

# Basis of Estimate

1. **WBS ID** 1.4.4 \$210,429 total cost for this WBS

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2. **WBS Name** CPT Central Infrastructure

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3. **Estimated by** John Kelley (University of Wisconsin)

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## 4. WBS Dictionary Description

This element includes design, production and testing of the electronics infrastructure required to distribute timing signals from the IceCube master clock to the FieldHubs in the IceCube Laboratory (ICL). This element also includes the power supplies which will supply power to in-ice devices through the FieldHubs. Associated comms/power/timing (CPT) infrastructure for the Northern Test System is also included.

## 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).
- Vendor quote 1 (Seven Solutions, 2019, White Rabbit switches and WR-LEN timing nodes)
- Vendor quote 2 (Digi-Key, 2022, Mean Well DC power supply modules)
- Vendor quote 3 (Digi-Key, 2022, Mean Well DC power supply chassis)
- Vendor quote 4 (Digi-Key, 2022, Bulgin power connectors)
- Vendor quote 5 (Digi-Key, 2022, Alpha Wire power cable)

## 6. Scope

The scope of this BOE covers the following L3 areas:

1.4.4.1	CPT Central Infrastructure — Network and Timing	The labor and materials required to design, test, and install custom or semi-custom electronics necessary for distributing timing signals from and network
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# Basis of Estimate

		communications from the IceCube DAQ to the FieldHubs in the ICL.
1.4.4.2	CPT Central Infrastructure — Power Supply Modules	The labor and materials required to design, test, and install power supplies in ICL, for distribution to in-ice instrumentation through the FieldHubs.

The communications and timing distribution system (1.4.4.1) is based on the White Rabbit timing and optical fiber protocol developed by CERN and already in use in certain IceCube systems. It includes White Rabbit switches that interface to the existing IceCube Master Clock in the ICL. The White Rabbit switches connect in turn to White Rabbit nodes within the FieldHub electronics that provide precision timing signals and high-speed Ethernet connectivity to the FieldHubs within the ICL. Cross-domain timing electronics also provide monitoring of the offset of the IceCube Gen1 and Upgrade timing systems (IceCube Gen1 currently uses a legacy clock fanout tree, not the White Rabbit network). Initial purchases of this equipment were made in 2019 for prototype development.

The power distribution system (1.4.4.2) is designed to deliver the DC power needed for the in-ice devices to the FieldHubs (and then on to the surface cable assemblies (SCAs) and main cable assemblies (MCAs)). The system consists of DC power supplies connected to the ICL 208VAC electrical system, a fanout unit to provide a connection to each of the 7 FieldHubs, and a monitoring system connected to the DC power supplies to detect any fault conditions and alert operators. Initial purchases of the off-the-shelf equipment were made in 2020 for evaluation/testing and prototype development, and quotes have been updated in February 2022.

## 7. Materials, Supplies, Equipment, Travel

### 7.1. Procurement of Materials, Supplies, Equipment

Capital equipment for 1.4.4.1 includes:

- White Rabbit WR-LEN industrial OEM embedded timing nodes (Seven Solutions #BRD-LENI-01). Vendor: Seven Solutions. Costs are from a 2019 purchase for identical hardware, updated with Feb. 2022 EUR->USD exchange rates and 10% inflation.
- White Rabbit switches (Seven Solutions #EQP-WRS-01). Vendor: Seven Solutions. Costs are from a 2019 purchase for identical hardware, updated with Feb. 2022 EUR->USD exchange rates and 10% inflation.
- Cross-domain timing electronics. Vendor: custom. Costs are based on SME estimates for similar projects, including an early partial prototype.
- Various optical and coaxial patch cables and SFPs (off-the-shelf). Vendor: various. Costs are based on SME estimates from similar past purchases.

Capital equipment for 1.4.4.2 includes:

- DC power supply modules (Mean Well #RCP-1600-48). Vendor: Digi-Key. Costs are updated from a Feb. 2022 quote.
- DC power supply chassis (Mean Well #RHP-1UI-A). Vendor: Digi-Key. Costs are updated from a Feb. 2022 quote.

# Basis of Estimate

- Power patch cables (custom). Costs are based on updated Feb. 2022 quotes for components from Digi-Key (Bulgin power connectors, Alpha Wire power cable).
- Power fanout unit (custom). Costs are based on SME estimates for similar projects as well as updated Feb. 2022 quotes for key components from Digi-Key (e.g. Bulgin power connectors).
- Power monitoring unit (custom). Costs are based on SME estimates including development of the initial prototype.

