

## 2018 CamHD Refurbishment Report

Date	Initials	Notes
23 June 2017	AMM	Initial release
5 July 2017	AMM	Added ROS refurbishment documentation

TODO:

- SubC refurbishment paperwork (if any)

### Background

UW-APL manufactured two complete, nominally identical instances of the CamHD design, designated P1 and P2. A partial set of spares exists for a third instance (P3) including all electronics, pressure vessels. At present, CamHD is installed for a 1-year operational cycle, with the CamHD instances swapped during the Operations and Maintenance (O&M) cruise which occurs every summer.

Unit P2 was installed in the summer of 2014, before the formal commissioning of the Cabled Array, and was in place for two years, starting with approx. 16 months of quiescence (July 2014 – November 2015). Upon the formal commissioning of the CA in November/December 2015, CamHD started its regular sampling routine.

The deployment of P2 coincided with the switch from Impulse to Subconn cabling across much of the OOI system. Replacement cabling was procured from Subconn in the spring of 2015. P1 was recabled immediately. P2 was recabled during the 2016-2017 season.

Unit P2 was recovered and replaced by P1 during the Summer 2016 O&M cruise. Unit P1 was deployed for from summer 2016-summer 2017. In ~May-June of 2017 (~10-11 months in operation), it exhibited a steadily worsening ground fault which resulted in the instrument being turned off on June 14 2017 to prevent catastrophic failure.

From	To	In Water	On shore
Summer 2014	July 25, 2016	P2	P1 (SubConn installed)
July 29, 2016	June 14, 2017 (recovered Aug 2018)	P1: Ground fault in May-June	P2 (SubConn installed)
August 14, 2017	[Summer 2018]	P2: Ground fault in August	P1 ... refurbishment described here.

P1 was recovered during the 2017 O&M cruise and replaced with a refurbished P2. P2 started to exhibit a ground fault almost immediately. It ran for a period with a single light, then was turned off completely in October 2017. The CamHD system was off-line from Oct 2017 – July 2018.

During the 2017-2018 refurbishment, P1 was installed in the OSB test tank where it developed a ground fault within a matter of days. A short was discovered between pins on bulkhead A1J2 (camera power connector) and the main pressure vessel. This connector was removed from the bulkhead and supplied to SubConn for forensic examination.

Due to its high bandwidth requirement (10GB for uncompressed video), CamHD functions as a primary node in the Cabled Array and accepts the same inputs as the other primary nodes – 10GB ethernet via fiber and +/-187.5 VDC power referenced to seawater (+375 total potential).

CamHD's power system is based on a standardized design pattern from across other OE-designed CA projects where the incoming +375VDC is passed through a Vicor filter and isolated DC/DC converter. CamHD also contains circuitry for measuring input voltage (through a R-ladder & non-inverting opamp) and current (through a low-side shunt) – these sensing circuits are not isolated from the CamHD ground. CamHD contains two power boards which are identical in layout but populated differently, with +375 input entering via one board then passing to the second via a short jumper.

In CamHD the input ground (which referenced -187.5V relative to seawater) is connected *via a trace on the power boards* to CamHD system DC ground. We surmise this places all wet cabling at -175 to -187.5 V potential relative to seawater. The SubConn micro-series rubber molded connectors and bulkheads used extensively in the system are rated for prolonged exposure to ~300VAC/DC RMS, however we believe the extended exposure to this high potential was damaging to both connectors and wet cabling.

The following documents the actions taken to refurbish CamHD P1 in January-June 2018.

## Bulkhead Replacement

A full set of SubConn Micro-series bulkhead connectors was ordered under Ocean Innovations Quote 1802270, APL PO EI857842.<sup>1</sup>

Qty Ordered	Designators	PN	Description
3	A1J8, A1J9, A1J10	MCBH6MTI-WB	Aux connectors 1-3
2	A1J7, A1J4	MCBH4MTI-G2 WB	Attitude and Pan/Tilt connectors

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<sup>1</sup> A copy of this quote is included in the appendix.

4	A1J6, A1J5, plus 2x SubC lights	MCBH5MTI-WB	Lights
1	ROS pan/tilt unit	MCBHRA4MTI-G2	Pan tilt (drop shipped to ROS)
2	A1J2, SubC camera	MCBH8MTI-WB	Camera power (1x drop-shipped to SubC)

On the main electronics housing, A1J1 (Teledyne ODI DMS) and A1J3 (MIN-L coax camera data connector) bulkheads were not replaced.

The MCBHRA4M was supplied directly to ROS for replacement during refurbishment of the pan/tilt unit (as described below).

