Basis of Estimate

1. **WBS ID**	1.4.1	$545,040 total cost for this WBS

2. **WBS Name** Downhole Cable Assemblies

3. **Estimated by** Tyce DeYoung (Michigan State University)

4. WBS Dictionary Description

This element includes design, procurement, and quality assurance of the physical cable assemblies running to the in-ice sensors and calibration devices, as well as their delivery to Port Hueneme.

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:

1.4.1.1.1	Main Cables	Design, prototyping and procurement of the raw main cables
1.4.1.1.2	Breakout Connections	Design, prototyping and procurement of the breakout connections installed in the main cables at various points throughout the bottom 1 km of their length

1.4.1.1.3	Main Cable Assembly Production	Oversight of production and testing of the finished MCAs, including breakout connections and end terminations, packaging and shipping to Pt Hueneme
1.4.1.2	Breakout Cable Assemblies	Design, prototyping and procurement of the BCAs connecting the MCA breakout connectors to the DOMs and other devices
1.4.1.3	Penetrator Cable Assemblies	Design, prototyping, procurement, and retesting of the PCAs connecting to the BCAs and carrying the cable conductors through the DOM pressure housing, and of mating cables to be used for South Pole Acceptance Testing of DOMs
1.4.1.4	String Hardware and Support Rope	Design, prototyping and procurement of the mechanical support structures connecting the DOMs to the MCA
1.4.1.5	Cable Emulators	Design and production of cable load emulator circuits for lab electronics development work
1.4.1.6	On-ice support	

7. Materials, Supplies, Equipment, Travel

7.1. Procurement of Materials, Supplies, Equipment

Materials, supplies and equipment in this area are related to design, prototyping and testing of all downhole cable elements: the main cables, BCAs, PCAs, string hardware, cable load emulators, and cables for South Pole Acceptance Testing (SPAT) of DOMs immediately prior to deployment. Procurement or production of the BCAs, pDOM PCAs, string hardware, cable emulators are also included. The production main cable assemblies are an in-kind contribution from MSU.

Cost of components for the production BCAs includes raw pressure-rated cable, estimated at $15/m based on the cost of PCA pressure-rated cable (SB 45027), and the cost of MCA-side connectors, estimated at $350/mating pair based on costs of PCA mating connectors. A total of 6,556 m of cable and 172 MCA-side connectors are required for the seven strings, including spares (see RFI). PCA-side connectors have already been purchased in conjunction with PCA procurement. Cost of shipping is SME estimate based on experience with PCA shipping costs.

Costs of cables and connectors for SPAT DOM testing are estimated by Subject Matter Expert based on costs of NTS cables.

Costs of physical qualification (PQ) medical exam and rental of extreme cold weather (ECW) gear for SMEs deploying to South Pole in support of installation activities is based on guidance from the project office.

An allowance for miscellaneous supplies of $500/year for the duration of the effort in each L4 area is based on SME experience.

Basis of Estimate

7.2. Summary of Materials, Supplies, and Equipment Resources

WBS	Activity	Subtype	12mo Subtotal PY5	12mo Subtotal PY6	12mo Subtotal PY7	12mo Subtotal PY8	Estimating Technique	Contingency
1.4.1.2.3.1	BCA connectors - first two strings, MCA side (62 connectors)	CapEx	$21,700	$0	$0	$0	A - Analogy	C3
1.4.1.2.3.1	BCA cable - first two strings (2,000 m)	CapEx	$30,000	$0	$0	$0	A - Analogy	C4
1.4.1.2.3.1	BCA fabrication costs - first two strings	CapEx	$25,000	$0	$0	$0	D - Expert Opinion	C4
1.4.1.2.4.1	BCA connectors - last five strings, MCA side (110 connectors)	CapEx	$38,500	$0	$0	$0	A - Analogy	C3
1.4.1.2.4.1	BCA cable - last five strings (4,556 m)	CapEx	$68,340	$0	$0	$0	A - Analogy	C4
1.4.1.2.4.1	BCA fabrication costs - last five strings	CapEx	$0	$45,000	$0	$0	D - Expert Opinion	C4
1.4.1.2.3.3	BCA shipping costs to PTH (1st two strings)	M & S	$1,500	$0	$0	$0	D - Expert Opinion	C4
1.4.1.2.4.2	BCA shipping costs to PTH (remaining strings)	M & S	$0	$2,000	$0	$0	D - Expert Opinion	C4
1.4.1.2.5	Breakout Cable Assembly miscellaneous supplies	M & S	$500	$125	$0	$0	F - Parametric	C1
1.4.1.3.4.2	SPAT cable materials	M & S	$960	$0	$0	$0	C - Engineering Buildup	C2
1.4.1.3.5	Penetrator Cable Assembly Miscellaneous supplies	M & S	$125	$0	$0	$0	F - Parametric	C1
1.4.1.4.2	String hardware miscellaneous supplies	M & S	$250	$0	$0	$0	F - Parametric	C1
1.4.1.6.3	Cable SME FS3 PQ costs (Headcount 2)	M & S	$0	$0	$1,400	$0	C - Engineering Buildup	C2
1.4.1.6.3	Cable SME FS3 ECW costs (Headcount 2)	M & S	$0	$0	$500	$0	C - Engineering Buildup	C2