## 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
1.4.4.1.1.1	White Rabbit OEM nodes for NTS and SPTS (10 total, 6 to be purchased)	CapEx	\$6,475	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.1.1.1	White Rabbit OEM nodes for ICL (10)	CapEx	\$10,791	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.1.2.2	Timing monitoring prototype	CapEx	\$0	\$3,000	\$0	\$0	A - Analogy	C3
1.4.4.1.2.4	Timing monitoring system for ICL	CapEx	\$0	\$6,000	\$0	\$0	A - Analogy	C3
1.4.4.2.1.5	DC power supply chassis for ICL (3)	CapEx	\$1,995	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.2.1.5	48V DC power supply modules for ICL (15)	CapEx	\$7,230	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.2.2.4	Custom power fanout unit for NTS	CapEx	\$1,275	\$0	\$0	\$0	D - Expert Opinion	C3
1.4.4.2.2.4	Power fanout cables for NTS (5)	CapEx	\$800	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.2.2.4	Custom power fanout units for ICL (2)	CapEx	\$2,550	\$0	\$0	\$0	D - Expert Opinion	C3
1.4.4.2.2.4	Power fanout cables for ICL (10)	CapEx	\$1,600	\$0	\$0	\$0	C - Engineering Buildup	C2
1.4.4.2.3.4	Power control unit for NTS	CapEx	\$750	\$0	\$0	\$0	D - Expert Opinion	C3
1.4.4.2.3.4	Power control units for ICL (2)	CapEx	\$1,500	\$0	\$0	\$0	D - Expert Opinion	C3

WBS	Activity	Subtype	12mo Subtotal PY5	12mo Subtotal PY6	12mo Subtotal PY7	12mo Subtotal PY8	Estimating Technique	Contingency
1.4.4.1.1.1	Fiber patch cables for ICL (10)	M & S	\$200	\$0	\$0	\$0	C - Engineering Bt	C2
1.4.4.1.1.5	Shipping costs	M & S	\$300	\$0	\$0	\$0	A - Analogy	C4
1.4.4.1.2.6	Shipping costs	M & S	\$0	\$300	\$0	\$0	A - Analogy	C4
1.4.4.1.3	Timing systems miscellaneous supplies	M & S	\$500	\$500	\$125	\$0	F - Parametric	C1
1.4.4.2.4.4	Shipping costs	M & S	\$500	\$0	\$0	\$0	A - Analogy	C4
1.4.4.2.5	Power systems miscellaneous supplies	M & S	\$500	\$500	\$500	\$250	F - Parametric	C1
1.4.4.3.2	Electronics SME FS2 PQ costs (slot 1)	M & S	\$0	\$700	\$0	\$0	C - Engineering Bt	C2
1.4.4.3.2	Electronics SME FS2 ECW costs (slot 1)	M & S	\$0	\$250	\$0	\$0	C - Engineering Bt	C2
1.4.4.3.2	Electronics SME FS2 PQ costs (slot 2)	M & S	\$0	\$700	\$0	\$0	C - Engineering Bt	C2
1.4.4.3.2	Electronics SME FS2 ECW costs (slot 2)	M & S	\$0	\$250	\$0	\$0	C - Engineering Bt	C2
1.4.4.3.7	Electronics SME FS3 PQ costs (slot 1)	M & S	\$0	\$0	\$700	\$0	C - Engineering Bt	C2
1.4.4.3.7	Electronics SME FS3 ECW costs (slot 1)	M & S	\$0	\$0	\$250	\$0	C - Engineering Bt	C2
1.4.4.3.7	Electronics SME FS3 PQ costs (slot 2)	M & S	\$0	\$0	\$700	\$0	C - Engineering Bt	C2
1.4.4.3.7	Electronics SME FS3 ECW costs (slot 2)	M & S	\$0	\$0	\$250	\$0	C - Engineering Bt	C2

## 7.3. Travel

Two domestic trips are budgeted for developer travel to NTS to install and test timing and power systems.

Two electronics SMEs are budgeted to deploy to South Pole in each of FS2 and FS3. The FS2 deployment is to support installation of electronics in ICL. Travel to Wisconsin to attend off-ice safety training is budgeted for one SME in FS3 as the FS3 duties include support of string deployment (no travel costs are budgeted for the other SME as he is a UW employee). PQ and ECW costs associated with the deployments are budgeted under M&S.