One MCBH5M was supplied directly to SubC for replacement during refurbishment of the camera.

All other bulkheads on the main pressure vessel, and those on the two SubC lights, were replaced by APL OE.

### **Wet Cabling Replacement**

Replacement cables were ordered for all of the conventional molded cables under Ocean Innovations Quote 1802379, APL PO EI870033.<sup>2</sup> With one exception, all cables feature SubConn Micro-series connectors. The Trexonics cable used in previous versions of CamHD was replaced with Macartney/SubConn cable to streamline manufacturing.

Description	Conn 1	Cable	Conn 2	Previous cable
HD Camera Power/Control	MCIL8F	18ft PC4TSP20#	MCIL8F	Trexonics 61509 20AWG x 9
Pan & Tilt	MCIL4F-G2	18ft PC4C18#OS	MCIL4F-G2	Trexonix 61404 18AWG x 4
Lights (qty 2)	MCIL5F	18ft PC4C18#OS	MCIL5F	Trexonix 61404 18AWG x 4
IMU	MCIL4F-G2	18ft SPC-01	IE55-1204-CCP	

The ODI Teledyne hybrid fiber power cable and the MIN-K-based coaxial video cable were not replaced.

### **ROS Actuator Refurbishment**

As per the standard refurbishment procedure, the ROS pan/tilt mechanism, S/N 70502 was returned to Remote Ocean Systems on approx. Feb 26 2018 under ROS RMA 04662, APL PO EI857070.

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<sup>2</sup> A copy of this quote is included in the appendix.

While at ROS, the bulkhead connector MCBHRA4MTI-G2 on S/N 70502 was replaced with a unit from the replacement bulkhead order. The bulkhead was replaced at ROS and the unit was re-certified. S/N 70502 was received at APL on ...

While retrieving the packing material for this unit, it was noticed that the spare ROS actuator, SN 70503 was leaking oil, despite having never been deployed. It was returned to ROS for refurbishment on approx. March 5 2018 under ROS RMA 4666.

The bulkhead on S/N 70503 was **not** replaced. It had not been deployed and thus had not been subjected to the high voltage potential. S/N 70503 was received at APL on ....

### **SubC Camera Refurbishment**

The camera unit S/N SUBC13115 was returned to SubC for repair and refurbishment under SubC Quote SubCQ2018-2041, APL PO 180228005INVRH.<sup>3</sup> It was sent to SubC on approx. 1 March and received at APL on 7 May 2018.

The service included replacement of a backup battery on the internal unit, replacement of the bulkhead connector (as supplied by SubConn), refurbishment and pressure testing.

### **Power Board Modification**

Upon examination, it was determined that the CamHD DC ground could be isolated from the incoming -187V supply by cutting a single trace on each of the two power boards. The engineering work order for this modification is included in the Appendix.

(What happened to the V&I circuits?)

### **Testing**

After bench testing, CamHD was installed in the OSB tank on 13 June 2018. It was run through 18 June 2018 with no measured ground faults.

### **Notes for 2018-2019 refurbishment of CamHD P2:**

- Hybrid SubConn-Impulse cable used for attitude sensor has long lead time, order early if replacing --- or reuse instance purchased this year.
- Cable lengths are too long, revise before reordering.

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<sup>3</sup> A copy of this quote is included in the appendix.

**Appendices:**

- Ocean Innovations Quote 1802-270 for SubConn bulkheads.
- Ocean Innovations Quote 1802-379 for SubConn cablings.
- SubC Quote SubCQ2018-2041 for camera refurbishment
- Engineering Change Reqeust for rework of power boards



7416 Cabrillo Ave.  
La Jolla, CA 92037  
(858)454-4044  
brock@o-vations.com  
www.o-vations.com

## QUOTE

ADDRESS	SHIP TO	QUOTE #	DATE
University of Washington 4300 Roosevelt Way NE Seattle, WA 98105	University of Washington ATTN: Henderson Hall (APL) 1013 NE 40th St. Seattle, WA 98105	1802-270	02/26/2018

SALES REP	PO NUMBER	TRACKING NO.
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PRODUCT/SERVICE	DESCRIPTION	QTY	RATE (USD)	AMOUNT (\$ USD)
MCBH6MTI-WB	SubConn 6 Contact, Male Micro Bulkhead Connector, Titanium Body - WATERBLOCKED	3	262.80	788.40T
MCBH4MTI-G2 WB	SubConn 4 Contact, Male Micro Bulkhead Connector, Titanium Body with water block, ***available as G2 style only*** MCBH4MTI-G2-WB	2	196.48	392.96T
MCBH5MTI-WB	SubConn 5 Contact, Male Micro Bulkhead Connector, Titanium Body with water block***add low quantity fee***	4	252.37	1,009.48T
MCBHRA4MTI-G2	SubConn, 4 Contact, Male, Micro Bulkhead Right Angle Connector, Titanium - G2 (Low Qty. Fee applies)	1	236.12	236.12T
MCBH8MTI-WB	SubConn Micro Bulkhead Connector 8 Contact, Male, Titanium- Water-Blocked. Low quantity fees apply	2	308.12	616.24T