7.3. Travel

WBS	Activity	12mo Subtotal PY4	12mo Subtotal PY5	12mo Subtotal PY6	12mo Subtotal PY7	12mo Subtotal PY8	Estimating Technique	Contingency
1.4.1.6.3	Cable SME FS3 Deployment travel (Headcount 2)	$0	$0	$0	$0	$3,600	E - Extrapolation fr	C1
1.4.1.6.1	Off-Ice Safety Training FS3 Cable SMEs (Headcount 2)	$0	$0	$0	$3,600	$0	E - Extrapolation fr	C1
1.4.1.4.1.5	String hardware final design review	$0	$3,600	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.2.4.1	BCA manufacturing	$0	$6,400	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.2.3.1	BCA manufacturing - first two strings	$0	$6,400	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.2.2.2	BCA final design review	$0	$5,400	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.2.1.5	BCA prototype evaluation	$0	$9,600	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.1.3.2	MCA production	$0	$6,400	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.1.2.2.4	Breakout final design review	$0	$5,400	$0	$0	$0	E - Extrapolation fr	C1
1.4.1.1.2.2.3	Breakout prototype testing	$0	$9,600	$0	$0	$0	E - Extrapolation fr	C1

We budget for two Main Cable Assembly SMEs to travel to Pole in FS3 to support deployment activities, using cost guidance from the Key Assumptions Document. A trip to Wisconsin to attend off-ice safety training prior to deployment is also budgeted.

One trip is budgeted for two people (cable SME and L2) to WIPAC for the final design review of string mechanical hardware.

One trip for three people (cable SMEs and L2) to the BCA production site (assumed to be foreign) is budgeted for observation of BCA prototype testing.

Two trips to the supplier facility (assumed to be foreign) are budgeted for two cable SMEs in conjunction with oversight of the BCA production process.

One domestic trip (to WIPAC) is budgeted for three people (cable SMEs and L2) for the final design review of the Main Cable Assembly breakout terminations.

One trip for three people (cable SMEs and L2) to the MCA production facility (assumed to be foreign) is budgeted for observation of MCA breakout prototype testing.

One trip for two people to the MCA production facility (assumed to be foreign) is budgeted for oversight of MCA production.

All foreign and domestic trips are budgeted using cost guidance from the Key Assumptions Document.

Basis of Estimate

8. Labor

8.1. Labor Estimate

Labor in this area is related to design, prototyping, testing, and procurement; oversight of production of major cable elements by suppliers; and production of non-pressure-rated cables and cable load emulators conducted in-house. Labor rates are calculated based on current rates of the personnel assigned to the task as per the Key Assumptions document. Major task groups and their basis of estimate are:

Main cable first article production, acceptance testing, and shipping: Subject Matter Expert estimate of 16 hours/month engineering labor for liaison with vendor; 4 days labor for each engineer/technician to oversee acceptance testing and review results; 32 hours to coordinate shipping of first article from cable supplier to breakout installation facility

Main cable production readiness review: based on past design reviews, 2 days (16 hours) spent in review plus 1 week (40 hours) to prepare for review for each engineer/technician working on the design

Main cable production, acceptance, and shipping: Subject Matter Expert estimate of 16 hours/month engineering labor for liaison with vendor; 32 hours to coordinate shipping from cable supplier to breakout installation facility

Breakout final design: Subject Matter Expert estimate of 200 hours engineering/technican labor working with breakout supplier to finalize design (beginning in PY4); 16 hours/month engineering labor for liaison with supplier during prototype production; 1 week for each engineer/technician to prepare test protocols, travel to observe tests, and analyze results. Based on past design reviews, 2 days (16 hours) spent in review plus 1 week (40 hours) to prepare for review and 1 week to document response to review report for each engineer/technician working on the design

MCA production: Subject Matter Expert estimate of 16 hours/month engineering labor for liaison with vendor; 32 hours to coordinate shipping from vendor to USAP logistics hub

MCA pre-ship review: based on past reviews, 2 days (16 hours) spent in review plus 1 week (40 hours) to prepare for review for each engineer/technician working on the design

BCA prototype procurement and testing: based on past experience, 40 hours (beginning in PY4) for each engineer/technician to prepare test protocols, travel to observe tests, and analyze results.