# Basis of Estimate

WBS	Activity	12mo Subtotal PY5	12mo Subtotal PY6	12mo Subtotal PY7	12mo Subtotal PY8	Estimating Technique	Contingency
1.4.4.1.2.3	Installation and testing at NTS/SPTS	\$0	\$1,800	\$0	\$0	E - Extrapolation f	C1
1.4.4.2.4.1	Installation and testing at NTS	\$1,800	\$0	\$0	\$0	E - Extrapolation f	C1
1.4.4.3.2	Electronics SME FS2 Deployment travel (slot 1)	\$0	\$0	\$1,800	\$0	E - Extrapolation f	C1
1.4.4.3.2	Electronics SME FS2 Deployment travel (slot 2)	\$0	\$0	\$1,800	\$0	E - Extrapolation f	C1
1.4.4.3.5	Office safety training FS3 Electronics SMEs	\$0	\$0	\$1,800	\$0	E - Extrapolation f	C1
1.4.4.3.7	Electronics SME FS3 Deployment travel (slot 1)	\$0	\$0	\$0	\$1,800	E - Extrapolation f	C1
1.4.4.3.7	Electronics SME FS3 Deployment travel (slot 2)	\$0	\$0	\$0	\$1,800	E - Extrapolation f	C1

## 8. Labor

### 8.1. Labor Estimate

Labor estimates for WBS 1.4.4 are dominated by the design, testing, and production of custom electronics, including the cross-domain timing monitoring system, the power fanout system, and the power monitoring system.

Significant labor for 1.4.4.1 includes:

- Final design, testing, and production of the cross-domain timing monitoring system. This estimate is based on SME expert opinion.

Significant labor for 1.4.4.2 includes:

- Final design, testing, and production of the power fanout system. This estimate is based on SME expert opinion.
- Final design, testing, and production of the power monitoring system. This estimate is based on SME expert opinion.

### 8.2. Summary of Labor Resources

WBS	Activity	Resource ID	LPY5	LPY6	LPY7	LPY8	Estimating Technique	Contingency
1.4.4.1.1.1	Procurement	SS	40	0	0	0	E - Extrapolation from Actuals	C1
1.4.4.1.1.5	Shipping to PTH	SS	24	0	0	0	D - Expert Opinion	C3
1.4.4.1.2.1	Final design	SS	0	140	0	0	D - Expert Opinion	C4
1.4.4.1.2.2	Prototype production	SS	0	80	0	0	D - Expert Opinion	C3
1.4.4.1.2.3	Installation and testing at NTS/SPTS	SS	0	60	0	0	D - Expert Opinion	C3
1.4.4.1.2.4	Production of ICL system	SS	0	80	0	0	D - Expert Opinion	C3
1.4.4.1.2.6	Shipping to PTH	SS	0	24	0	0	D - Expert Opinion	C3
1.4.4.2.1.5	Procurement	SS	56	0	0	0	E - Extrapolation from Actuals	C1
1.4.4.2.2.1	Final design	SS	16	0	0	0	D - Expert Opinion	C4
1.4.4.2.2.4	Production	SS	60	0	0	0	A - Analogy	C1
1.4.4.2.3.4	Production	SS	120	0	0	0	A - Analogy	C1
1.4.4.2.4.1	Installation and testing at NTS	SS	40	0	0	0	D - Expert Opinion	C3
1.4.4.2.4.2	Power system final design review	SS	96	0	0	0	E - Extrapolation from Actuals	C3
1.4.4.2.4.3	Pre-ship review	SS	40	0	0	0	A - Analogy	C3
1.4.4.2.4.4	Shipping to PTH	SS	24	0	0	0	A - Analogy	C2
1.4.4.3.3	Electronics SME support for FS2 activities	PO	0	0	150	0	D - Expert Opinion	C1
1.4.4.3.8	Electronics SME support for FS3 activities (slot 1)	SS	0	0	0	150	D - Expert Opinion	C1

# Basis of Estimate

## 9. References

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

[Ref-2] 2. —. *Cost Estimating Plan*.

