Geo-Sense Preliminary Design Review

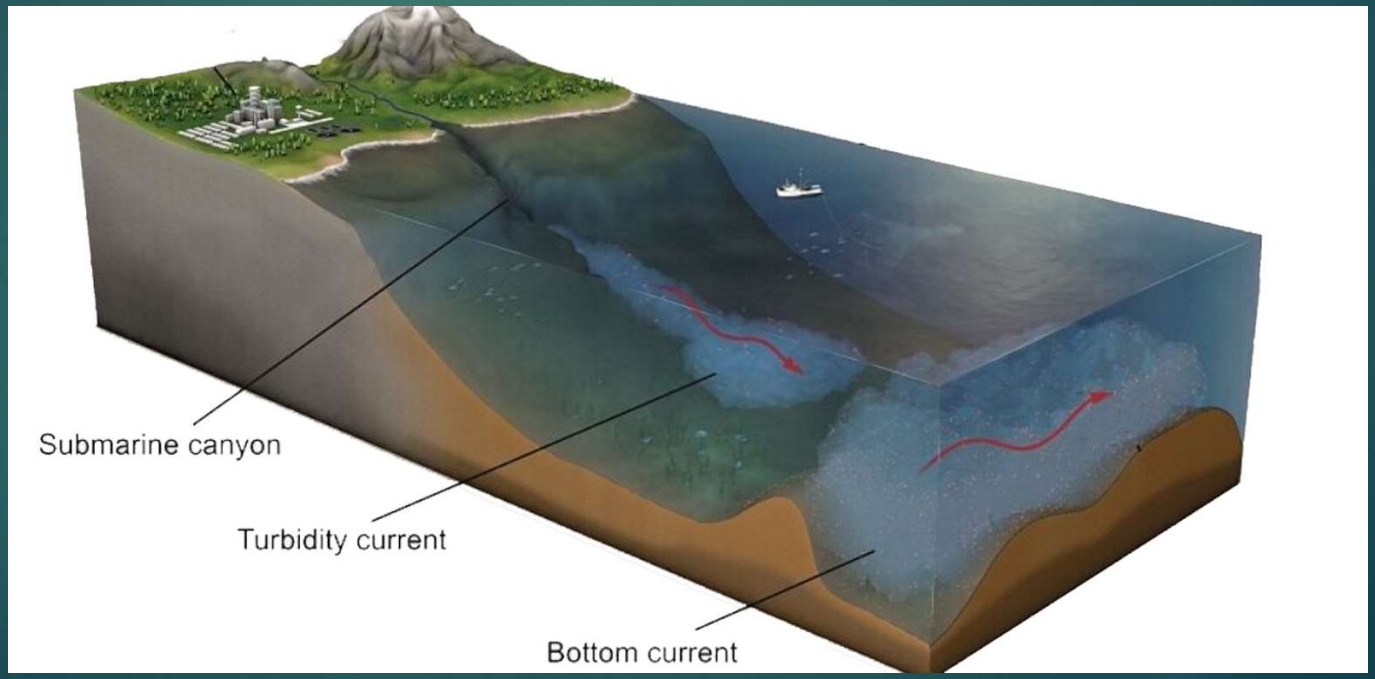
MAY 9, 2024

Review Outline

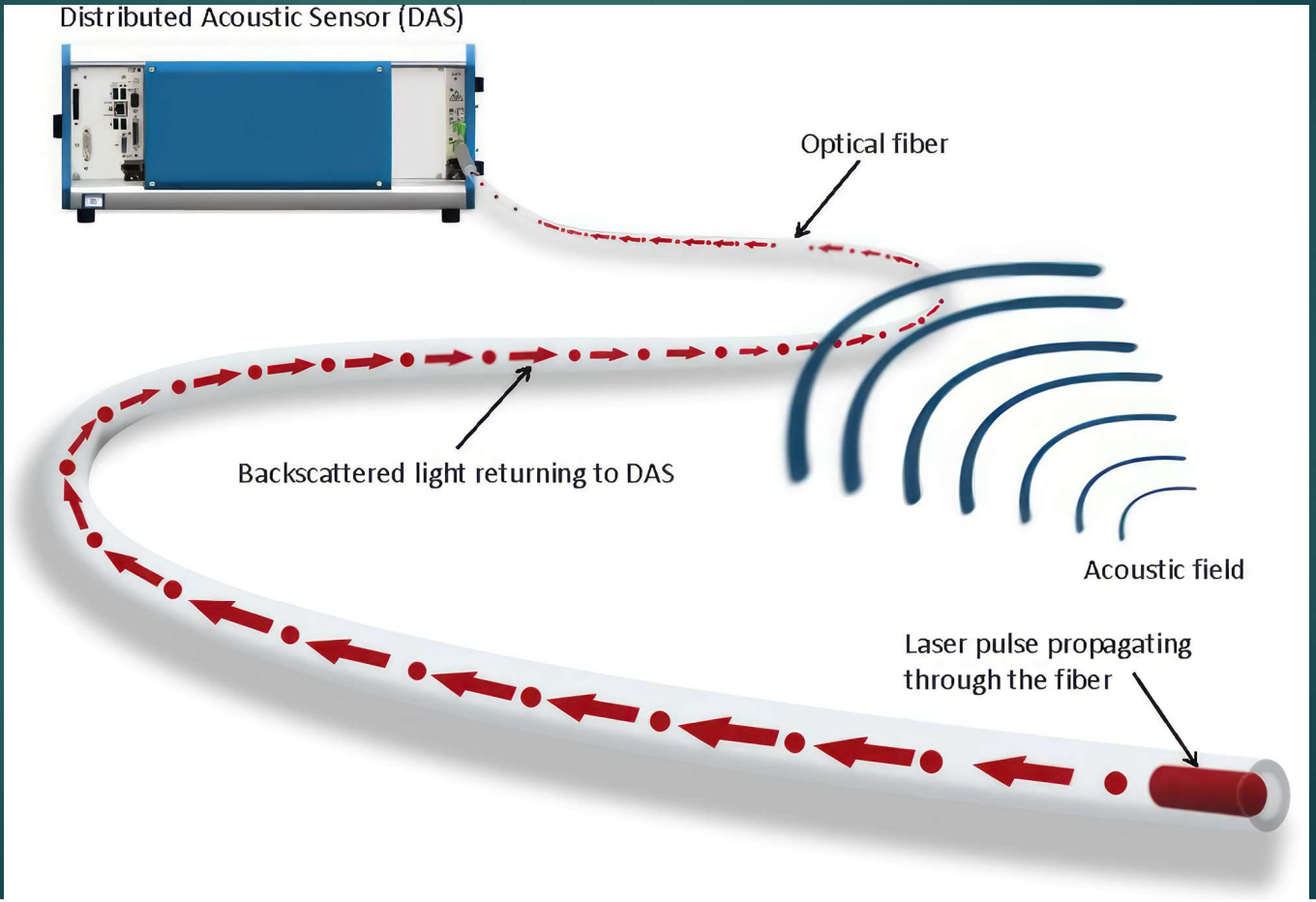
- Science Motivation
- Geo-Sense Concept
- Operational Concept: Deployment and Recovery
- System Requirements
- Electrical System
- Mechanical System
- Schedule
- Test and integration plan
- High-risk elements

Science Motivation

Can we capture high-resolution measurements of seafloor processes in areas with no connection to shore power or communications?