BCA final design and procurement: Subject Matter Expert estimate of 220 hours of engineering and technician labor for design revision based on prototype test results and communications with potential suppliers. Based on past design reviews, 2 days (16 hours) spent in review plus 1 week (40 hours) to prepare for review and 1 week to document response to review report for each engineer working on the design. Based on past experience, 80 hours of engineering labor to support procurement process.

BCA production, acceptance, and shipping: Subject Matter Expert estimate of 16 hours/month engineering labor for liaison with vendor; 32 hours to coordinate shipping from cable supplier to breakout installation facility for each shipment (initial shipment of BCAs for first two strings and final shipment of BCAs for remaining five strings)

BCA pre-ship review: based on past reviews, 2 days (16 hours) spent in review plus 1 week (40 hours) to prepare for review

SPAT cable design, procurement and production: Subject Matter Expert estimate of 40 hours technician labor for production and testing of cables, and 8 hours for packaging and shipping of finished cables to WIPAC.

String hardware: Subject Matter Expert estimate of 16 hours to coordinate cable grip shipping to MCA production facility.

Basis of Estimate

On-ice cable SME support for installation: labor estimate based on Installation lead guidance regarding cable SME support required for installation and planned on-ice dates.

8.2. Summary of Labor Resources

WBS	Activity	Resource ID	LPY5	LPY6	LPY7	LPY8	Estimating Technique	Contingency
1.4.1.1.1.3.2.1	First article cable fabrication	EN-ME	48	0	0	0	A - Analogy	C1
1.4.1.1.1.3.2.2	First article acceptance testing	EN-ME	32	0	0	0	D - Expert Opinion	C4
1.4.1.1.1.3.2.2	First article acceptance testing	TE	32	0	0	0	D - Expert Opinion	C4
1.4.1.1.1.3.2.4	First article shipping to breakout installation facility	EN-ME	32	0	0	0	A - Analogy	C3
1.4.1.1.1.3.3	Production readiness review	EN-ME	56	0	0	0	A - Analogy	C2
1.4.1.1.1.3.3	Production readiness review	TE	56	0	0	0	A - Analogy	C2
1.4.1.1.1.3.4	Production of final six main cables	EN-ME	48	0	0	0	A - Analogy	C1
1.4.1.1.1.3.6	Production cable shipping to breakout installation facility	EN-ME	32	0	0	0	A - Analogy	C3
1.4.1.1.2.2.1	Breakout final design	TE	8	0	0	0	D - Expert Opinion	C5
1.4.1.1.2.2.1	Breakout final design	EN-ME	40	0	0	0	D - Expert Opinion	C5
1.4.1.1.2.2.2	Breakout prototype production	EN-ME	32	0	0	0	A - Analogy	C1
1.4.1.1.2.2.3	Breakout prototype testing	EN-ME	40	0	0	0	A - Analogy	C2
1.4.1.1.2.2.3	Breakout prototype testing	TE	40	0	0	0	A - Analogy	C2
1.4.1.1.2.2.4	Breakout final design review	TE	96	0	0	0	A - Analogy	C3
1.4.1.1.2.2.4	Breakout final design review	EN-ME	96	0	0	0	A - Analogy	C3
1.4.1.1.3.2	MCA production	EN-ME	56	0	0	0	A - Analogy	C1
1.4.1.1.3.3	Pre-ship review	TE	56	0	0	0	A - Analogy	C3
1.4.1.1.3.3	Pre-ship review	EN-ME	56	0	0	0	A - Analogy	C3
1.4.1.1.3.4	Main Cable Assembly shipping to PTH	EN-ME	16	16	0	0	A - Analogy	C3
1.4.1.2.1.5	BCA prototype evaluation	EN-ME	30	0	0	0	A - Analogy	C4
1.4.1.2.1.5	BCA prototype evaluation	TE	30	0	0	0	A - Analogy	C4
1.4.1.2.2.1	BCA final design	EN-ME	140	0	0	0	D - Expert Opinion	C4
1.4.1.2.2.1	BCA final design	TE	80	0	0	0	D - Expert Opinion	C4
1.4.1.2.2.2	BCA final design review	EN-ME	96	0	0	0	A - Analogy	C2
1.4.1.2.2.2	BCA final design review	TE	96	0	0	0	A - Analogy	C2
1.4.1.2.2.4	BCA procurement	EN-ME	80	0	0	0	D - Expert Opinion	C4
1.4.1.2.3.1	BCA manufacturing - first two strings	EN-ME	80	0	0	0	A - Analogy	C1
1.4.1.2.3.2	BCA pre-ship review	EN-ME	56	0	0	0	A - Analogy	C3
1.4.1.2.3.3	Shipping to PTH	EN-ME	32	0	0	0	A - Analogy	C3
1.4.1.2.4.1	BCA manufacturing	EN-ME	48	16	0	0	A - Analogy	C1
1.4.1.2.4.2	Shipping to PTH	EN-ME	0	32	0	0	A - Analogy	C2
1.4.1.3.4.3	SPAT cable production	TE	40	0	0	0	A - Analogy	C3
1.4.1.3.4.4	SPAT cable shipping	TE	8	0	0	0	A - Analogy	C2
1.4.1.4.1.7	String hardware shipping to MCA production facility	EN-ME	16	0	0	0	A - Analogy	C3
1.4.1.6.4	On-Ice Cable SME support for FS3 activities (slot 1)	EN-ME	0	0	0	300	C - Engineering Buildup	C1
1.4.1.6.5	On-Ice Cable SME support for FS3 activities (slot 2)	EN-ME	0	0	0	190	C - Engineering Buildup	C1