## Revision History

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<b>Date</b>	<b>Revised by</b>	<b>Summary of changes</b>
2022-02-22	John Kelley	First version created
2022-02-23	John Kelley	Attached vendor quotes
2022-03-09	Tyce DeYoung	Updated travel. Added tables from smartsheets
2022-04-10	Tyce DeYoung	Updated total cost based on recalculated labor/fringe rates

# Basis of Estimate

## Vendor Quote 1



C/ PERIODISTA RAFAEL GÓMEZ MONTERO, 2.  
 EDIF. CETIC-OFICINA 13-1ª Plta  
 18014 GRANADA  
 Tel. 958285024  
 Fax 858080218  
 e-Mail info@sevensols.com  
 Web: www.sevensols.com  
 C.I.F. B18763979

## QUOTATION

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**WIPAC / Univ. of Wisconsin–Madison**  
 222 W. Washington Ave., Suite 500 Madison, WI  
 Madison  
 Wisconsin, USA

Number	Date	Reference	Estimated Delivery Date :
131	21/05/2019		/ /

Units	Code	Item	Price/Unit	Amount
5	EQP-WRS-01	WR SWITCH 18 PORTS (v3.4) Main element in a WR network which provides precision timing and high synchronization. Features: Virtex-6 FPGA (LX240T), ARM (AT91-9G45), 18 SFP connectors, GigE, PTP, Sync-E, sub-ns synchronization, etc...	2.924,000	14.620,00
1	SUP-WR-01	WR Switch Support Open Source ( 3 Years) Commissioning and Set-up Support Firmware Update -> Available every release (1 per year) Reaction Time to tickets-> 72 Hours (answer email) WR PTP Gateway/Software Bug Fixes -> Hot fixes (max 3 months)* 3 hours Hotline -> within 72 Hours to the appointment request from 9:00 - 21:00 UTC+2 *Seven Solutions does provide support to the timing components (software, gateway and hardware) of the White Rabbit Switch. Seven Solutions doesn't provide support to the switching gateway and software. All this support is provided to equipment running the last two official firmware	4.500,000	4.500,00
<b>Total Amount</b>				<b>19.120,00</b>

# Basis of Estimate



C/ PERIODISTA RAFAEL GÓMEZ MONTERO, 2.  
 EDIF. CETIC-OFICINA 13-1ª Pta  
 18014 GRANADA  
 Tel. 958285024  
 Fax 858080218  
 e-Mail info@sevensols.com  
 Web: www.sevensols.com  
 C.I.F. B18763979

## QUOTATION

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**WIPAC / Univ. of Wisconsin-Madison**  
 222 W. Washington Ave., Suite 500 Madison, WI  
 Madison  
 Wisconsin, USA

<b>Number</b>	<b>Date</b>	<b>Reference</b>	<b>Estimated Delivery Date :</b>
131	21/05/2019		//

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Units	Code	Item	Price/Unit	Amount
		releases. (eg. latest release v2.1, supported releases: v2.1 & v2.0)		
10	BRD-LENI-01	WR-LENI OEM (WITHOUT ENCLOSURE)	864,00000	8.640,00
10	BRD-LENI-02	WR-LEN Industrial	1.315,000	13.150,00
1	STK-LEN-02	WHITE RABBIT LEN STANDALONE KIT FULL 3 x WR-LEN 2 x AXGE-3454 (1490TX/1310RX) 2 x AXGE-1254 ( 1310TX/1490RX) 4 x Coaxial cable SMA to BNC 2 x Optical fiber 2 M 1 x Cable usb (A) to mini USB male 3 x Power supply: 5V & 1.2A	3.500,000	3.500,00
1	14	SHIPMENT AND INTERNATIONAL INSURANCE (CIP Inc (NOT INCLUDED)		
<b>Total Amount</b>				<b>44.410,00</b>

<b>Discount</b>	<b>Tax Base</b>	<b>VAT</b>	<b>TOTAL QUOTATION</b>
%	44.410,00		<b>44.410,00 €</b>

This quote is valid for 30 days.	<b>Warranty and Liability:</b> Twelve months warranty against defects and workmanship from date of shipment on all our products. Only the products returned with prepaid charges, and only if our liability does not exceed the purchase amount, they will be serviced, adjusted or replaced.
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**Bank Account**  
 Bank Name : La Caixa  
 Bank Address : C/ Rodriguez de la Fuente, 13  
 18210 Peligros (Granada), Spain  
 Beneficiary : Seven Solutions, SL  
 Account number : 2100 2560 1202 1011 0480  
 IBAN : ES64 2100 2560 1202 1011 0480  
 BIC / SWIFT : CAIXESBBXXX

**Authorized Acceptance**

# Basis of Estimate



## Vendor Quote 2



All Products

Enter keyword or pa



Product Index > Power Supplies - External/Internal (Off-Board) > AC DC Converters > MEAN WELL USA Inc. RCP-1600-48

### RCP-1600-48



*Image shown is a representation only. Exact specifications should be obtained from the product data sheet.*

**Digi-Key Part Number**

1866-3970-ND

**Manufacturer**

MEAN WELL USA Inc.

