

1. **WBS ID** 1.5 \$620,205 total cost for this WBS
2. **WBS Name** Calibration and Characterization
3. **Estimated by** Dawn Williams (University of Alabama)
4. **WBS Dictionary Description**

This category is responsible for calibrating and characterizing the detector, which consists of both modules and ice. The deliverables are well characterized modules which meet the high level design requirements of the IceCube upgrade for stability and performance, and improved measurements of the modules and the ice relative to our current knowledge of the detector.

5. Assumptions and Related Documents

The estimates described in this document rely on the following assumptions, which are consistent with the Project’s “Key Assumptions” document” (1) and the “Cost Estimating Plan” (2).

- The cost estimate technique classifications (A-L) follow the US Government Accountability Office (GAO) best practices. These are summarized in the Project’s Key Assumptions document (1). The techniques are: A=Analogy; C=Engineering build-up; D=Expert opinion; E=Extrapolation from actuals; F=Parametric; L=Learning Curves.
- Contingency codes are assigned to each item: C1—C8. These reflect the estimated uncertainty in the estimate. The meanings of the contingency codes and the percentage of contingency in each case are described in the Key Assumptions document (1).

6. Scope

The scope of this BOE covers the following L3 areas:

1.5.2	Pencil Beam	Responsible for overall coordination of the pencil beam
1.5.3	Array Calibration	This element is responsible for characterization and calibration of the deployed array.
1.5.4	Calibration Management	Responsible for management of the calibration effort.

7. Materials, Supplies, Equipment, Travel

1. Procurement of Materials, Supplies, Equipment

There are no equipment costs in this BOE – all equipment are in kind contributions. M&S covers lab supplies for calibration and shipping of the dust logger and winch to PSL for testing and then to Port Hueneme.

Summary of Materials, Supplies, and Equipment Resources

The summary of Materials and Supplies is given in the table below.

WBS	M&S/Equipment Activity	FY23	FY24	FY25	FY26	Institution	GAO Estimation Technique	Contingency Code
1.5.3.5.1	Dust logger shipping UCB to UW/PSL	M & S	\$0	\$1,000	\$0	\$0	D - Expert Opinion	C1
1.5.3.5.3	Shipping of logger and winch to PTH	M & S	\$0	\$0	\$4,000	\$0	D - Expert Opinion	C1
1.5.4.1	Miscellaneous supplies for calibration and outreach activities	M & S	\$3,000	\$0	\$0	\$0	D - Expert Opinion	C1

3. Travel

Travel WBS 1.5 covers travel for the L2 for Calibration and Characterization (Prof. Dawn Williams, U. Alabama) and UA postdocs (to be hired) to travel to project reviews and calibration device design reviews. Additional travel is budgeted for a research scientist to test the dust logger. Total trips/year are summarized in Table 1. Using the average domestic and international cost per trip as given in gives the final travel table (Table 2) of direct costs.

	FY23	FY24	FY25	FY26
Domestic	2	3	2	1
International	2	2	2	0

Table 1 Travel supported on project for WBS 1.5.

WBS	Travel Activity	FY23	FY24	FY25	FY26	Institution	GAO Estimation Technique	Contingency Code
1.5.3.5.1	Travel to test dust logger	\$0	\$1,800	\$0	\$0	UW	E - Extrapolation from Actuals	C1
1.5.4.2	Travel to reviews and working meetings - Domestic	\$3,600	\$3,600	\$3,600	\$1,800	UA	E - Extrapolation from Actuals	C1
1.5.4.2	Travel to reviews and working meetings - International	\$6,400	\$6,400	\$6,400	\$0	UA	E - Extrapolation from Actuals	C1

Table 2 Direct costs of travel covered on project for WBS 1.5.

8. Labor

1. Labor Estimate

Labor covers the management of the calibration effort, and two postdoctoral scholars to prepare for and collect calibration data from the deployed devices. There is also engineering support for the PencilBeam effort at UW Madison. A small amount of labor is allocated to test the dust logger and associated winch.

2. Summary of Labor Resources

WBS	Labor Activity	Resource ID	FY23	FY24	FY25	FY26	Institution	GAO Estimation Technique	Contingency Code
1.5.2.2.0	Overall coordination for Pencil Beam	SS	450	412.5	0	0	UW	D - Expert Opinion	C1
1.5.3.1.1	Simulation Studies	PO	0	450	900	0	UA	D - Expert Opinion	C1
1.5.3.2.4	Create Database Structure for Timing Calibration Data	PO	0	450	900	225	UA	D - Expert Opinion	C1
1.5.3.2.5	Analyze Timing Calibration Data from Deployed Modules	PO	0	0	0	225	UA	D - Expert Opinion	C1
1.5.3.3.2	Create Database Structure for Geometry Calibration Data	PO	0	450	900	225	UA	D - Expert Opinion	C1
1.5.3.3.3	Analyze Geometry Calibration Data from Deployed Modules	PO	0	0	0	225	UA	D - Expert Opinion	C1
1.5.3.4.2	Software Development	PO	0	450	900	450	UA	D - Expert Opinion	C1
1.5.3.4.3	Execution	PO	0	0	0	450	UA	D - Expert Opinion	C1
1.5.3.5.1	PSL Engineering support for summer 2024 testing	TE	0	48	0	0	PSL	D - Expert Opinion	C1
1.5.3.5.1	Research Scientist to test dust logger	SS	0	160	0	0	UW	D - Expert Opinion	C1
1.5.4.1	Calibration Management	KE	80	80	80	0	UA	D - Expert Opinion	C1

9. References

1. **IceCube Upgrade Project.** *Key Assumptions Document for the IceCube Upgrade Project.* 2021.
2. —. Cost Estimating Plan for the IceCube Upgrade Project. [Online] <https://sharepointurl> for the document.

Revision History

Date	Revised by	Summary of changes
2022-02-25	Dawn Williams	First version created
2022-03-30	Dawn Williams	Added PencilBeam Engineering effort
2022-04-03	V. O'Dell	General cleanup