Quotes are valid for 30 days. Prices do not include shipping or any applicable sales tax, unless otherwise noted. Locking sleeves, nuts and washers are not included in connector pricing unless specifically stated. Please let us know if you need them. Visit our website at [www.o-vations.com](http://www.o-vations.com) for Terms and Conditions. Thank you for the opportunity to provide this quote.

SUBTOTAL	3,043.20
TAX (0%)	0.00
<b>TOTAL</b>	<b>\$3,043.20</b>

Accepted By

Accepted Date



7416 Cabrillo Ave.  
La Jolla, CA 92037  
(858)454-4044  
brock@o-vations.com  
www.o-vations.com

## QUOTE

<b>ADDRESS</b>	<b>SHIP TO</b>	<b>QUOTE #</b> 1802-379
University of Washington 4300 Roosevelt Way NE Seattle, WA 98105 206-685-7765	University of Washington ATTN: Aaron Marburg Henderson Hall (APL) 1013 NE 40th St. Seattle, WA 98105 206-685-7765	<b>DATE</b> 04/03/2018

<b>SHIP VIA</b>	<b>SALES REP</b>	<b>PO NUMBER</b>
Please Advise	Sheila Johnson	Please Advise

PRODUCT/SERVICE	DESCRIPTION	QTY	RATE (USD)	AMOUNT (\$ USD)
CABLE ASSEMBLY	revised HD CAMERA CONTROL Cable Assembly consisting of MCIL4F-G2+MCDLSF // 18ft PC4C18#OS // MCIL4F-G2+MCDLSF	1	182.82	182.82T
CABLE ASSEMBLY	revised PAN-TILT INTERFACE Cable Assembly consisting of MCIL5F+MCDLSF// 18ft PC4C18#OS //MCIL5F+MCDLSF	2	334.57	669.14T
CABLE ASSEMBLY	revised LIGHT #1 INTERFACE Cable Assembly consisting of MCIL8F+MCDLSF // 18ft P4TSP20# // MCIL8F+MCDLSF	1	514.37	514.37T
CABLE ASSEMBLY	ATTITUDE SENSOR INTERFACE Cable Assembly per Dwg. 4830-70185 MCIL4F-G2+MCDLSF//18 ft. SPC-01 cable // Impulse IE55-1204-CCP Wire per dwg. Add Labels.  LEAD TIME IS 6-7 WEEKS	1	355.47	355.47T

Quotes are valid for 30 days. Prices do not include shipping or any applicable sales tax, unless otherwise noted. Locking sleeves, nuts and washers are not included in connector pricing unless specifically stated. Please let us know if you need them. Visit our website at [www.o-vations.com](http://www.o-vations.com) for Terms and Conditions. Thank you for the opportunity to provide this quote.

SUBTOTAL	1,721.80
TAX (0%)	0.00
<b>TOTAL</b>	<b>\$1,721.80</b>



**SubC Control Ltd.**  
317 Memorial Drive  
Clarenville NL Canada A5A 1R8  
Tel: +1 (709) 702-0395

**Customer:** University of Washington  
**Quote No:** SubCQ2018-2041  
**Date:** February 19, 2018  
**Attention:**

Item	Part No. / Description	Unit Price	Qty	Ext Price
	<b>1Cam S/N SUBC13115 Repair/Servicing</b>			
1	<b>Parts</b> - Internal camera battery	5.00	1	5.00
2	<b>Labour @ \$120/hr</b> - Replace Battery - Replace Bulkheads (Bulkheads to be supplied by University of Washington) - Full inspection, servicing and QC	120.00	8	960.00
3	<b>Pressure Test</b>	480.00	1	480.00
	<b>Total Purchase Value (USD)</b>			<b>1,445.00</b>

\* All prices in United States Dollars (USD)  
\* Prices do not include VAT, Freight, Insurance or Duty

**Quote Validity** 30 Days  
**Payment Terms** Net 30  
**Warranty** 1 Year  
**Contact** Ron Collier  
[rco@subcimaging.com](mailto:rco@subcimaging.com)

#### Delivery and Expediting

Lead time is given as a indication of when equipment will be ready to ship from facility. Lead times do not include shipping time as this varies from country to country. It does not take into account customs and shipping delays that are out of vendor's control.