**Manufacturer Product Number**

RCP-1600-48

**Supplier**

[MEAN WELL USA Inc.](#)

**Description**

AC/DC CONVERTER 48V 1608W

QTY	UNIT PRICE	EXT PRICE
1	\$532.92000	\$532.92
5	\$515.73200	\$2,578.66
10	\$498.54100	\$4,985.41

2/15/22, 12:48 PM

500-48 MEAN WELL USA Inc. | Power Supplies - External/Internal (Off-Board) | D... <https://www.digikey.com/en/products/detail/mean-well-usa-inc/RCP-1600-48/7705966?s=N...>

QTY	UNIT PRICE	EXT PRICE
25	\$481.35040	\$12,033.76
50	\$464.15920	\$23,207.96
100	\$389.23200	\$38,923.20



# Basis of Estimate

## Vendor Quote 3



All Products

Enter keyword or pa



Product Index > Power Supplies - External/Internal (Off-Board) > Accessories > MEAN WELL USA Inc. RHP-1UI-A

### RHP-1UI-A



*Image shown is a representation only. Exact specifications should be obtained from the product data sheet.*

#### Digi-Key Part Number

1866-3991-ND

#### Manufacturer

MEAN WELL USA Inc.

#### Manufacturer Product Number

RHP-1UI-A

#### Supplier

[MEAN WELL USA Inc.](#)


#### Description



RACK SYST FOR RCB-1600/RCP-1600

QTY	UNIT PRICE	EXT PRICE
1	\$674.51000	\$674.51
5	\$663.45400	\$3,317.27
10	\$619.22400	\$6,192.24
25	\$597.10840	\$14,927.71

# Basis of Estimate

## Vendor Quote 4



All Products  

[Product Index](#) > [Connectors, Interconnects](#) > [Circular Connectors](#) > [Bulgin PXM7010/03S/ST/0507/SN](#)



### PXM7010/03S/ST/0507/SN

**Digi-Key Part Number**

708-1774-ND

**Manufacturer**

Bulgin

*Image shown is a representation only. Exact specifications should be obtained from the product data sheet.*

**Manufacturer Product Number**

PXM7010/03S/ST/0507/SN

**Supplier**

[Bulgin](#)

**Description**

CONN PLUG FEMALE 3P NICKEL SCREW



### Bulk

QTY	UNIT PRICE	EXT PRICE
1	\$62.54000	\$62.54

# Basis of Estimate



All Products



Product Index > Connectors, Interconnects > Circular Connectors > Bulgin PXM7012/03P/ST



*Image shown is a representation only. Exact specifications should be obtained from the product data sheet.*

## PXM7012/03P/ST

### Digi-Key Part Number

708-1841-ND

### Manufacturer

Bulgin

### Manufacturer Product Number

PXM7012/03P/ST

### Supplier

[Bulgin](#)

### Description




CONN RCPT MALE 3POS NICKEL SCREW

### Bulk

QTY	UNIT PRICE	EXT PRICE
1	\$33.98000	\$33.98
10	\$29.75900	\$297.59
25	\$28.47360	\$711.84
50	\$27.55500	\$1,377.75
100	\$26.63650	\$2,663.65
250	\$25.71800	\$6,429.50

# Basis of Estimate

## Vendor Quote 5


All Products



Product Index > Cables, Wires > Multiple Conductor Cables > Alpha Wire 80158 SL005



*Image shown is a representation only. Exact specifications should be obtained from the product data sheet.*

### 80158 SL005

**Digi-Key Part Number**

80158SL005-ND

**Manufacturer**

Alpha Wire

**Manufacturer Product Number**

80158 SL005

**Supplier**

[Alpha Wire](#)

**Description**

ECOFLEX PUR 3 COND 12AWG BRAID

### Spool

QTY	UNIT PRICE	EXT PRICE
1	\$712.57000	\$712.57
3	\$660.53000	\$1,981.59
5	\$624.50200	\$3,122.51
10	\$601.81400	\$6,018.14