Risk Management & Mitigation Plan

2019-004.3

	Approval	Date
Project Manager	F. Feyzi	02/04/2020
Quality & Safety Manager	M. ZERNICK	02/03/2020

Change Log

Revision	Description : Author	Date
0	Original document : M. Zernick	1/31/19
1	Added Monte Carlo reference: M. Zernick	4/09/19
2	Added cost tracking, contingency and scope planning: F. Feyzi	10/1/2019
3	Updated per comments received from NSF: F. Feyzi	02/03/2020

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1. Purpose

This plan describes how the IceCube Upgrade Project manages and mitigates Risk.

2. Scope

This plan governs all IceCube Upgrade WBS Collaborators, including UW-Madison who have Upgrade Project responsibility and control budgets and schedules. In addition to risks collaborators' scope, external risks that apply to suppliers to the IceCube Upgrade Project are also included in this plan.

3. References

IceCube Upgrade Risk Registry
NSF Major Facilities Guide

4. Definitions

Risk ID: Risk ID is type of risk. Types of risk are Technical, External, Organizational, and Project Management.
Risk Title: Risk Title is a very brief description of the risk.
Risk Handling Approach: Response is either Mitigate (actions required), Watch, Accept, Avoid or Research.
Technical Risk: Technical risks are related to requirements, technology, interfaces, performance and quality.
External Risk: External risks are related to suppliers.
Organizational Risks: Organizational risks are related to project dependencies, logistics, resources, budget, etc.
Project Management Risks: Project Management risks are related to planning, schedule, estimation, controls, communications, etc.
Risk Trigger: A risk trigger identifies the risk symptoms or warning signs. It indicates that a risk has occurred or is about to occur.

The risk type definitions are according to NSF Major Facilities Guide.

5. Roles and Responsibilities

The basic risk management approach of the IceCube Upgrade Project is to leverage the immense technical experience within IceCube: everyone is responsible for identifying risks, and once a risk is identified someone is assigned formal responsibility for managing it.

This is done using a risk register. The risk register is organized by each major subsystem of the project, consistent with the Level 2's of the project. The L2 managers and their teams are responsible for the maintenance of the registry and for regular assessment. As the project moves forward, the registry is focused on the risks that might affect successful execution of the baseline plan. In many cases the plan will include mitigation efforts, so the success of these tasks is also evaluated.

6. Risk and Opportunity Review and Management Process

The risk register is reviewed and updated quarterly; so, it can support an evaluation of risk exposure through the ongoing progression of the project. In addition, individual risks are actively monitored and risk status is reported as part of the monthly reporting process.

The project Quality Manager is responsible for the risk register and works with each Level 2 manager to adjust the cost and risk scoring to an equivalent basis. Risks are manually reviewed in this manner to ensure that entries developed by many personnel across the project are captured and assessed with similar leveling, allowing for project-wide integrated assessment of risk and exposure.

Risk management also include opportunities and the project is actively pursuing identification of additional funding from partners as well as cost-saving opportunities such as identifying alternate, more cost-effective sources of major capital subsystems, e.g. funding for PMTs or cables. These opportunities are captured in the risk register alongside risks and are used in an equivalent manner to help the project management assess scope as the project evolves. Opportunities are identified actively and will be utilized in order to reduce overall project risk, e.g. early shipping of equipment.

Management of risks and opportunities forms an integral part of the Project Execution Plan and is governed by the guidelines of NSF Major Facilities Guide. As such, risk and opportunity review is a necessary component of yearly detail planning and contingency planning. Risks are assigned a project year in which they are expected to no longer be a factor. This contributes to the derivations of the contingency amount needed per project year.

7. Risk Classification

Risks are classified by their probability of occurrence and by their impact to the project as tabulated below. The risk score is then determined from the risk scoring table.