DAS (Distributed Acoustic Sensing): Optical Method of Measuring Acoustic Signals



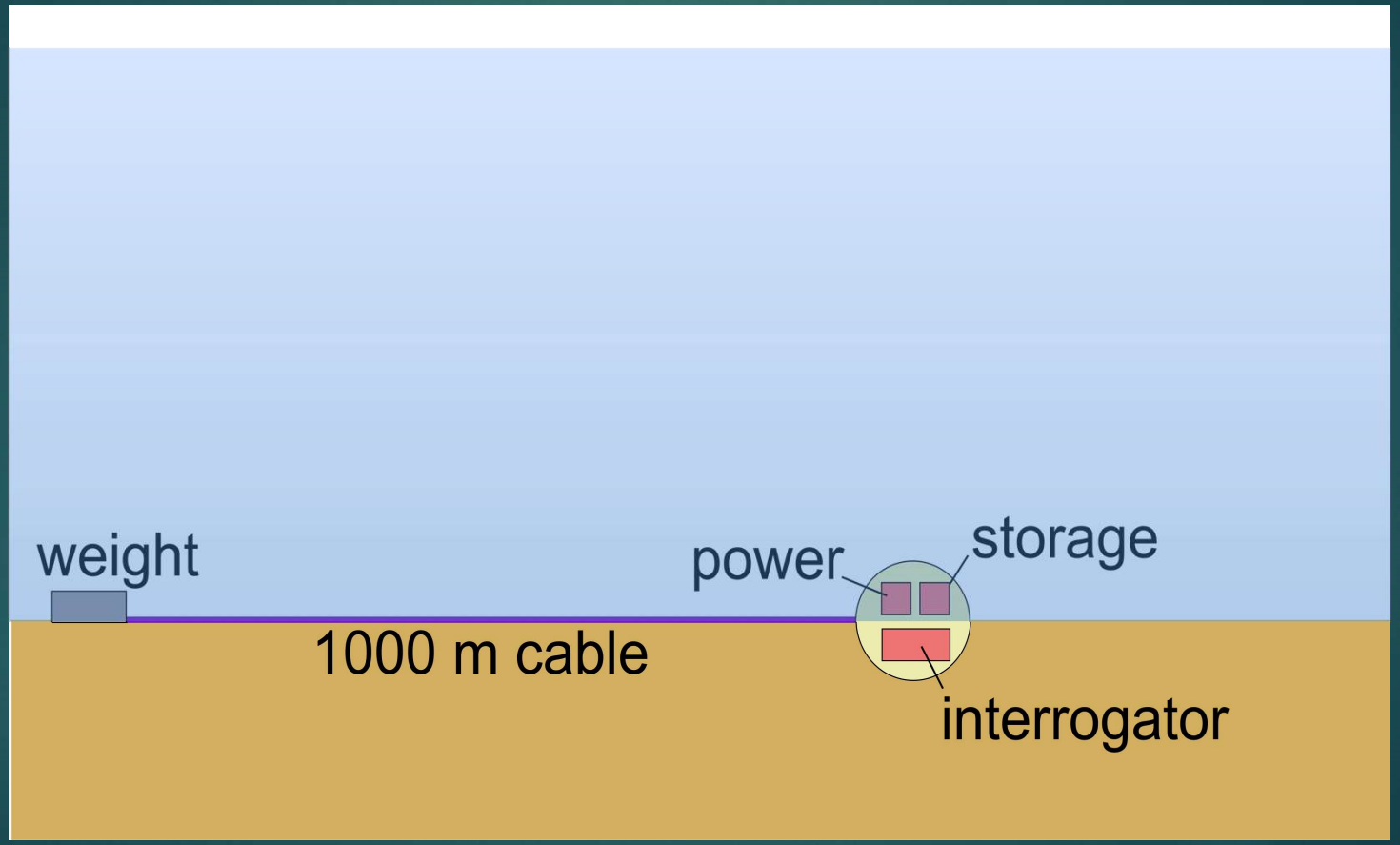
DAS

- Advantages:
  - Incredibly sensitive measurements over a large area
  - Can measure acoustic strain and temperature
- Challenges
  - Currently used only on cables running to shore
  - Large volume and high-power instruments

Enabling Tech: New compact DAS Instrument

- We are working with Sintela Ltd to develop a custom version of their product in development the Onyx Nano
- Key features:
  - Smaller size: 30 cm x 20 cm x 7.5 cm vs. 3U in 19" rack
  - Lower power <40W vs. 100 W continuous
  - Can set trigger to record only samples above a certain threshold
  - Works up to 10 km, which is far more than we need

