

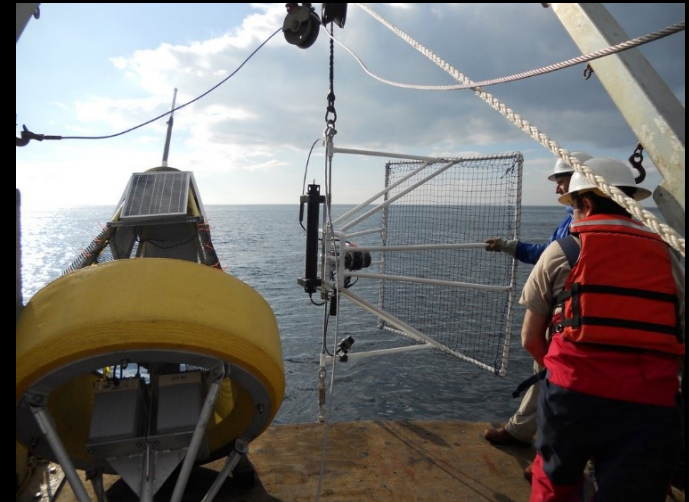
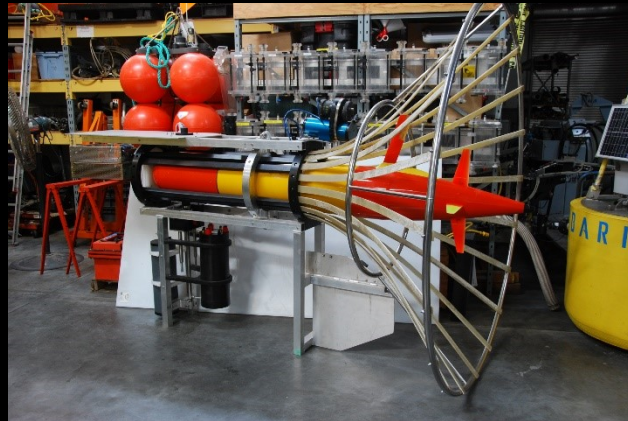
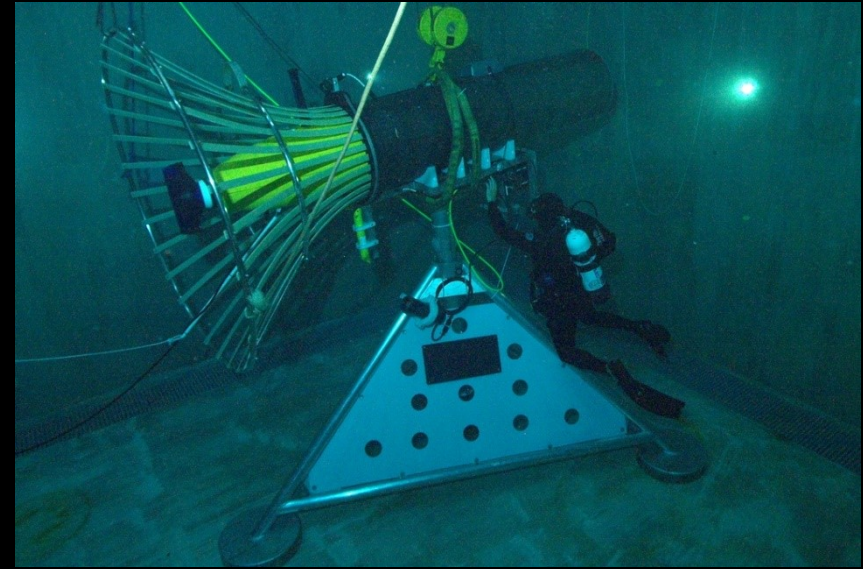
AUV Docking 2021

PDR for the Test Mooring

26 January 2021

AUV Docking Backstory:

- 2007 -Designed, built, deployed and tested a docking station for Dorado
 - Inductive power transfer of 500 watts,
 - Thru-water WiFi 802.11g 100b Ethernet data transfer
 - Sonardyne USBL-based acoustic homing system
- 2012 – started the design of a cone dock for the LRAUV under DARPA funding
 - AUV Docking component was canceled to focus on WEP
 - Planned to use ODI connector for power and data transfer
 - Benthos DAT-based homing; proved unreliable at that time, though it works well now



Recent Developments

- DHS/US Coast Guard funded, under-ice oil spill mapping project
 - LRAUV can now home to a cable and capture that cable using a WHOI Whisker Box docking device with a WHOI Micromodem + linear USBL array
- Northrop Grumman developed their Neobium, naturally self sealing conductive metal contact connector
 - MBARI has (almost) secured a license from NG to use this material for an AUV dock power transfer system