Risk Probabilities Table		**Limits for Calculation**	
Probability of Occurrence Descriptor	**Numerical Ranges**	**Low**	**High**
Very Low	**< 5%**	**1%**	**5%**
Low	**5% - 25%**	**5%**	**25%**
Moderate	**25% - 50%**	**25%**	**50%**
High	**50% - 75%**	**50%**	**75%**
Very High	**> 75%**	**75%**	**95%**

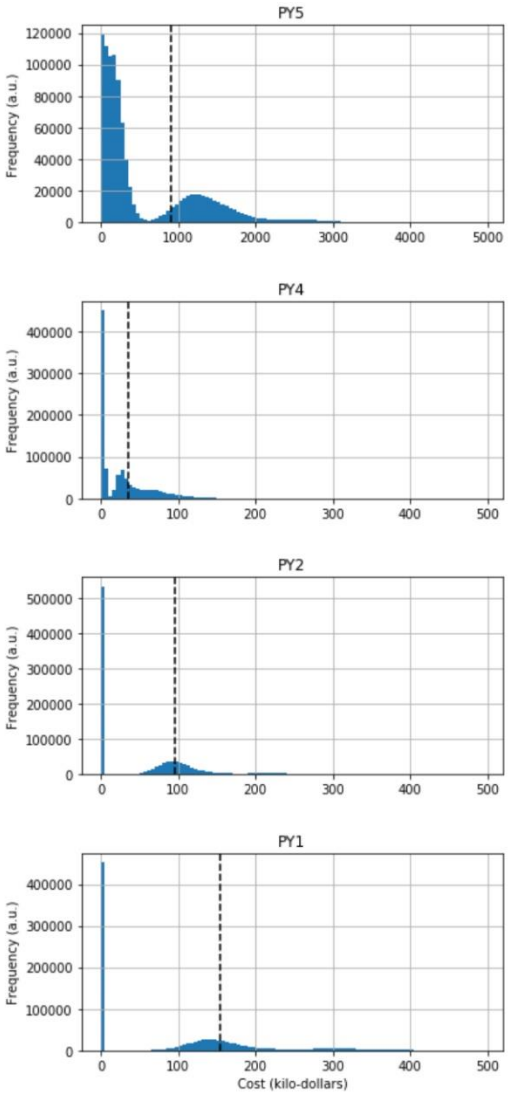
Impacts					
Project Objective	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Cost	**Less than $10k**	**$10k - $50k**	**$50k - $250k**	**$250k - $1M**	**> $1M**
Time	**Less than 1 week**	**Month**	**3 months**	**6 months**	**Greater than 6 months**
Scope	**Scope decreases barely noticeable**	**Minor areas of scope affected**	**Major areas of scope affected**	**Scope reduction unacceptable to sponsor**	**Project item is effectively useless**
Quality / Performance	**Quality / performance degradation barely noticeable**	**Only very demanding applications are affected**	**Quality / performance reduction requires sponsor approval**	**Quality / performance degradation unacceptable to sponsor**	**Project item is effectively useless**

Probability and Impact Matrix for Risk Scoring					
	Impact				
Probability	Very Low	Low	Moderate	High	Very High
Very High	Moderate	Moderate	High	High	High
High	Low	Moderate	High	High	High
Moderate	Low	Moderate	Moderate	High	High
Low	Low	Low	Moderate	Moderate	Moderate
Very Low	Low	Low	Low	Low	Moderate

Risk mitigation strategies are then defined and a post-mitigated risk is derived with new impacts and probabilities assigned. This gives a qualitative estimate of the associated degree of risk so that major risks can be identified easily. To quantitatively assess an equivalent cost of the risk, the post-mitigated risk is assigned a total cost exposure, i.e. what amount of money would need to be spent in the event of risk occurrence.