Geo-Sense Concept



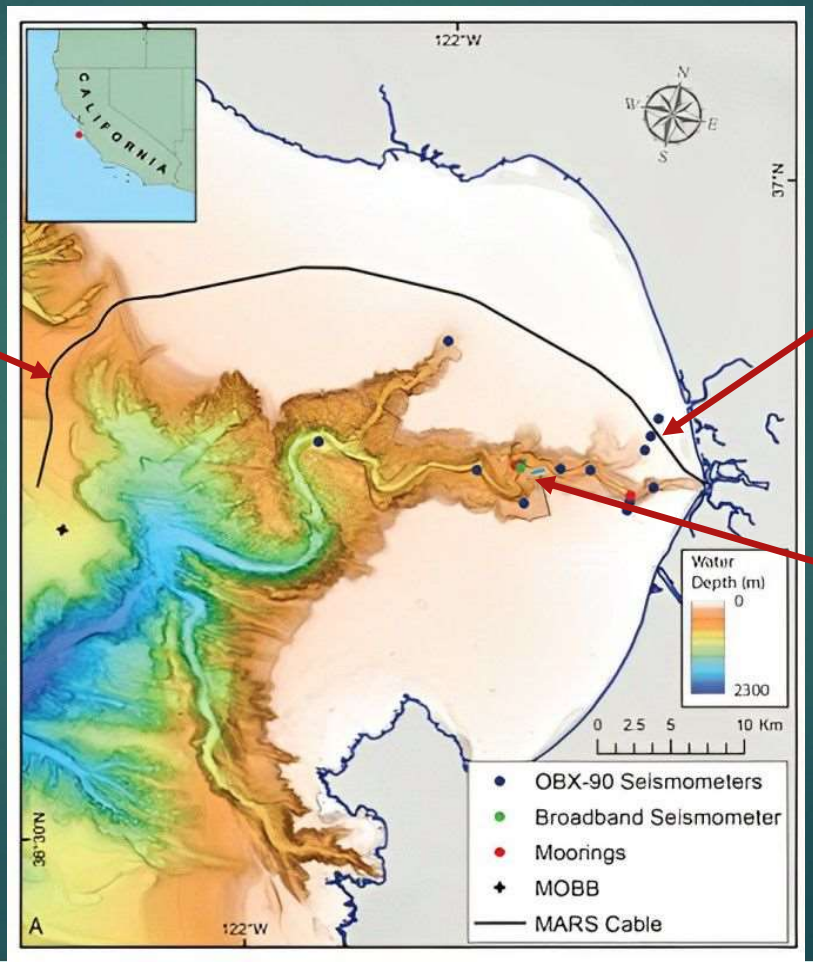
Motivation for Development Schedule

MARS cable

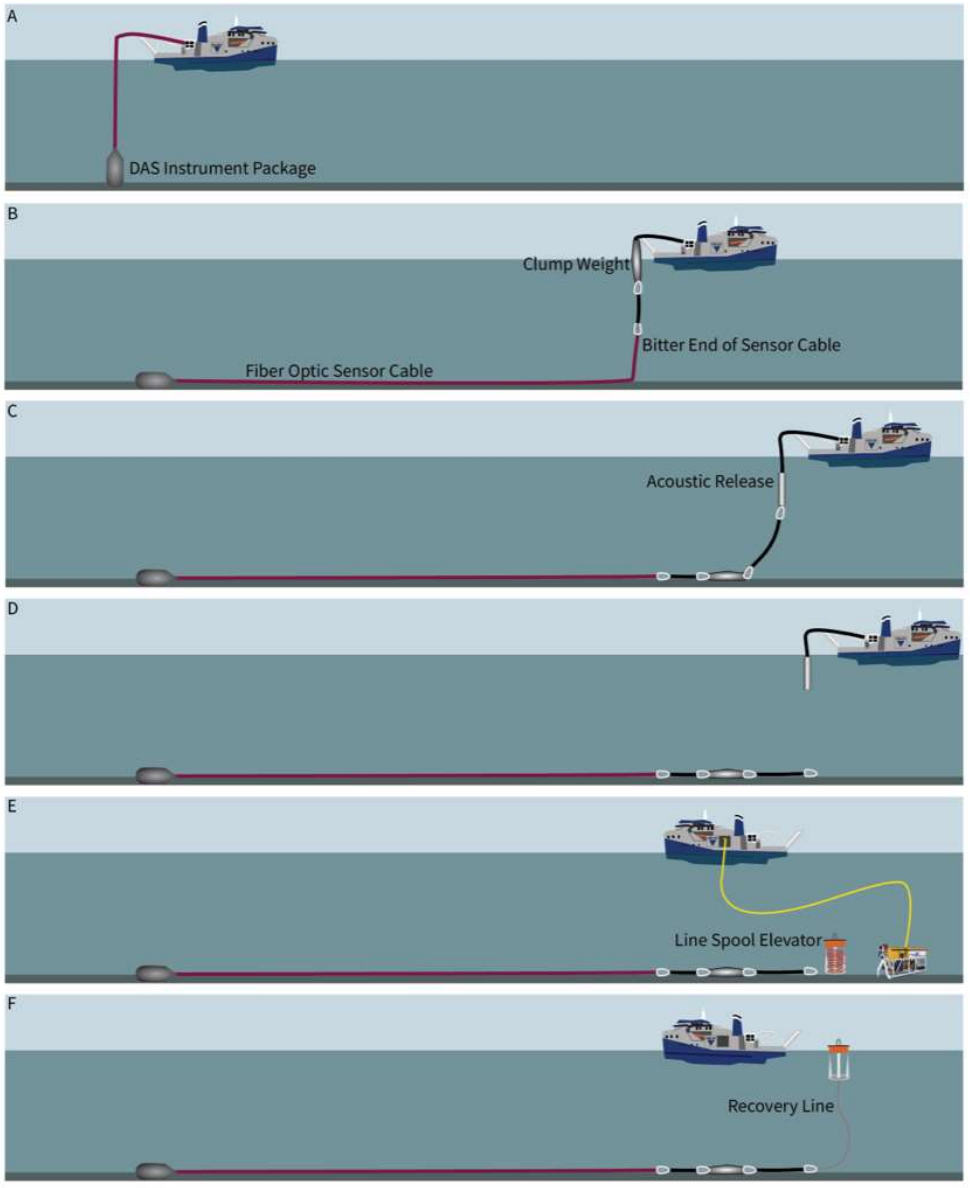
Seismometers

Geo-Sense

The ongoing seismic experiment (Winter 2024-25) provides a rare opportunity to ground truth DAS results with many instruments making simultaneous measurements.



Deployment & Recovery



Select Requirements – System Level

- The system shall resolve seismic waves with a frequency range of 0 - 20 Hz.
- The system shall resolve seismic waves with a spatial resolution of 5 meters.
- The system shall be able to operate autonomously (without operator intervention) for 1 to 2 months. This includes locally recording data.
- The system shall be deployable from MBARI vessel R/V *David Packard*
  - Size limit based on A-frame: 18 ft
  - Desired package weight based on previous experience: 300 lbs (water weight)
  - Cable bend radius limited by winch and sheave: 12" bend radius
- The system shall be deployable to depths of 1000 meters (for the initial design)
- The cable shall be well coupled to the seafloor (lay flat/similar density to sediment/visible for inspection) – these are combined requirements for measurement and permitting.

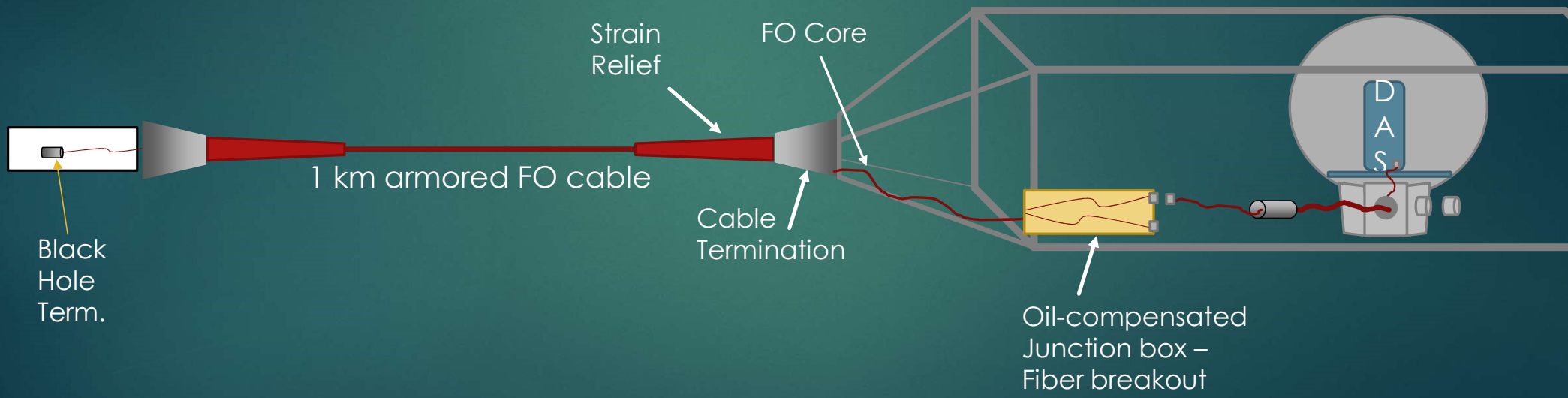
System Requirements – Electrical/Mechanical

- Batteries and instrument shall fit into the volume of existing spherical housings (17" diameter)
- The DAS system must be mounted robustly enough to withstand deployment and recovery.
- The DAS system shall be capable of operating at likely temperatures on the seafloor 4 - 8 deg C (in 5-15% humidity non-condensing environment).
- The DAS system shall be capable of operating in any orientation to Earth's gravity field.
- The system shall operate from the existing battery design for 17" pressure housings. Desired voltage range = 24V - 32V.
- The system shall be capable of shutting down gracefully in case the energy from batteries is depleted before recovery.
- The system shall include a means to disconnect the fiber optic cable from the electronics pressure housing on deck. (Desired)

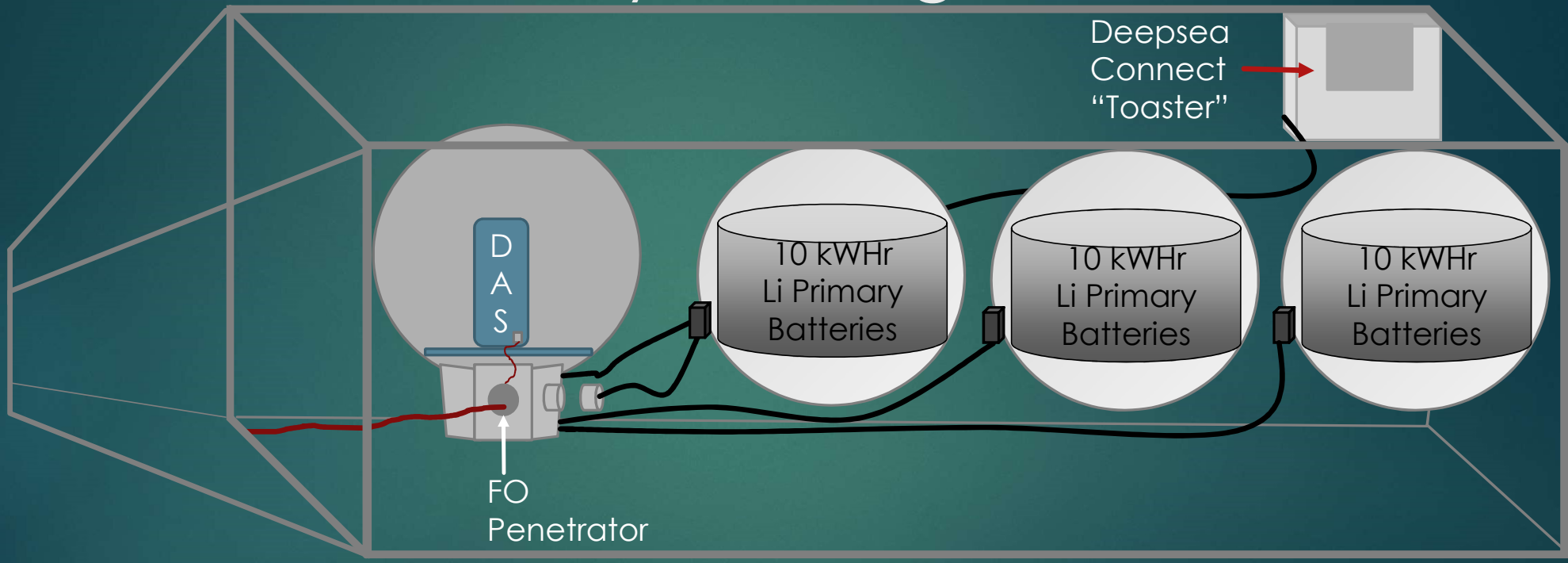
Requirements - Software

- The user shall be able to communicate with the instrument and set it in “deployment mode” on deck
- The user shall be able to connect with the system while deployed via Ethernet and retrieve instrument status (Required) and data (Desired).
- The instrument shall record data to non-volatile memory. (Required).
- Data shall be stored on redundant drives (Desired) – risk vs. cost tradeoff

System Block Diagram – Cable Termination



System Block Diagram – Instrument/Battery Package



Ti sphere housing, glass spheres, battery pack design, and Deepsea Connect are reused technologies.