A ship date requested earlier than the quoted lead time will be subject to expediting fees. These fees cover component expediting, over-time and express courier to shipping drop-off locations.

CAMHD 1.0 Removing 375v to 24v Ground Connection Work Request  
Rev1.00.docx

**OCEAN ENGINEERING DEPARTMENT**  
**ELECTRICAL FABRICATION WORK REQUEST**

Procedure:

1. Fill out table below and Job Description
2. Rename document and save with following file naming convention:  
*Project X.X Job Description Work Request RevX.XX.doc*, e.g.  
SAMS 2.1 Motor Cable Assembly Work Request Rev1.00.doc
3. E-mail work request document to Field Engineer and cc to OE Dept Head
4. Print out request and deliver with all materials and hardcopy drawings to Field Engineer

<b>TITLE OF WORK</b>	Removing 375v to 24v Ground Connection
<b>ORIGINATOR</b>	Brand
<b>ORIGINATOR PHONE</b>	1-8040
<b>DATE SUBMITTED</b>	14 may 2018
<b>ESTIMATED HOURS</b>	4
<b>DESIRED COMPLETION DATE</b>	16 may 2018
<b>PJN</b>	416456 66-2856

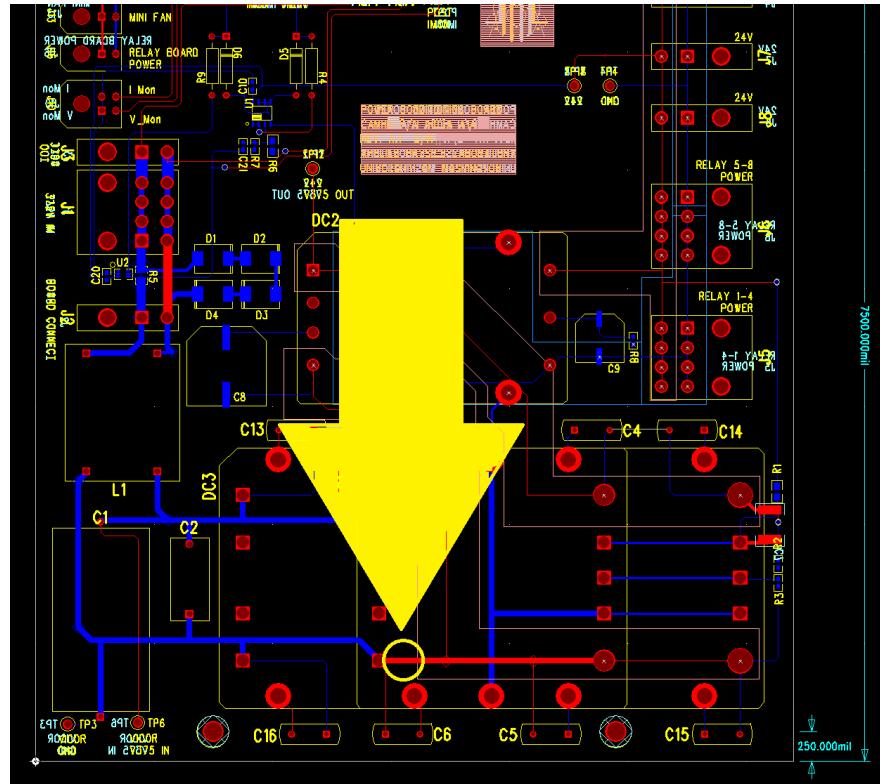
**WORK DESCRIPTION**

Drawing File List (insert required path and filenames to necessary support drawings)

CAMHD is supplied with 375v. +187v WRT seawater. When the system was designed, the -187v was tied to gnd on the 24v converters outputs. While all power is galvanically isolated from seawater, this put the gnd and 24v running through underwater cables and connectors at -187v and -163v WRT seawater, respectively, which may be contributing to some of the neoprene failures in the MCBH connectors that we have seen. Because of this we are cutting the ties between the -187v input and the ground output of the 24v converters. This also means tying the ground outputs of the two 24v converters together as they will now be isolated from each other. A side effect of the original ground tie was that the filter / biasing capacitors between the rails and the ground of the vicor converter case were not balanced. The upper rail caps saw a continuous dc voltage of ~375, while the lower rail caps saw 0v. With the ground tie removed, they will all see an equal voltage, about half of the 375v, and bias the Ground and 24v output rails between the + 187v, making the potential in the cables and connectors within ~24v of seawater, rather than ~187v. Because the upper rail caps were seeing such a high voltage, possibly stressing them, they will be replaced.

