	FY14		Current Risk	M	N	VH	N	N	40	T. Lackowski	\$ (1,200)		50%	\$ (600)	0
PM-010	3366	Threat	Unexpected increase in Fermilab overhead rates	FY14-FY19		Current Risk	M	N	VH	N	N	40	Ron Ray	\$ 1,500	0	50%	\$ 750	0
SOL-157	4225	Threat	PS conductor first article does not meet specifications	FY15-FY16	\$ 400,000	Current Risk	M	VH	VH	M	N	40	M. Lamm	\$ 2,000	250	25%	\$ 500	62.5
ACCEL-015	3331	Threat	Injection damper required for Delivery Ring	FY16-FY19		Current Risk	L	N	N	VH	N	24	J. Morgan	\$ 185	0	10%	\$ 19	0
ACCEL-151	3833	Threat	Redesign the Remote Handling System for Water cooled target	FY14-FY17	\$ 100,000	Current Risk	L	N	VH	M	N	24	M.Campbell, R.Coleman	\$ 3,300		10%	\$ 330	0
CAL-148	3834	Threat	Cannot develop UV-extended solid state photodetector that is blind to longer wavelengths	FY14-FY15	\$ 100,000	Current Risk	M	M	N	H	N	24	D. Hitlin	\$ -	40	50%		20
CONST-050	3352	Threat	Conventional construction bids exceed estimated cost.	FY14		Current Risk	L	N	VH	N	N	24	T. Lackowski	\$ 1,200		10%	\$ 120	0
MUON-138	3360	Threat	Detector installation takes longer than expected.	FY19		Current Risk	M	M	H	N	N	24	G. Ginther	\$ 400	0	50%	\$ 200	0
PM-005	3362	Threat	Construction funds not available as assumed.	FY14		Current Risk	L	H	VH	N	N	24	Ron Ray	\$ 500	120	10%	\$ 50	12
PM-153	3844	Opportunity	Commodity prices decrease	FY15-FY17		Current Risk	L	N	VH	N	N	24	Ron Ray	\$ (1,173)		50%	\$ (587)	
PM-154	3845	Threat	Commodity prices escalate faster than inflation	FY15-FY17		Current Risk	L	N	VH	N	N	24	Ron Ray	\$ 1,173		10%	\$ 117	
SOL-066	3367	Threat	Critical path delayed due to solenoid schedule delay.	FY18-FY20	\$ 20,000	Current Risk	M	H	VH	N	N	24	M. Lamm	\$ 1,384	200	50%	\$ 692	100
SOL-070	3368	Threat	Interface problems with the solenoids.	FY14-FY19		Current Risk	L	H	VH	N	N	24	M. Lamm	\$ 1,000	60	20%	\$ 200	12
SOL-080	3372	Threat	Insufficient testing of DS and/or PS at Vendor	FY18-FY20	\$ 50,000	Current Risk	L	VH	VH	N	N	24	M. Lamm	\$ 2,000	200	10%	\$ 200	20
SOL-148	3837	Threat	Production Solenoid must be installed through PS hatch using a large rented crane.	FY18-19		Current Risk	M	N	H	N	N	24	T. Page	\$ 300		50%	\$ 150	0
SOL-155	3954	Opportunity	Cryo Distribution Box Funded by Cryo AIP	FY16-FY18		Current Risk	M	VH	VH	N	N	24	M. Lamm	\$ (2,500)		50%	\$ (1,250)	0
TRIG-128	3393	Threat	Insufficient manpower for DAQ software.	FY14-FY19		Current Risk	M	N	H	N	N	24	M. Bowden	\$ 500		25%	\$ 125	0
VETO-164	4258	Threat	More CRV coverage is needed.	FY14-FY15		Current Risk	H	N	VL	N	N	24	C. Dukes	\$ 60	0	80%	\$ 48	0
ACCEL-020	3333	Threat	Cannot use TLMs to control beam losses.	FY14-FY19		Current Risk	L	N	VH	N	N	24	T. Leveling	\$ 2,000		2%	\$ 40	0