Electrical Design

- DAS Onyx Nano Specification
- System Power and Communications
- System Interconnects
- Fiber Optic Connection

DAS Details – Onyx Nano

- Modification to commercial product in development
- Preliminary design specifications:
  - Fiber Range: 10 km
  - Spatial Resolution: 2 m (possibly 1 m)
  - Noise floor: Approx. -63 dB rad.Hz–½
  - Acq. Sample Rates: 10, 20, 50 kHz
  - Weight: c. 5 kg
  - Dimensions: c. 300 x 200 x 75 mm
  - Operating Temp: -10 °C to 50 °C
  - Power: 20 V – 60 V DC, 40 W
  - External I/O: 1 x 1 Gb Copper LAN
  - Software ONYX standard SW

Power Budget

- DAS should run directly from 28 V main battery, so no DC-DC loss
- Sintela estimates “less than 40 W” for DAS
- Using waste heat from FPGA to warm laser, which must be kept at 25 degC
- We will have 30 kWh of Li primary batteries
- Batteries would last 31 days at 40 W, 42 days at 30 W
- DAS will operate down to ~20 V, by which time the batteries are completely depleted

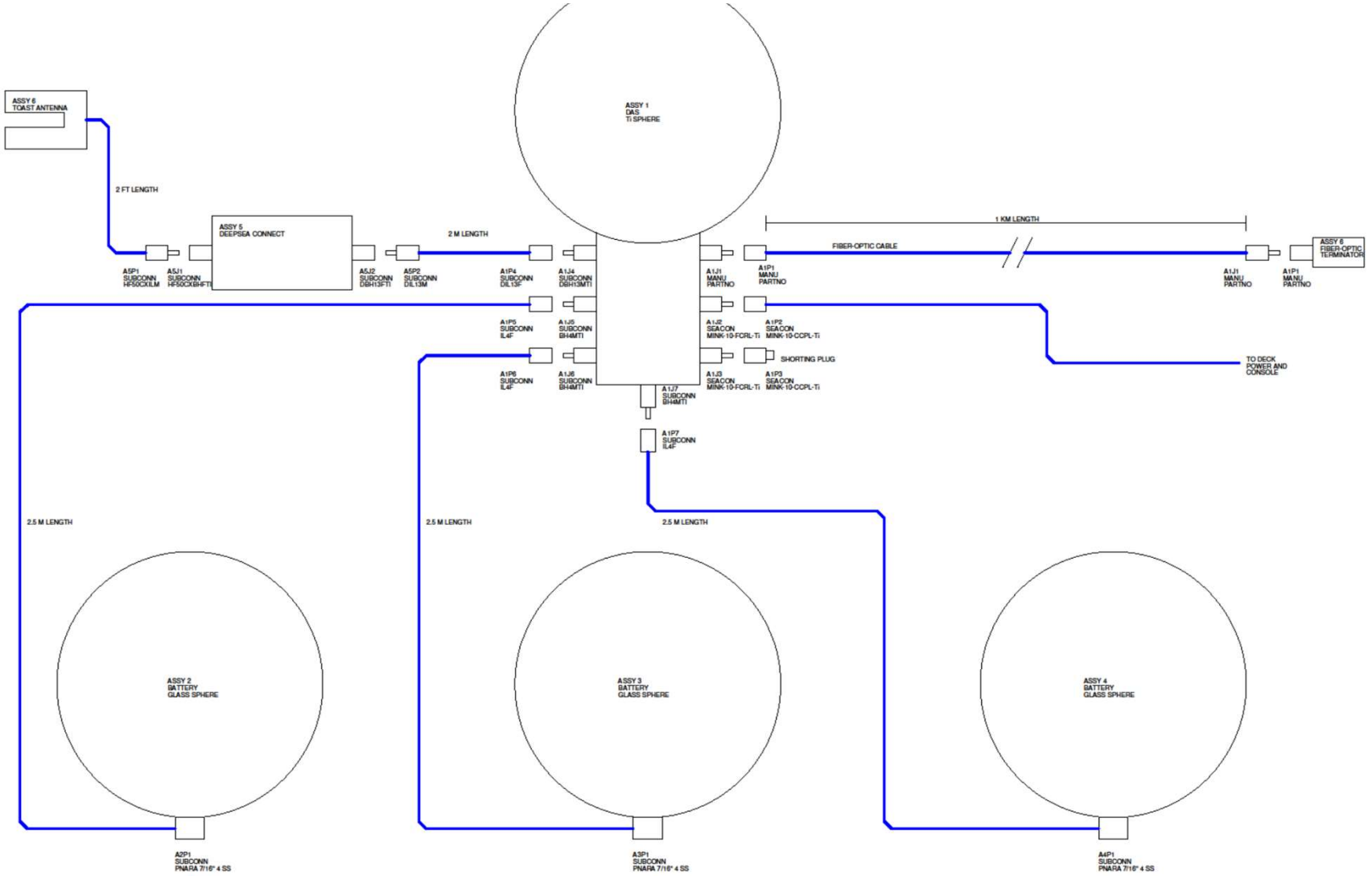
Data Budget

- At 200 Hz sampling with 2 m channel pitch, system will record 17.3 GB per day
- In 42 days, this would be 727 GB, easily stored on a 1 TB SSD
- Sintela is investigating the cost and power of adding a redundant SSD
- System power only increases by ~1.5 W while recording, so not worth it to use triggered sampling to save on storage and possibly miss events

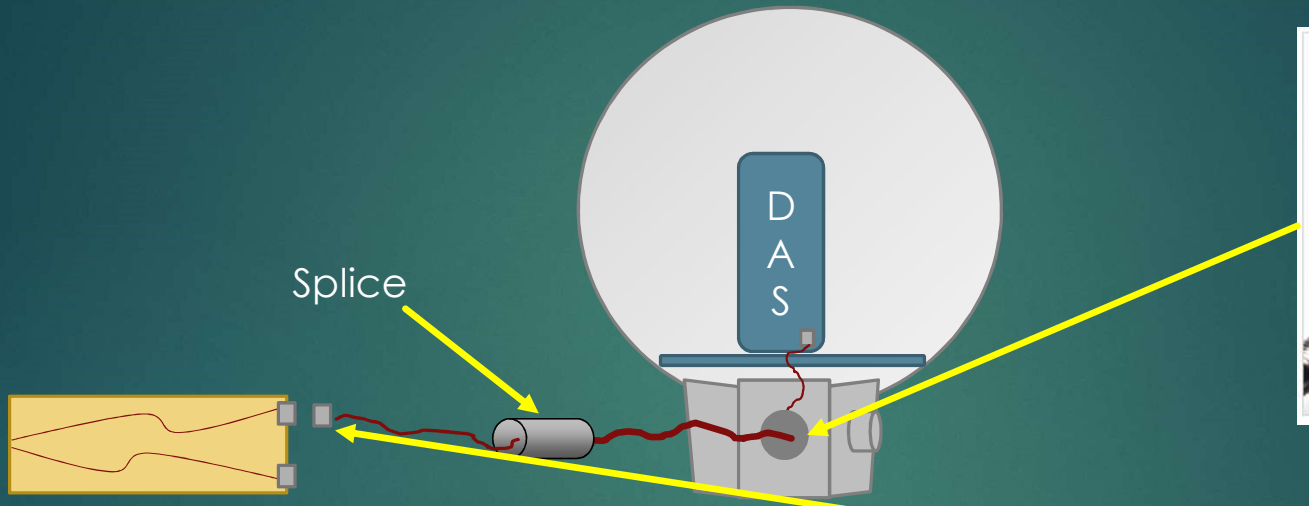
Communications

- Underwater comms during deployment provided by field-proven Deepsea Connect
- Deck cable will provide power to DAS and DSC, and DSC will provide WiFi connectivity to DAS
- Data offload can be done through DSC port on DAS sphere with hardwired GbE
- Fallback for data offload is to open DAS sphere