CAMHD 1.0 Removing 375v to 24v Ground Connection Work Request  
Rev1.00.docx

1. Cut the trace shown in the yellow circle on A2 and A3 boards



2. Replace C3 and C4 on A2, and C13 and C14 on A3 with identical caps provided, discard removed caps.
3. Make wiring harness that connects grounds of A2 and A3 24v supplies using J7 on both boards, and separate drawing provided (A1W19)



5618 Copley Drive  
San Diego, CA 92111

Tel: (858) 565-8500  
Fax: (858) 565-8808

R04666

**PT-25 & R-25 160:1 Gear Ratio – High Precision  
RS-485 Controlled Pan and Tilt / Rotator Inspection & Test Certification**

General Information

Model	<u>PT-25FB, TI, OIL, RS-485</u>
Part Number / Rev	<u>20-10197-02/ REV.D</u>
Protocol 21-30022	Rev. V
Serial Number	<u>70502</u>

Gear Ratio	<u>160:1</u>
Connector Type & Pos	<u>MCBH-RA-M4-TI</u>
Pan/Rotator Range (°)	<u>15 ° -345 °</u>
Tilt Range (°)	<u>90 ° -270 °</u>

**Pan / Rotator Motor Driver Information**

Driver P/N & Rev	<u>21-060208/M</u>
Dash Number	<u>07</u>
Node ID Number	<u>A</u>
Feedback Enabled?	<u>YES</u>
Factory CCW/CW	<u>12/963</u>
Set User Limits at 15 ° and 345 °	<u>52/924</u>
PCA Serial Number	<u>1439</u>
Positioner Type	<u>R/PT-25 160:1</u>
Baud Rate	<u>9600</u>
Firmware Rev	<u>7.0</u>

**Tilt Motor Driver Information**

Driver P/N & Rev	<u>21-06028/M</u>
Dash Number	<u>08</u>
Node ID Number	<u>B</u>
Feedback Enabled?	<u>YES</u>
Factory CCW/CW	<u>12/970</u>
Set User Limits at 90 ° and 270 °	<u>252/731</u>
PCA Serial Number	<u>1472</u>
Positioner Type	<u>R/PT-25 160:1</u>
Baud Rate	<u>9600</u>
Firmware Rev	<u>7.0</u>

**Check List**

Housing Test

Reverse Polarity Protection	<u>✓</u>
Pre Pressure Test Isolation Test >10Meg	<u>✓</u>
Operational Voltage Range 22-28VDC	<u>✓</u>
Oven hold 30 mins @ 60 °C	<u>No</u>
Vacuum Test 25" Hg for 30 mins	<u>No</u>
Post Pressure Test Isolation >10 Meg	<u>✓</u>

Oil filled only  
Air filled only

**Pan / Rotator Test at 24VDC**

Verify there is no wobble using laser	<u>✓</u>
No load current at 0.5 %/sec, 1.5 < I < 1.7	<u>✓</u>
No load current at 10%/sec, 0.2 < I < 0.4	<u>✓</u>
Torque test 40 lb.ft @ 4%/sec	<u>✓</u>
Brake test 40 lb.ft, set at 100% in Helios, @ 2%/sec, 0.9 < I < 1.2	<u>✓</u>
Verify User Limits at 15 ° and 345 °	<u>✓</u>
Set braking = 90 (56% in Helios), acceleration = 6 deg/s², max velocity = 10 deg/s, char echo enabled	<u>✓</u>
Reset to 180 °	<u>✓</u>

**Tilt Test 24VDC**

Verify there is no wobble using laser	<u>✓</u>
No load current at 0.5 %/sec, 1.5 < I < 1.7	<u>✓</u>
No load current at 10%/sec, 0.2 < I < 0.4	<u>✓</u>
Torque test 40 lb.ft @ 4%/sec	<u>✓</u>
Brake test 40 lb.ft, set at 100% in Helios, @ 2%/sec, 0.9 < I < 1.2	<u>✓</u>
Verify User Limits at 90 ° and 270 °	<u>✓</u>
Set braking = 90 (56% in Helios), acceleration = 6 deg/s², max velocity = 10 deg/s, char echo enabled	<u>✓</u>
Reset to 180 °	<u>✓</u>

We hereby certify that the above referenced unit has been tested, inspected, and all Q.A. requirements have been met in accordance with standard ROS Inc. operating procedures.

Technician

Quality Assurance

Date 25 APR -18

Date 4/26/18