Wisconsin IceCube Particle Astrophysics Center

Cost Estimating Plan for the IceCube Upgrade Project

2022-004.5

Approvals

Role	Name	Date	Signature
Principal Investigator	K. Hanson	Mar 10, 2022	
Project Director	V. O'Dell	Mar 17, 2022	Vivian O'Dell (Mar 17, 2022 19:20 CDT)
Project Manager	F. Feyzi	Mar 16, 2022	

Change Log

Version	Date	Author	Summary of changes
1.0	2021-07-27	V. O'Dell	1st version
2.0	2021-07-29	V. O'Dell	2st version
3.0	2021-08-12	M. Rogal	Full version for IceCube Upgrade
4.0	2021-08-17	V. O'Dell	Incorporated comments from Kael, Marek, Vivian
4.1	2021-08-18	V. O'Dell	Updated Monte Carlo description after discussion with Marek
4.2	2021-08-19	V. O'Dell	Updated Table 1
4.3	2021-08-19	M. Rogal	Updated Table 2
4.4	2021-08-25	M. Rogal	Updated Table 2
4.5	2021-08-30	M. Rogal	Cleanup
4.6	2021-09-21	V. O'Dell	Sync up with latest KA (v1.8).
4.7	2021-09-30	V. O'Dell	Incorporated comments from R. Yasky, Mark Coles
5.0	2022-02-19	V. O'Dell	Update org chart. Update rebaseline date to April.

Contents

1. Purpose

This document documents the official procedures for the development of the cost estimates for the IceCube Upgrade Project. This Cost Estimating Plan (CEP) documents the guidance used for the project cost development as well as providing the plan for the cost estimation during replanning and rebaselining efforts. Some core assumptions for the cost development are described in the Key Assumption document (1) which compliments this cost estimating plan.

2. Responsibilities

2.1 Project Manager (PM)

- Issuing estimate preparation guidance and instructions through the Key Assumptions document
- Establishing the project's WBS and Cost Account (CA) structure
- Establishing the project baseline budget consistent with the technical and schedule portions of the project baseline
- Approving time-phased CA budgets, including subaward budgets
- Documenting the baseline budget in the Project Execution Plan (PEP)
- Approves all budget and schedule change requests

2.2 Cost Managers (CMs)

Cost managers consists of WBS L2 and some L3 managers. Their responsibilities consist of:
- Developing cost estimates and establishing time-phased Cost Account (CA) budgets
- Managing the opening and closing of Project Task Codes as appropriate to support the current active authorized work scope
- Identifying and documenting risk and contingency estimates. Once the contingency has been established, CMs do not directly own or manage that contingency. Contingency is released only through official approved change requests, as documented in the Project Execution Plan (PEP) (2).
- Managing the execution of the work
- Working with Project Controls to set up and maintain an accurate Integrated Master Schedule that interfaces with the project's Earned Value Management System (EVMS)
- Providing periodic status update information
- Keeping the Project Manager apprised of any changes to the estimated cost at completion
- Preparing basis of estimate documentation

2.3 Project Controls

- Collecting and applying the most current indirect rates, depending on Universities and Institutional overhead and fringe rates charged.

- Integration of individual estimates into a complete project cost estimate
- Assurance of compliance of cost estimates with GAO guidelines
- Reviews data with CMs to ensure data correctness and accuracy
- Scrutinizes all budget and schedule change requests for accuracy, and implements approved change requests into the PMB

3. Procedure

Cost estimates are prepared in a clear, consistent, and comprehensive format that facilitates reviewing the details and assumptions throughout the cost estimate review process. Activities to be estimated are identified in sufficient detail to support the cost estimate methodology used. Cost estimates have backup documentation in a centrally located file that explains the assumptions and calculations on which the estimate was based.

For the IceCube Upgrade project, the cost estimate documentation is assembled in Cost Model Workbooks that are stored centrally in a controlled and restricted environment (Sharepoint) that is accessible to project personnel for review.