9. References

1. **IceCube Upgrade Project.** *Key Assumptions Document for the IceCube Upgrade Project.* 2021.

2. —. *Cost Estimating Plan.*

Basis of Estimate

Revision History

Date	Revised by	Summary of changes
2022-02-28	T. DeYoung	First version
2022-03-08	T. DeYoung	Added vendor quotes/POs for main cable test system components. Added tables from Smartsheets.
2022-03-09	T. DeYoung	Added total cost for PY5-8
2022-03-28	V. O'Dell	Checked over, general cleanup.
2022-03-30	T. DeYoung	Corrected foreign trip cost, added second on-project ME in FS3
2022-04-08	T. DeYoung	Removed basis of PY4 costs. Added on-ice cable SME support info

Basis of Estimate

Basis of Estimate

South Bay Cable Corp.

P.O. Box 67 • Idyllwild, California 92549 • (951) 659-2183 • FAX (951) 659-3958
www.southbaycable.com

Michigan State University
567 Wilson Road
Lansing, MI 48824

Attn: Chris Ng

QUOTATION IN RESPONSE TO RFQ: Verbal

OUR QUOTATION NO.: 85358-A

AGENT: No Agent

DATE: March 6, 2019

WE ARE PLEASED TO OFFER OUR QUOTATION IN REPLY TO YOUR REQUEST ABOVE AS FOLLOWS:

1a	100 Ft.	SB-45027 *Length: 1 X +/-0%*	$45.10/Ft.
1b	750 Mtrs.	SB-45027 *Lengths: 250 Meter Mults*	$17.05/Mtr.
1c	1,000 Mtrs.	SB-45027 *Lengths: 250 Meter Mults*	$14.90/Mtr.

FOB: IDYLLWILD [X] OTHER: _____ REELS: NO CHARGE [X] OTHER: _____

FIRM FOR: 30 DAYS [X] OTHER: _____

TERMS: NET 30 [X] OTHER: _____ TOLERANCE ON QTY: + 10%-0% [ ] OTHER: +/-0%

SHIPPING ESTIMATE: 16 - 18 Weeks

*Terms subject to credit approval

Mark Collis, Sales Representative
FOR SOUTH BAY CABLE CORP.

Basis of Estimate

MICHIGAN STATE
UNIVERSITY

PURCHASE ORDER

PO Number: 514568	**Contract Mgr:** Croswhite, Janice
	Phone: 517-432-7255

Supplier 118653-0 HYDRO GROUP SYSTEMS INC ATTN: KMILDON@HYDROGROUPSYSTEMS.COM 2188 PALM WAY LARGO FL 33771		**Shipping Address** UNIVERSITY STORES ANGELL BLDG 166 SERVICE RD EAST LANSING, MI 48824
Shipping Terms FREIGHT PREPAID AND ADDED - SHIPPING POINT		**Payment Terms** Net 30 Days
Delivery Required By 08-23-2019		
Order Date 09-06-2019	**Customer #**	**Billing Address** MSU Accounts Payable Department 166 Service Rd. Rm 103 East Lansing, MI 48824 517-353-2011 Invoice status inquiry: Emailing Invoice Instructions: https://usd.msu.edu/accounts-payable/e-mailing-invoices/index.html
Delivery Instructions	**Contract ID**	

Supplier Note(s)
Reference quote Q0013652 rev: 02 items 01, 02, 03.