8. Risk Simulation

Risks identified in the risk register are used as inputs to a Monte Carlo risk simulation. First, risks are collated by project year where the risk is anticipated to be retired. For each project year, 1 million probabilistic simulations of possible risk outcomes are performed as follows:



- Risks for a given project year are iterated over.
- Each risk is assigned a probability of occurrence in the current scenario. This probability is assigned by first associating a numerical high probability and low probability based on the risk's probability in the risk register: very low, low, moderate, high, and very high. For example, risks assigned the 'Low' probability have a low probability of 5% (0.05) and a high probability of 25% (0.25). The probability in a given scenario is selected with a uniform random variate with these limits.
- The occurrence of that risk is simulated by generating another uniform random variate on the interval [0, 1). If the resulting number is less than the probability assigned in the previous step, the risk is realized: the cost associated with the risk is multiplied by a random normal variate with mean 1.0 and sigma 0.25 to simulate a 25% uncertainty in the evaluation of the risk's true cost.
- The sum of realized risk costs in each of the million simulations is input into a histogram to arrive at the distribution of risk costs in a given project year (see figure).

The resulting histograms for each project year are evaluated to find the cost which separated the bottom 70% of the distribution from the upper 30% of the distribution (dotted black line in figure). This is the cost which was sufficient to mitigate risks in 70% of the simulated risk scenarios.

9. Project Risk Register Summary

The resulting risk exposure per project year is as follows.

Project year	**PY1**	**PY2**	**PY3**	**PY4**	**PY5**
Remaining risk exposure based on qualitative and quantitative analysis	$1,252,465	$1,026,605	$965,689	$965,689	$940,845
Difference to prior year		$225,860	$60,916	$0	$24,844
Simulated risk per year with 70% confidence level	$155,000	$95,000	$0	$35,0000	$900,000

The results based on qualitative and quantitative analysis are used for project planning. The simulated results are shown for comparison. There are some difference between the results of the two method. However, the total project risk exposure using both methods is in good agreement.

10. Detail Project and Contingency Planning

The project office will conduct a rolling-wave yearly detail planning exercise for the future years prior to close of current year. The focus of the planning is the upcoming year. Future years are also planned in as much detail as possible. The objectives of the planning exercise are:

- Detail cost estimate and schedule review for future years
- Review of milestones and deliverables
- Review of remaining risks and modification per current year experience
- Review of remaining cost uncertainty
- Close of current year actual costs
- Contingency analysis vs. estimate to complete

10.1. Project Year Detail Planning

Detail planning of future years is conducted within the last two months of the current year. A uniform tool is used by the project office and level 2 mangers for this task.

Each of the level 2 managers will review future year plans and:

- Review the start and finish date of each task and make necessary adjustments

- Add detail level tasks by breaking down each task as necessary in order to track more accurately
- Continue to optimize the project schedule to take full advantage of opportunities

The detail future year schedule will be used to plan future cost estimates. Each level 2 manager will plan future year expenditures based on tasks necessary to complete their assigned scope. The project office will assemble the future year cost estimates to arrive at the cost to complete.

The detail task cost and schedule will be used as input for planned value within the earned value management system (EVMS). The planned value will be compared to earned value which will be tracked within the same integrated system. Actual cost values will be added to EVMS in order to arrive at monthly cost and schedule variances. In this way of future detail planning, the EVMS system will be based on best estimates going forward at any given time.

10.2. Risk Assessment and Contingency Planning

The risk register is reviewed and updated quarterly. In addition, cost uncertainty on estimated cost to complete is also calculated. As with risk, cost uncertainty calculations become more accurate as the project progresses. Risk exposure and cost uncertainly are added in order to arrive at a minimum contingency value.

At the end of each period, actual costs to date (AC) are added to estimate to complete (ETC) to arrive at an updated estimate at completion (EAC). Project scope adjustment options are evaluated and prioritized. Options will be incorporated in order that remaining contingency is commensurate with minimum required contingency and project phase. Exercise of scope adjustment options and use of available contingency are handled though the change control process.

Approvers for IceCube Upgrade Risk Management Plan 2/6/2020

Title	Assigned To	Status	Priority	Date and Time	Outcome
IceCube Upgrade Risk Management Plan	Mike Zernick	Completed	(2) Normal	2/3/2020 11:00	Signed
IceCube Upgrade Risk Management Plan	Farshid Feyzi	Completed	(2) Normal	2/4/2020 11:00	Signed