The main objectives of cost estimating are to:
- Support the establishment of the Performance Measurement Baseline (PMB)

- Serve as a basis for change control

- Support the establishment of the Estimate at Completion (EAC)

- Support the establishment of the Estimate to Complete (ETC)

Figure **1** shows how the cost estimating is connected to the overall project management flow for the project. The CEP (this document) and the project's Key Assumptions document provide the guidance for cost estimation. The Cost Model Workbooks serve as the main inputs to the cost estimate.
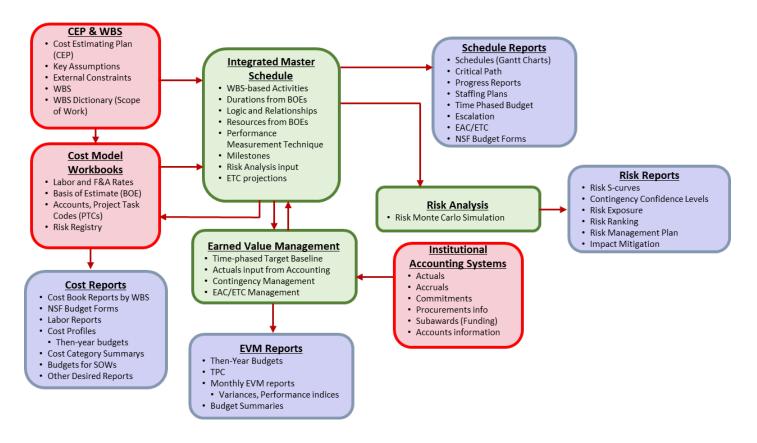
Figure 1: IceCube Upgrade project management flow diagram (based on the NSF Major Facilities Guide **(3)** Fig 4.2.2-1).

3.1 Cost Estimate Development

The schedule and methodology of cost estimating to support NSF approval process and preparation or update of the construction phase of the project are described below.

The Project has developed a WBS structure with clear delineation of technical, procedural, reporting and accounting competencies. The cost estimate is documented in Basis of Estimate (BOE) part of the Cost Model Workbooks. These are Excel workbooks, one for each of the Level 4 WBS elements, that contain details of the tasks within that L4 element down to a level 5 or deeper, as necessary, in a time-phased manner. These tasks were then entered in the master schedule, i.e., there is a one-to-one correspondence between the schedule tasks and budget entries in the workbooks.

The Cost Model Workbook templates allowed managers to plan labor, materials, capital equipment, travel, and subcontracts for each individual task at the lowest level planned under the L4 element. The cost model workbooks were then used to form the overall project budget cost book. Labor, materials, equipment, and travel estimates were made based on the tasks in the schedule provided by L2 and L3 WBS managers and updated in a detailed PY2 project re-plan exercise that took place during August and September 2019. When possible, actual names of lead personnel were included.

Current labor rates as well as up-to-date fringe and overhead rates are available from the NSF-supported institutions.

Cost Estimation uncertainties are assigned to the cost and effort for each activity. These uncertainties are used in the determination of contingency and are defined in current Project Execution Plan.

The project anticipates a rebaselining exercise in April, 2022 to adjust the cost and schedule impacted mainly by COVID19 and subsequent cancellations of on-ice seasons.

Table 1 shows a timeline with the project cost and schedule development milestones.

Q4 – 2017	Total Project Cost approved
Q1 – 2021	Updated costs for rebaselining scenarios
Q2 – 2022	Planned update cost, risk, and contingency for rebaselining.

Table 1 Cost estimating milestones for the IceCube Upgrade Project. Quarters are expressed in CY.

3.2 Cost Estimating

Cost estimating is a key component of the project baseline budget development process. Estimates are developed and maintained from project initiation through project completion. Cost estimates are created with sufficient levels of detail to identify CA resources and to take into consideration schedule activity durations. The cost estimate is prepared at the lowest level of the WBS and is activity based, consistent with the schedule and technical elements of the baseline scope of work.

Cost estimates are prepared using appropriate estimating methodologies with the issuance of guidelines and instructions from the PM in the "Key Assumptions Document". Estimates should be consistent with the GAO Cost Estimating and Assessment Guide (4).