Electrical Interconnects



Fiber Optic Connection to Housing



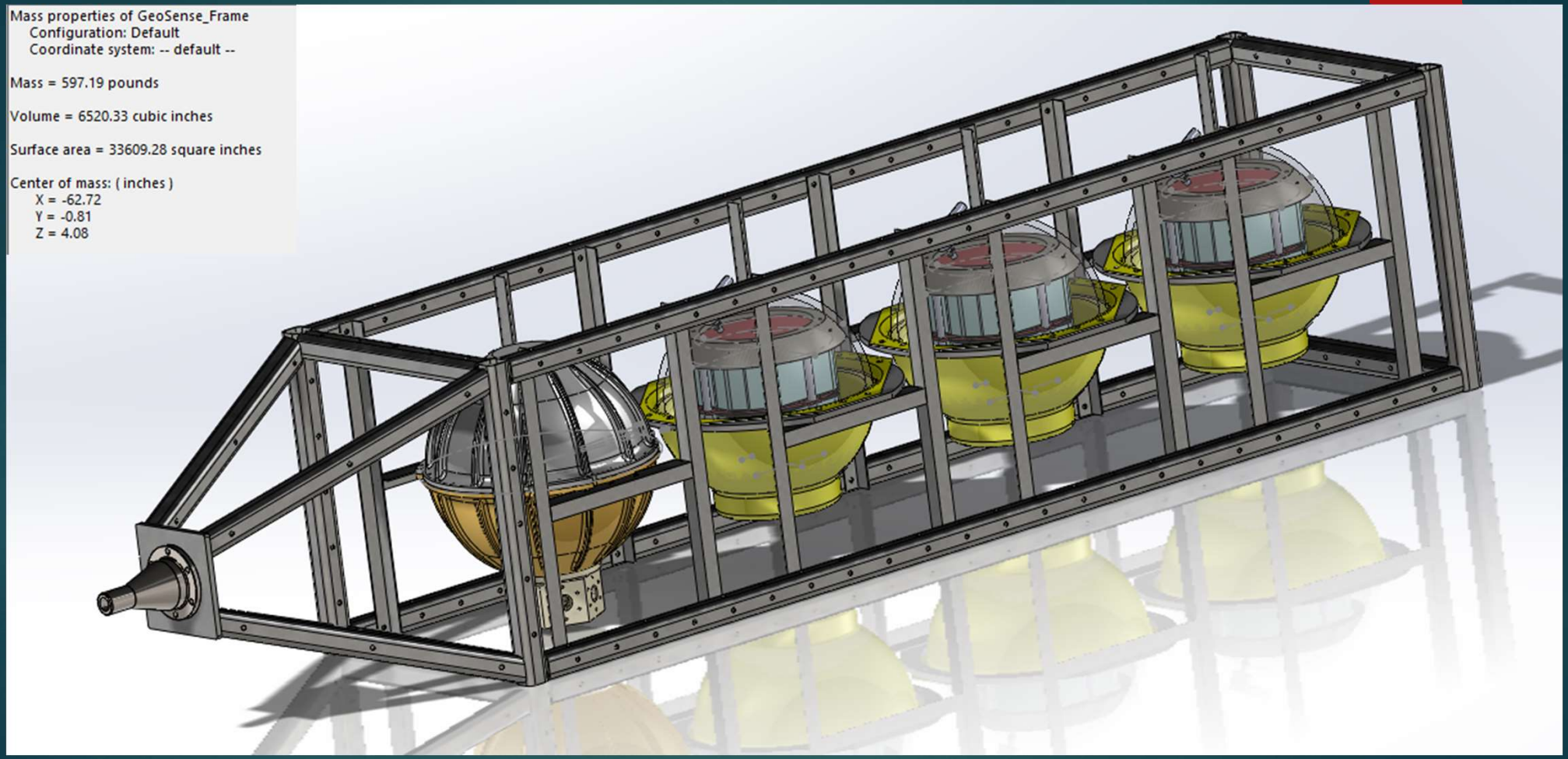
Manufacturer	Part Number	fiber passes	Insertion loss (dB)	Return Loss/ Back Reflection (dB)	depth rating (closed face)	Cost	Lead Time
Green Tweed/Lancer	500-BST-ST-S1-B02	1	<1	?	5000 psi	$478.45	10 weeks if out of stock
Macartney	optolink penatrator, Ti	4	0.2		6000 m	$3,815	6 weeks

Mechanical Design

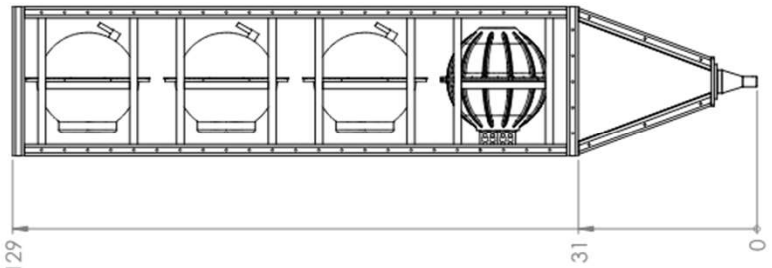
- Instrument in Ti Sphere
- Frame
  - ROV interaction
- cable
  - Strain relief
- Speltzer and bitter end

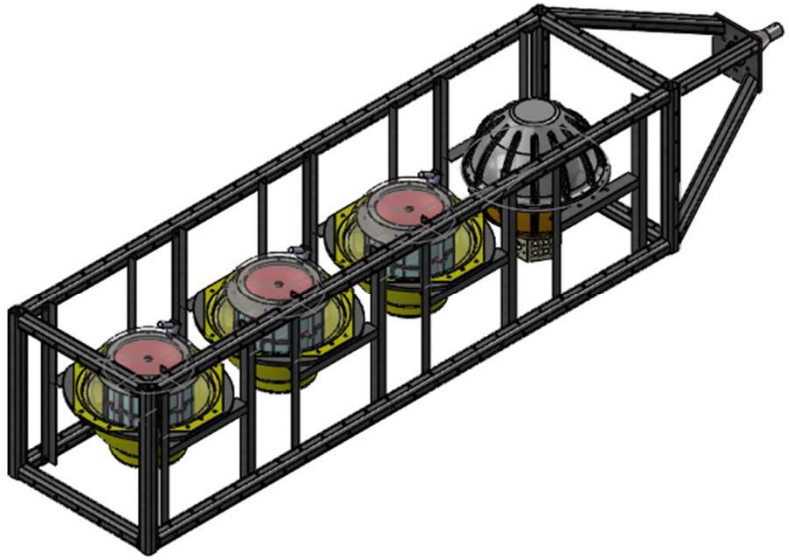
Instrument Mounted in Ti Sphere

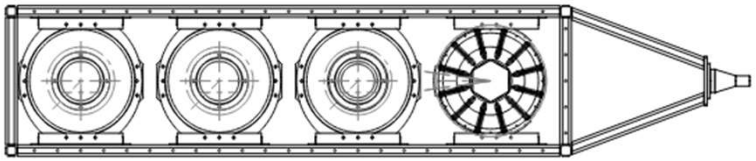
- MBARI Geo-Sense Design Review 05-09-2024.pdf


Mass properties of GeoSense_Frame
Configuration: Default
Coordinate system: -- default --
Mass = 597.19 pounds
Volume = 6520.33 cubic inches
Surface area = 33609.28 square inches
Center of mass: (inches)
X = -62.72
Y = -0.81
Z = 4.08