Supplier Stipulations and Information

This purchase is being made with United States Federal Government funding. The supplier agrees to comply with the Federal Acquisition Regulations (FAR) and Defense Federal Acquisition Regulation Supplement (DFARS) as provided and available at http://usd.msu.edu/purchasing/policies-procedures/federal-procurement/index.html.

This order is being issued using funding from a federal contract or grant. Through acceptance of this order, the supplier agrees to all requirements of Executive Order 11246, available at http://www.dol.gov/ofccp/regs/statutes/eo11246.htm

Item No.	Quantity	UOM	Description	Unit Cost	Extended Cost
1	5.00	EA	PCA10000-2 - Penetrator Assembly with 24" inches of cable on inboard side and 18" of cable iwth connector plug - CR10000	1510.3200	$7,551.60
2	10.00	EA	PCA10000-3 - Penetrator Assembly with 24" inches of cable on inboard side (New Cable Red) and 18" of cable with connector plug - CR10000	1510.3200	$15,103.20
3	10.00	EA	CP10000 - Connector plug kit	354.8600	$3,548.60
			Total order amount:		$26,203.40

1 By fulfilling this purchase order, you agree to MSU standard terms and conditions found at: http://usd.msu.edu/purchasing/purchase-orders/terms-conditions/index.html

K. M. Demir
Executive Mng Director, University Services
MICHIGAN STATE UNIVERSITY
PURCHASING DEPARTMENT

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Basis of Estimate

MICHIGAN STATE
UNIVERSITY

PURCHASE ORDER

PO Number: 562532	**Contract Mgr:** Croswhite, Janice
	Phone: 517-432-7255

Supplier 118653-0 HYDRO GROUP SYSTEMS INC 2188 PALM WAY LARGO FL 33771		**Shipping Address** UNIVERSITY STORES ANGELL BLDG 166 SERVICE RD EAST LANSING, MI 48824
Shipping Terms FREIGHT PREPAID AND ADDED - SHIPPING POINT		**Payment Terms** Net 30 Days
Delivery Required By		
Order Date 07-06-2020	**Customer #**	**Billing Address** MSU Accounts Payable Department 166 Service Rd. Rm 103 East Lansing, MI 48824 517-353-2011 Invoice status inquiry. Emailing Invoice Instructions: https://usd.msu.edu/accounts-payable/e-mailing-invoices/index.html
Delivery Instructions	**Contract ID**	

Supplier Note(s)
Reference Quotation Number : Q0013784 Rev : 03 – Line 1 only.

Supplier Stipulations and Information

This purchase is being made with United States Federal Government funding. The supplier agrees to comply with the Federal Acquisition Regulations (FAR) and Defense Federal Acquisition Regulation Supplement (DFARS) as provided and available at http://usd.msu.edu/purchasing/policies-procedures/federal-procurement/index.html.

This order is being issued using funding from a federal contract or grant. Through acceptance of this order, the supplier agrees to all requirements of Executive Order 11246, available at http://www.dol.gov/ofccp/regs/statutes/eo11246.htm

For invoicing please either MAIL to the billing address on the Purchase Order or request payment by email by following the instructions listed below:

1. Prepare each invoice as a separate PDF file.
2. For security purposes, redact social security numbers.
3. Send only one invoice per e-mail.
4. Send an original e-mail. Do not forward from another e-mail.
5. In the e-mail subject line, include the PO number and the supplier name. Example: PO23456 James Company
6. Send email to MSUPAY@msu.edu

Item No.	Quantity	UOM	Description	Unit Cost	Extended Cost
1	100.00	EA	CP10000 - Connector kit - Includes the plug shell, two piece insert (PEEK), contacts, retaining ring, "O" ring and protective cap.	166.5200	$16,652.00
2	25.00	EA	CP10000 - Connector kit - Includes the plug shell, two piece insert (PEEK), contacts, retaining ring, "O" ring and protective cap.	166.5200	$4,163.00
3	18.00	EA	CP10000 - Connector kit - Includes the plug shell, two piece insert (PEEK), contacts, retaining ring, "O" ring and protective cap.	166.5200	$2,997.36
4	37.00	EA	CP10000 - Connector kit - Includes the plug shell, two piece insert (PEEK), contacts, retaining ring, "O" ring and protective cap.	166.5200	$6,161.24
5	24.00	EA	CP10000 - Connector kit - Includes the plug shell, two piece insert (PEEK), contacts, retaining ring, "O" ring and protective cap.	166.5200	$3,996.48
6	931.00	EA	CP10000 - Connector kit - Includes the plug shell, two	166.5200	$155,030.12

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Basis of Estimate