To effectively estimate project costs, it is necessary to have a thorough understanding of the project work scope. The level of detail and accuracy of the budget becomes more definitive as the project's scope is refined. Each BoE clearly describes the scope of the work.

The cost estimate has an uncertainty that is related to the level of maturity of the design and available cost information. Detailed guidance on the uncertainty used is given in the Key Assumptions Document (1).

Contingency estimates are identified outside the baseline budget and schedule and are based on the likelihood and severity of the uncertainty. Each task is assigned an uncertainty as described in the Key Assumptions Document. These uncertainties are used to describe the probability distribution for the cost, e.g. using a flat distribution as used for most of the risks**.** The contingency estimates are summed to form the "cost uncertainty" part of the overall contingency.

Labor costs are estimated in current Fiscal Year (FY) rates and include overhead rates to arrive at fully burdened dollars. Future year escalated rates are obtained using agreed on escalation rates. Labor costs and escalation rates are described in the Key Assumptions Document.

All cost information is entered into the resource loaded schedule and a cost book based on the WBS structure is produced. This information will be used to populate the NSF 1030 forms.

3.3 The GAO Twelve Steps to Producing a Quality Cost Estimate

A consistent approach to cost estimating verifies that cost estimates meet all requirements, are based on standard requirements, are accurate, are traceable to technical requirements, and are consistent with generally accepted and sound industry cost estimating practices. Cost estimates also solidify the scope of work, providing a documented reference for identifying changes in scope and addressing future cost variances.

The GAO Cost Estimate and Assessment Guide (4) describes the following 12 steps to producing a quality cost estimate:

1. Define the estimate's purpose
2. Develop an estimating plan
3. Define the program (i.e. technical baseline description, assumptions)
4. Determine the estimating structure (e.g. WBS)
5. Identify ground rules and assumptions
6. Obtain data
7. Develop point estimate and compare to an independent cost estimate
8. Conduct sensitivity analysis
9. Conduct risk and uncertainty analysis
10. Document the estimate
11. Present the estimate for management approval
12. Update the estimate to reflect actual costs and changes

The following sections describe the application of these 12 steps.

Step 1 – Define the estimates purpose

The goal of the estimate is to produce a detailed bottom-up cost estimate for the Preliminary Design and estimate to completion. The estimate should support independent reviews and will be used for the project baseline and refined to support the implementation of EVMS and change control during the project execution.

Step 2 – Develop an estimating plan

The estimating plan is presented in this document.

Step 3 – Define the program (i.e. technical baseline, assumptions)

The project characteristics such as the overall science requirements, scope, and requirements of the upgrades have been developed by the IceCube Upgrade collaboration and documented in the IceCube Upgrade Project Execution Plan (2).

Step 4 – Determining the estimate structure (e.g. WBS)

The WBS structure has been established with L2 and L3 managers identified for the different areas. The scope for each WBS element is defined in the WBS dictionary and the interfaces between different areas will be documented in the interface control documents (ICDs) with clear responsibilities for the ownership of the interface. Cost Account Managers (CAMs), in general the same as project L3s, are responsible for the development of the cost estimate for their respective areas. The WBS is documented in the PEP (2) and Fig. 1 below shows the WBS to L3.
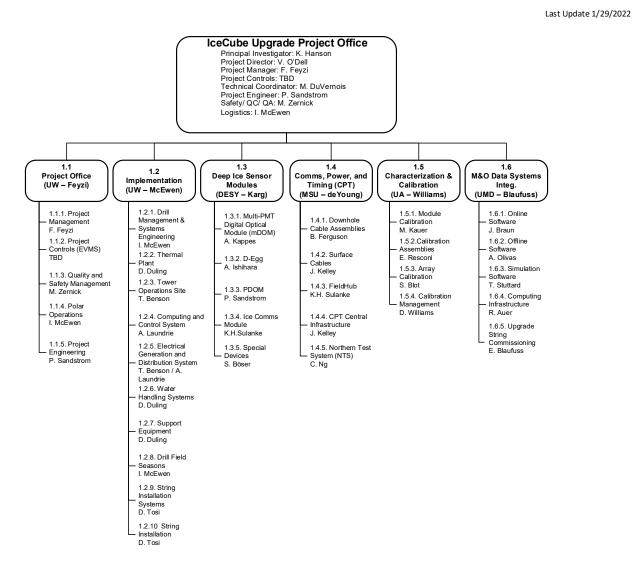
Last Update 1/29/2022

Figure 2. IceCube Upgrade Organization and WBS structure down to L3.