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
	INITIAL RELEASE		





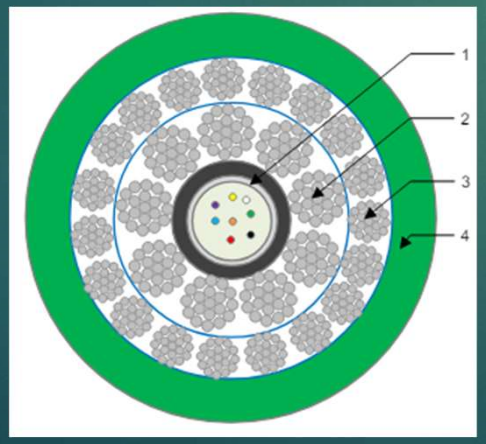


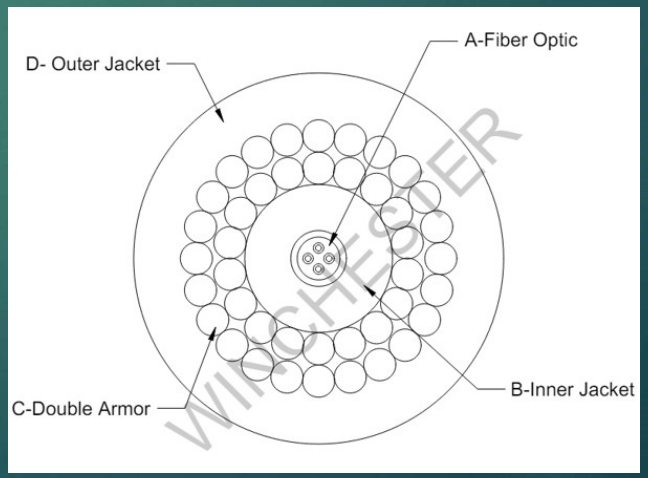
BILL OF MATERIALS

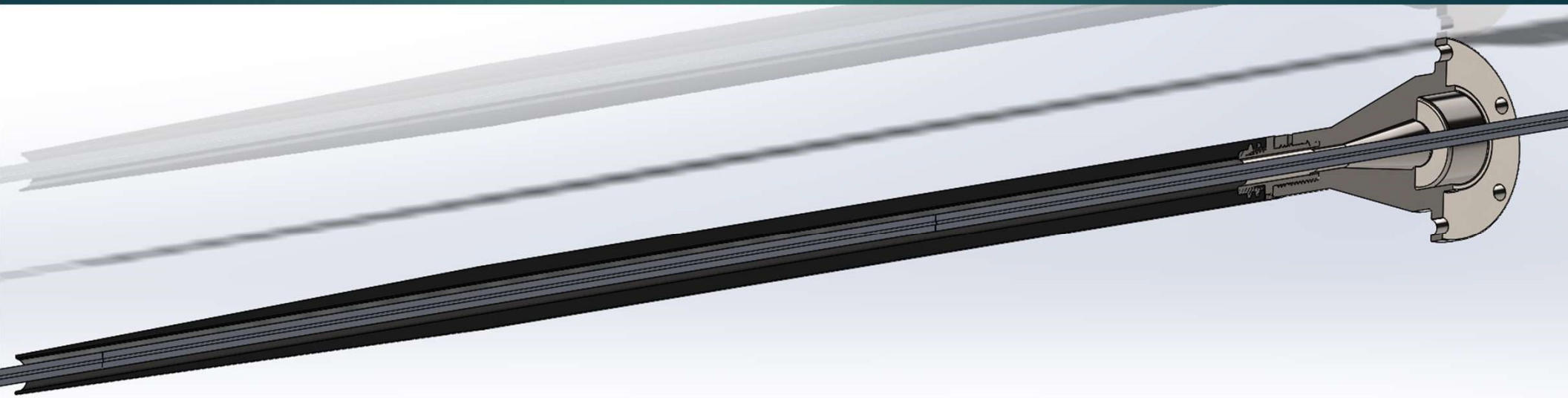
Shop / Q.C.		UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	APPROVALS DATE	Monterey Bay Aquarium Research Institute
Inspector		1 PLACE Dec ±.1 | 2 PLACE Dec ±.02 | 3 PLACE Dec ±.005 | ANGLES ±1°	DRAWN Aaron Schnitger 8/27/23	MBARI 7700 Sandholdt RD. Moss Landing, CA 95039 PH: (831) 775-1700
Shop Foreman		1. DIMENSIONS ARE IN INCHES 2. DIMENSION LIMITS HELD AFTER PLATING. 3. REMOVE BURRS AND SHARP EDGES .015 MAX. 4. MACHINED FILLET RADII .015/-.030.	ENGINEER Aaron Schnitger 9/27/23	
Engineer			CHECKED	
NEXT ASSY Description	NEXT ASSY Number	5. MACHINED DIAMETERS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005. 6. PERPENDICULARITY & PARALLELISM OF MACHINED SURFACES .002 PER INCH, MAX .012 INCHES FOR SINGLE SURFACE.	PROJECT NO. XXX PROJECT zzzzzzzz	GeoSense_Frame
Application		DO NOT SCALE DRAWING	WEIGHT	SIZE B | DWG. NO. 100XXXDWG | REV.
				SCALE 1:20 | CAD FILE: MECH ENG ON TORNADO | SHEET 1 OF 1

Subsea Cable Selection

- Software simulations informed requirements
- Request for quote sent to 8 manufacturers
- Cable specific design review held
- Decision down to two cables (Concept Cables and Winchester)







Status of project

- DAS system being designed by Sintela, expected delivery early Fall 2024
- All housings are identified and in the lab
- Rubber molded cables and connectors are purchased
- Batteries have arrived
- Components for Deepsea Connect are being purchased
- To do in next couple weeks:
  - Cable selection down to two choices (Concept Cables and Winchester) lead times for both are < 4 months, final decision to be made
  - FO connecter needs to be ordered
- Termination details to be worked out
- Housing designed or found for Deepsea Connect

Proposed Schedule

Task	Month (2024)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Identify latest suitable instruments	■											
Develop a conceptual design of a portable DAS system		■										
Carry out SWOT analysis			■									
Conduct a design review				■								
Critical design review and detailed design					■							
Selection of appropriate deployment and recovery protocol	■											
Identify components already available at MBARI					■	■	■					
Procurement of interrogator, cable and batteries						■						
Assembly of prototype								■	■			
Testing of prototype in the lab and field										■		
Permitting issues			■									

Status of Schedule

Task	Month (2024)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Identify latest suitable instruments	✓											
Develop a conceptual design of a portable DAS system		✓										
Carry out SWOT analysis			✓									
Conduct a design review				■	→							
Critical design review and detailed design					■							
Selection of appropriate deployment and recovery protocol	✓											
Identify components already available at MBARI					✓	■	■					
Procurement of interrogator, cable and batteries				→		■	→	→	→			
Assembly of prototype								■	■			
Testing of prototype in the lab and field										■	■	■
Permitting issues			OK?									

Testing and Integration Plan

- DAS instrument can be tested on the bench with a 1 km spool of fiber
- Software can be tested independently of hardware using docking image (platform is a jetson orin)
- Bench testing of Deepsea Connect
- Analysis of MARS DAS data by summer intern will inform expectations for data and sampling plans
- Cable unspooling?
- Test deployment?

Remaining High-Risk Elements

- Unforeseen delays with DAS instrument, FO cable, Termination
- Cable connection to the seafloor – will it lie flat
- New deployment scheme for MBARI
- Ship availability

Safety Considerations

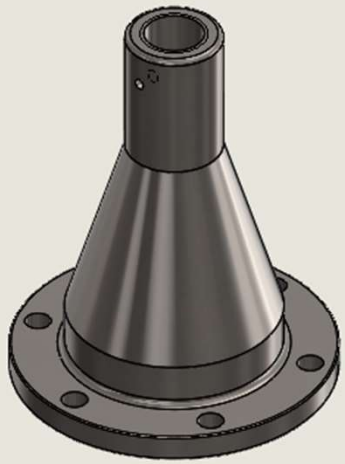
- Careful planning of deck operations due to heavy load
- Any laser safety issues: Denis

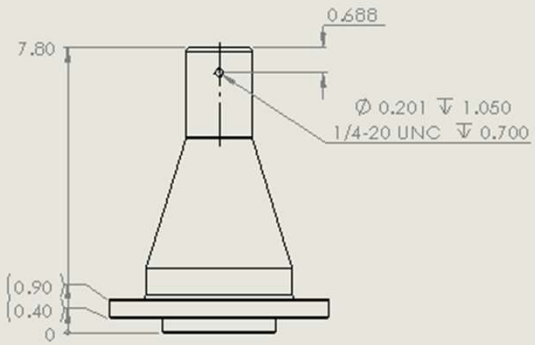
Discussion

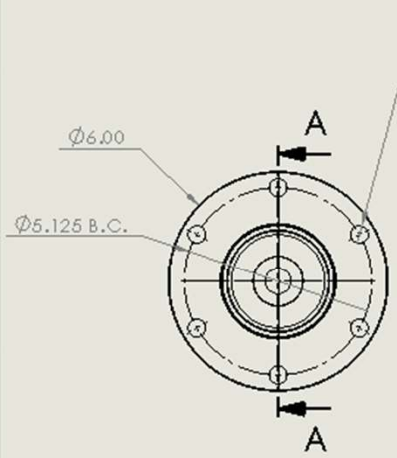
Electrical Design – FO connector options