Step 5 – Identify ground rules and assumptions

Common assumptions used in the cost estimate are defined in the "Key Assumptions" document (1). This includes

- What is included in the estimate

- Base year of estimate

- Escalation rates

- Definition of 'fully burdened' rates

- Labor productivity and availability of factors (e.g. number of hours available per FTE)

- Labor rates at participating institutions

- High-level schedule information

- Travel assumptions

- Dependencies on other events that are external to the project (including logistics)

All estimates should be based on best available information, that is estimates should not try to 'low-ball' costs to fit into a budget, nor should they be conservative and include hidden contingency. Cost uncertainties and risks are handled separately and should not be included in the estimate. Based on the design and cost maturity, an uncertainty is assigned to all activities, see the Key Assumptions document (1) for details. Risks are evaluated and documented in the risk registry and used to evaluate the contingency, but are not part of the baseline cost estimate. Cost associated with implementing the QA/QC procedures, safety, and oversight should be included and justified in the BoEs. Labor contributed to the project, such as graduate student and postdocs at universities, should be included in the resources estimates.

Certain activities cannot be associated with quantifiable units of work and are instead expressed as a defined level of effort over time (LOE tasks).

Step 6 – Obtain data

Data will be obtained from a variety of sources. Equipment, material, and services will be based on quotes from vendors or catalog prices. Unit prices for labor includes wages, taxes, insurance, fringe benefits, and overheads, and are collected from participating institutions. Labor effort are in many cases be based on experience from the original IceCube project.

Step 7 – Develop point estimate

All cost information has been included in the resource loaded schedule to obtain the full cost rollup. The process of determining the resources required to accomplish the defined scope within the required timeframes is an iterative process. This process leads to the definition of the Performance Measurement Baseline (PMB).

All cost estimates are peer reviewed to ensure consistency and professionally prepared cost estimates that are complete.

Step 8 – Conduct sensitivity analysis

One method to test the integrity of the estimate is to test its sensitivity to varying assumptions, schedules (including in-kind partner schedules, on-ice assumptions and schedule), funding profiles, etc. These what-if exercises will also help to determine which elements and assumptions are cost and schedule drivers. Carrying out the sensitivity analysis will be part of the vetting process of the cost and schedule for the rebaseline exercise. This has been done previously during the various on-ice scenario plans and costing during 2021, and will be documented in a separate sensitivity analysis document.

Step 9 – Conduct risk and uncertainty analysis

As discussed earlier the cost estimate should be based on the best available information, i.e. not try to minimize the cost or add hidden contingency. However, there are some events, risks, that can affect both the project cost and schedule, and are probabilistic in nature. Examples are the need to remake a board or resubmit a chip, and more global risks such as fluctuations in exchange rates or escalation rates.

Discrete risks are collected in the risk register, as described in the *IceCube Upgrade Risk Management Plan* (5). These risks are described by the probability of occurrence and impact, which can be on schedule or cost, or both. Both the cost impact and probability for a risk event are described by a flat probability distribution between a low and high estimate of the cost exposure and a low and high estimate of the risk probability. A risk Monte Carlo is performed, as described in (5), and the overall contingency due to discrete risks is defined as the cost needed to mitigate risks in in the majority of the simulated risk scenarios.

For the uncertainty on the point estimate, a slightly different approach is taken, where the cost uncertainty is modeled based on the maturity of the design and the estimation of the fidelity of the cost estimate. For details and uncertainty ranges see the Project's Key Assumptions Document (1).

Step 10 – Document the estimate

The cost estimates are maintained in a version controlled document database (Sharepoint) used by the project. This includes all supporting documentation; the Cost Model Workbooks, together with the Key Assumptions Document and the inputs such as labor rates defining the cost estimates.