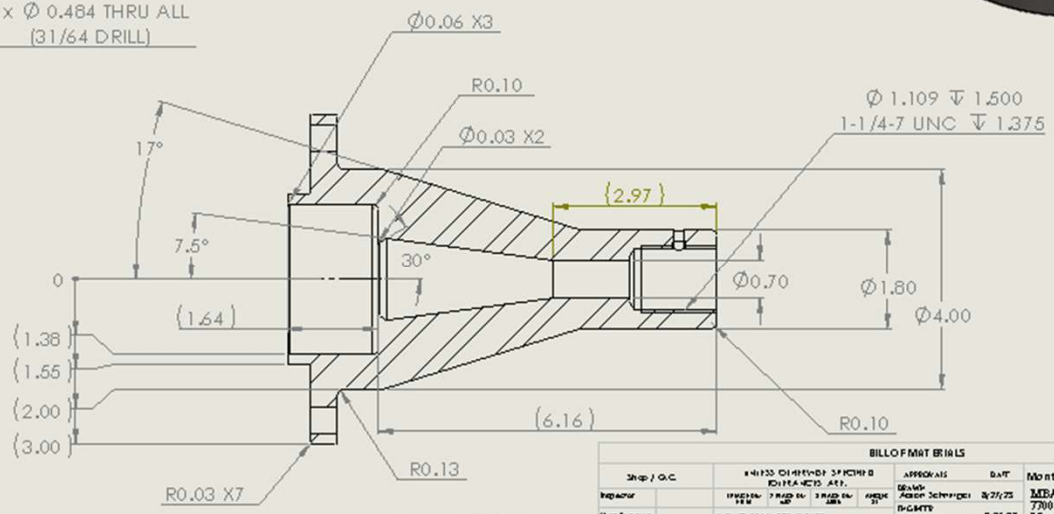
- Fiber penetrator from MacArtney:
  - Advantages: low loss, can fit with APC connectors on end
  - Disadvantage: can't disconnect the system from 1 km of cable
- Lancer connectors:
  - Advantage: can disconnect system easily; these are available and have been regularly used in other systems
  - Disadvantage: not the most robust design
- Birns
  - Advantages: can disconnect, best optical properties of connectors
  - Disadvantages: $10k, longer lead time, not most customer friendly experience

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
	INITIAL RELEASE		









SECTION A-A

SCALE 1 : 2

BILL OF MATERIALS

Shop / Q.C.						
Inspector						
Shop Foreman						
Planner						
NEXT ASSY Description	NEXT ASSY Number					
Application						

APPROVALS	DATE
DRAWN Aaron Schwenger	9/27/23
ENGR'R Aaron Schwenger	9/27/23
CHECKED	
PROJECT NO. XXX	
PROJECT zzzzzzzz	
MATERIAL	

Monterey Bay Aquarium Research Institute

MBARI
7700 Sandholdt RD.
Moss Landing, CA 95039
PH: (831) 775-1700

SpeltzerStyle_socket

SIZE	DWG. NO.	REV
B	100XXXDWG	

SCALE: NS CAD FILE MISMATCH OR FORMAT SHEET 1 OF 1

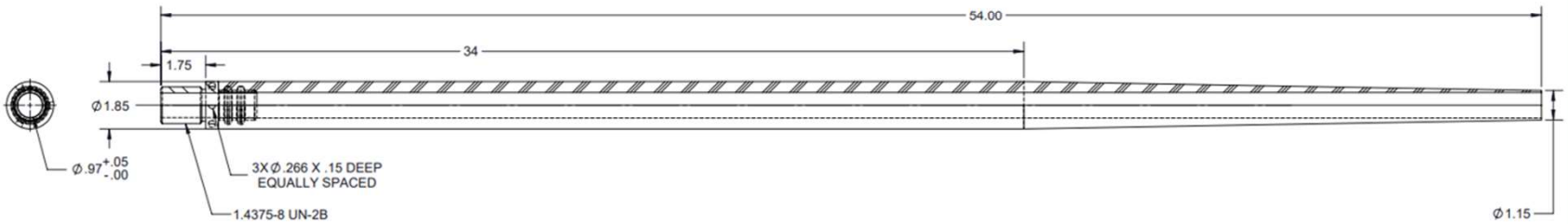
NOTES: UNLESS OTHERWISE SPECIFIED

1 MATERIALS:
ADAPTOR: UNS 31600
POLYURETHANE: PP1901, POLYETHER-BASED, NOMINAL 93 SHORE A HARDNESS, BLACK COLOR.

2 DESIGNED USE: ABRASION PROTECTION OF ROV FOAM PACKAGE AND STIFFENING OF Ø0.940" CABLE AT EXIT OF TERMINATION

3 VENDOR TO MANUFACTURE IAW PROD-005 TO ENSURE PROPER METAL TO URETHANE BONDING

-	A	CHANGED IAW DCR #3296	10/30/2002	J.C. MARINO
-	B	CHANGED IAW ECN #2874929	3/3/2020	T. MATHIS
-	C	CHANGED IAW ECN #2896429	12/1/2022	T. MATHIS
-	D	CHANGED IAW ECN #2901301	2/13/2023	T. MATHIS



B	B	REVISION	REV STATUS OF SHEETS
2	1	SHEET	

SHEET 1 - SPECIFICATION CONTROL DRAWING
(APPROVED FOR CUSTOMER RELEASE)

SHEET 2 - ASSEMBLY DRAWING
(PMI CONFIDENTIAL BUSINESS INFORMATION)

-	VENTANA
NEXT ASSY	USED ON
APPLICATION	
SIMILAR TO	9007132

INTERPRET DRAWING IAW MIL-DTL-31000C INCLUDING APPLICABLE DOCUMENTS REFERENCED THEREIN. INTERPRET DIMENSIONS AND TOLERANCES IAW ASME Y14.5M-1994.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:
DECIMALS .XX ± .05 .XXX ± .
ANGLES ± .
FRACTIONS ± ±1
MACHINED SURFACE FINISH TO BE: √
MACHINED FILLET RADII TO BE:-
BREAK ALL EDGES:
.
DO NOT SCALE DRAWING

CONTRACT NO. 14416

APPROVALS	DATE
DRAWN F. ALBERT	11/10/1995
CHECKED J.C. MARINO	12/7/1995
APPROVED J.C. MARINO	12/7/1995
APPROVED	
DESIGN ACTIVITY ALLAN R. METZLER, JR.	12/7/1995

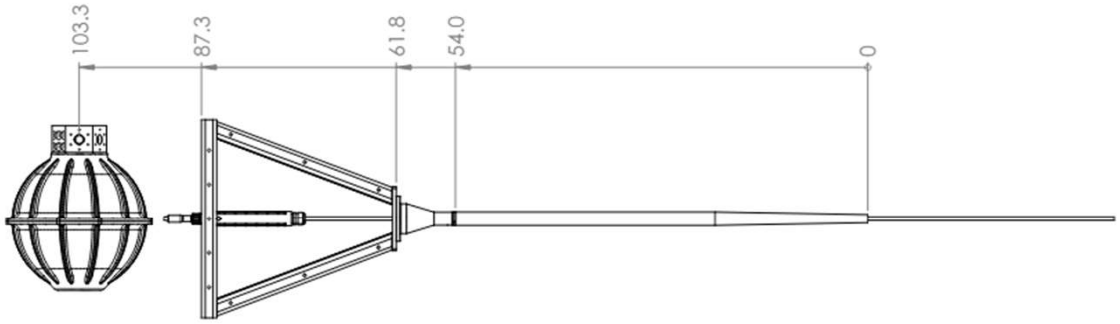
PMI Industries, Inc.
5300 ST. CLAIR AVENUE, CLEVELAND, OHIO