Step 11 – Present the estimate for management approval

The costs can be provided summarized in multiple ways. The cost book rollup provides a summary of the costs by WBS. We can also provide the summary in the NSF budget format (form 1030) as well as generating summaries of labor, equipment, and M&S costs and labor profiles and obligation profiles.

Step 12 – Update the estimate to reflect actual costs and changes

The estimates should be maintained to reflect the latest changes and progress. It is important that the latest cost and schedule information be included in the Estimate at Completions (EAC) or Estimate

to Complete (ETC) to ensure accuracy. The EAC/ETC is updated during the EVM reporting phase of the project. The EAC will be updated regularly, at least annually, along with estimate uncertainties and risk contingencies to ensure there is enough contingency to successfully complete the project. Labor rates will also be reviewed annually, as necessary.

3.4 Basis of Estimate Documentation

A well-documented estimate will withstand scrutiny. If rigorous documentation and estimate procedures are followed, the credibility of a cost estimate increases. It is important to document all the steps in the cost estimating process described above in the project's Basis of Estimates. The Basis of Estimates contain the following information:

1. WBS ID
2. WBS Description (Name)
3. Name(s) of Estimator(s)
4. WBS Dictionary Description
5. Description of Scope
6. Labor, Equipment, M&S, and Travel Description and Justification
7. Estimate Uncertainty category

References

1. **IceCube Upgrade Project.** Key Assumptions for the IceCube Upgrade Project. [Online]

2. —. Project Execution Plan for the IceCube Upgrade Project. [Online] 2021.

3. **National Science Foundation.** *Major Facilities Guide.* 2019.

4. **U.S. Government Accountability Office.** *Cost Estimate and Assessment Guide: Best Practices for Developing and Managing Program Costs.* 2020.

5. **IceCube Upgrade Project.** *IceCube Upgrade Risk Management and Mitigation Plan.*

IceCube Upgrade CEP

Final Audit Report   2022-03-18

Created:	2022-03-10
By:	Mike Zernick (zernick@wisc.edu)
Status:	Signed
Transaction ID:	CBJCHBCAABAAS8XvaXK2fLE1eqySIVq1dnFnHw776ilS

"IceCube Upgrade CEP" History

Document created by Mike Zernick (zernick@wisc.edu)
2022-03-10 - 8:38:33 PM GMT- IP address: 144.92.224.130

Document emailed to KAEL HANSON (kaelhanson@wisc.edu) for signature
2022-03-10 - 8:41:12 PM GMT

Document emailed to Vivian O'Dell (vodell@wisc.edu) for signature
2022-03-10 - 8:41:12 PM GMT

Document emailed to FARSHID FEYZI (ffeyzi@wisc.edu) for signature
2022-03-10 - 8:41:12 PM GMT

Email viewed by KAEL HANSON (kaelhanson@wisc.edu)
2022-03-10 - 9:01:28 PM GMT- IP address: 128.104.141.56

Document e-signed by KAEL HANSON (kaelhanson@wisc.edu)
Signature Date: 2022-03-10 - 9:54:38 PM GMT - Time Source: server- IP address: 128.104.141.56

Email viewed by Vivian O'Dell (vodell@wisc.edu)
2022-03-15 - 6:30:57 PM GMT- IP address: 128.104.141.56

Email viewed by FARSHID FEYZI (ffeyzi@wisc.edu)
2022-03-16 - 4:05:44 PM GMT- IP address: 128.104.141.56

Document e-signed by FARSHID FEYZI (ffeyzi@wisc.edu)
Signature Date: 2022-03-16 - 4:06:19 PM GMT - Time Source: server- IP address: 128.104.141.56

Email viewed by Vivian O'Dell (vodell@wisc.edu)
2022-03-18 - 0:19:41 AM GMT- IP address: 128.104.141.56

Document e-signed by Vivian O'Dell (vodell@wisc.edu)
Signature Date: 2022-03-18 - 0:20:08 AM GMT - Time Source: server- IP address: 128.104.141.56

Adobe Sign

✅ Agreement completed.
2022-03-18 - 0:20:08 AM GMT