ALL-POLY BSR, ROV UMBILICAL

SIZE	CAGE CODE	DWG NO.	REV.
C	0G5C2	9007238	D

DO NOT SCALE DRAWING	SCALE	PMI REF. NO.	SHEET	OF
	1:3	M7291	1	2

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
	INITIAL RELEASE		



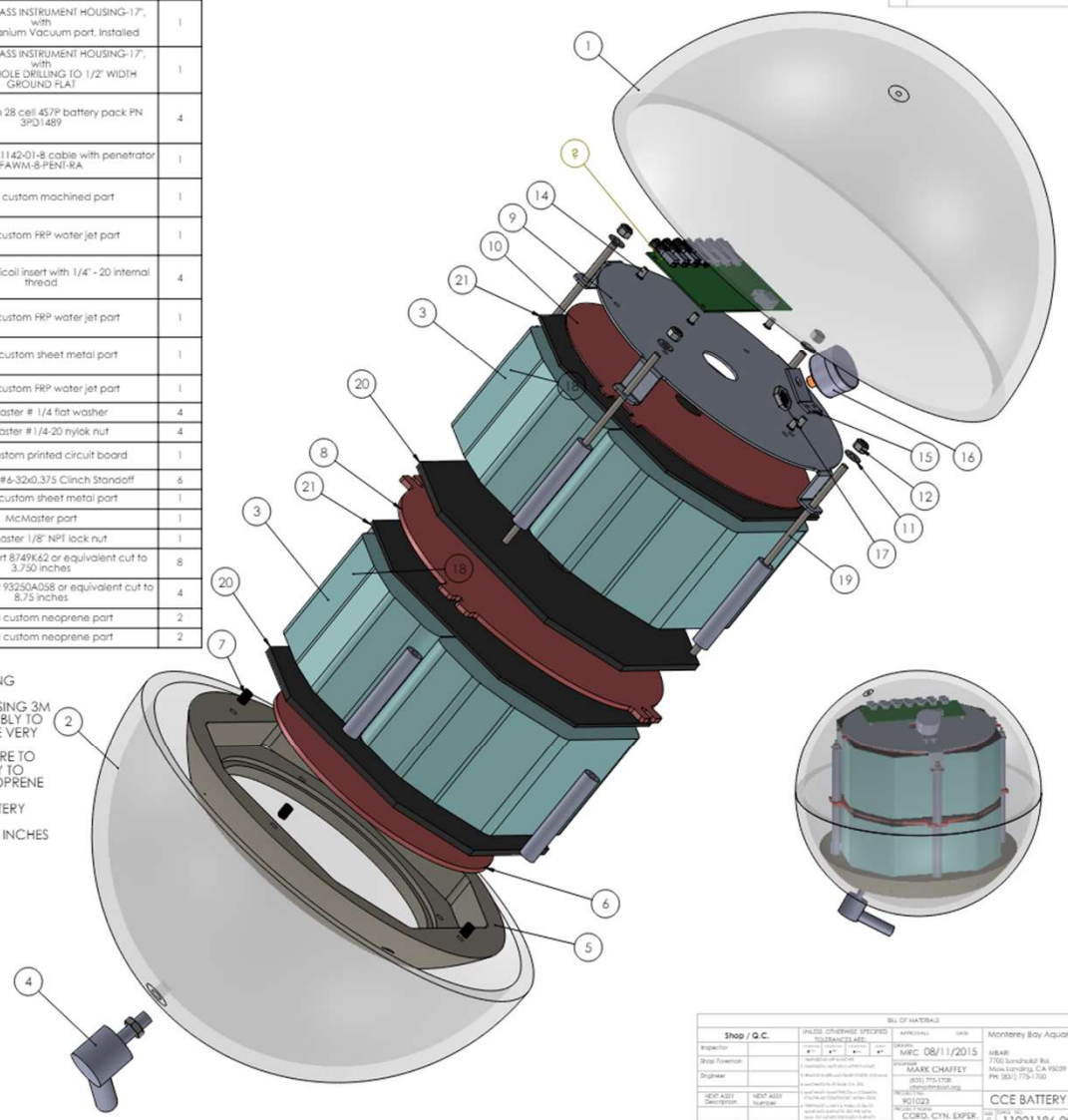
BILL OF MATERIALS

Shop / Q.C.		UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	APPROVALS	DATE	Monterey Bay Aquarium Research Institute
Inspector		1 PLACE DIM ±.1 | 2 PLACE DIM ±.02 | 3 PLACE DIM ±.005 | ANGLES ±1°	DRAWN Aaron Schnitger	8/27/23	MBARI 7700 Sandholdt RD. Moss Landing, CA 95039 PH: (831) 775-1700
Shop Foreman		1. DIMENSIONS ARE IN INCHES	ENGINEER Aaron Schnitger	9/27/23	
Engineer		2. DIMENSION LIMITS HELD AFTER PLATING.	CHECKED		
		3. REMOVE BURRS AND SHARP EDGES .015 MAX.	PROJECT NO.	XXX	
NEXT ASSY Description	NEXT ASSY Number	4. MACHINED FILLET RADII .015-.030.	PROJECT	ZZZZZZZ	Fiber2Sphere
		5. MACHINED DIAMETERS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005			
		6. PERPENDICULARITY & PARALLELISM OF MACHINED SURFACES .002 PER INCH, MAX .012 INCHES FOR SINGLE SURFACE.			SIZE B | DWG. NO. 100XXXDWG | REV.
Application		DO NOT SCALE DRAWING	WEIGHT		SCALE 1:20 | CAD FILE: MECH ENG ON TORNADO | SHEET 1 OF 1

8 7 6 5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BenthosGlassHemisphere_Bottom	2040-17H; GLASS INSTRUMENT HOUSING-17", with 204-VPT, Titanium Vacuum port, Installed	1
2	BenthosGlassHemisphere_Top	2040-17H; GLASS INSTRUMENT HOUSING-17", with 204-DHO; HOLE DRILLING TO 1/2" WIDTH GROUND FLAT	1
3	ElectroChemBatPack_3PD1489	Electrochem 28 cell 4S7P battery pack PN 3PD1489	4
4	SeaconPenetrator_FAWM-8-PENT-RA	MBARI PN 10021142-01-8 cable with penetrator FAWM-8-PENT-RA	1
5	11021186-01-A_BatteryMountBaseFrame	MBARI custom machined part	1
6	11021186-02-A_BatteryMountBasePlate	MBARI custom FRP water jet part	1
7	96246A208	McMaster Helicoil insert with 1/4" - 20 internal thread	4
8	11021186-03-A_BatteryMountMidPlate	MBARI custom FRP water jet part	1
9	11021186-04-B_BatteryMountUpperFrame	MBARI custom sheet metal part	1
10	11021186-06-B_BatteryFRPInsulator	MBARI custom FRP water jet part	1
11	90107A029	McMaster # 1/4 flat washer	4
12	90715A125	McMaster #1/4-20 nylok nut	4
13	11021186-07-A_BatteryPCB	MBARI custom printed circuit board	1
14	93090A240	McMaster #6-32x0.375 Clinch Standoff	6
15	11021186-08-A_BatteryGaugeMount	MBARI custom sheet metal part	1
16	3935K21_VacuumGauge	McMaster part	1
17	4429K121	McMaster 1/8" NPT lock nut	1
18	8749K62_x3.750	McMaster part 8749K62 or equivalent cut to 3.750 inches	8
19	93250A058_0.25-20x8.75ThreadedRod	McMaster part 93250A058 or equivalent cut to 8.75 inches	4
20	11021186-05-B_Battery0.250RubberPad	MBARI custom neoprene part	2
21	11021186-09-A_Battery0.125RubberPad	MBARI custom neoprene part	2

NOTES:
1. PROTECT GLASS SPHERE EDGES WITH TUBING DURING ASSEMBLY.
2. BASE FRAME IS BONDED INTO THE GLASS SPHERE USING 3M 5200 FAST CURE ADHESIVE. USE JIG DURING ASSEMBLY TO ENSURE CORRECT POSITIONING. CLEARANCES ARE VERY TIGHT SO CORRECT POSITIONING IS ESSENTIAL.
3. ASSEMBLE BATTERY STACK IN SEQUENCE USING CARE TO NOT APPLY MORE CLAMP FORCE THEN NECESSARY TO HOLD BATTERIES IN POSITION. USE ADDITIONAL NEOPRENE PADS AS FILLER IF NECESSARY.
4. CINCH HEAVY DUTY TIE-WRAP AROUND EACH BATTERY LAYER TO HOLD TOGETHER (NOT SHOWN).
5. SEAL AND VACUUM COMPLETED ASSEMBLY TO -10 INCHES OF Hg (~-5PSI)+ CONFIRM HOLDS VACUUM.



REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	08/11/15	MRC
B	MODIFIED TO MATCH BATTERY ACTUAL	08/13/15	MRC

BILL OF MATERIALS

Shop / Q.C.

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:

APPROVALS: MRC 08/11/2015

DRAWN: MARK CHAFFEY (831) 775-1708 chaffey@mbari.org

PROJECT NO.: 901023

PROJECT NAME: CORD. CYN. EXPER.

Monterey Bay Aquarium Research Institute

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CCE BATTERY ASSEMBLY

SIZE: C | DWG. NO.: 11021186-00-B-DWG | REV: B

NEXT ASSY Description | NEXT ASSY Number

APPLICATION

DO NOT SCALE DRAWING

SCALE: | CAD: Inst | SHEET 1 OF 1