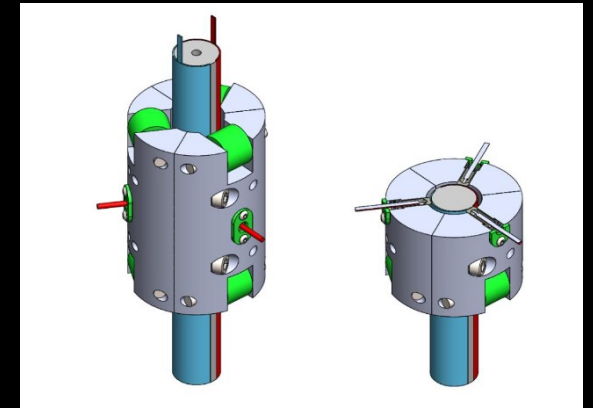
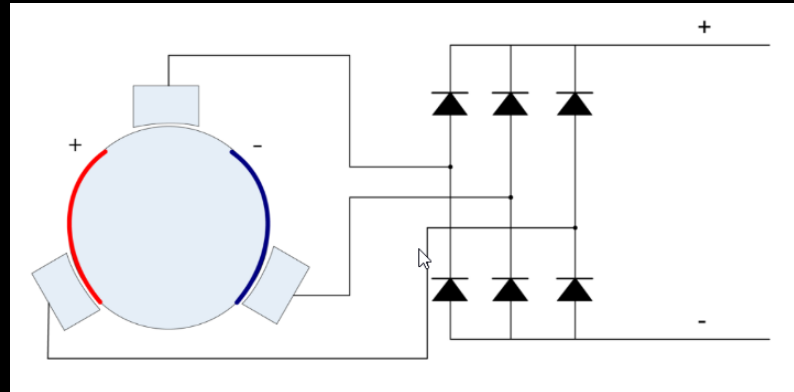
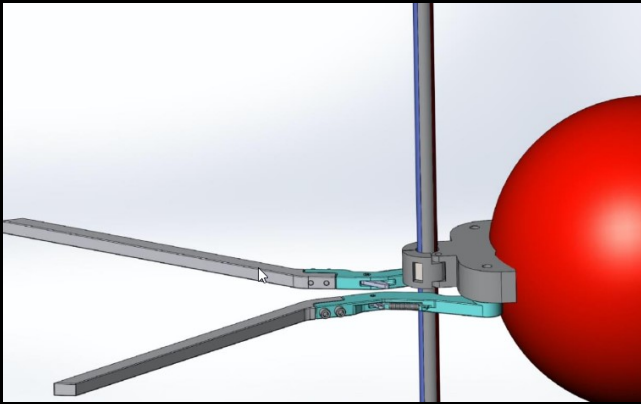


iCONN's Wet-Mate Connector

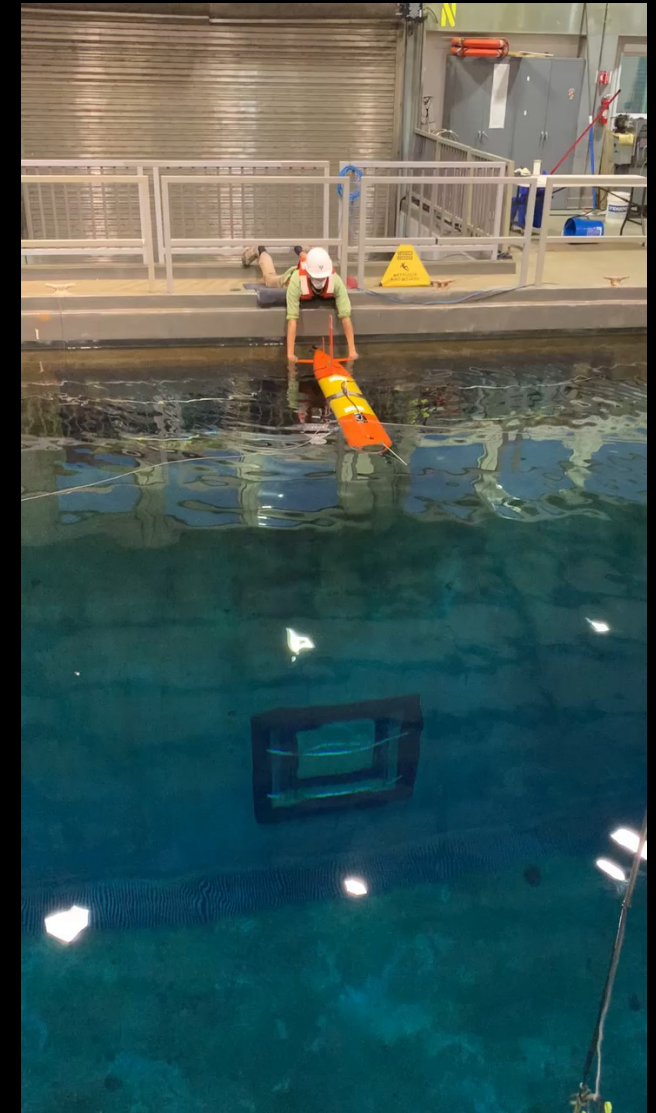
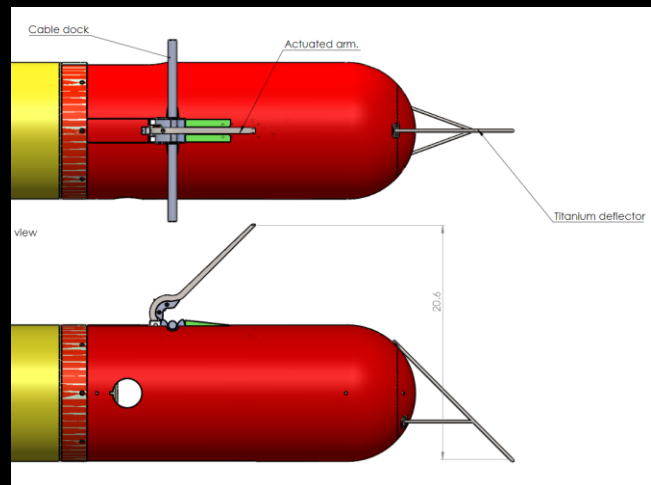
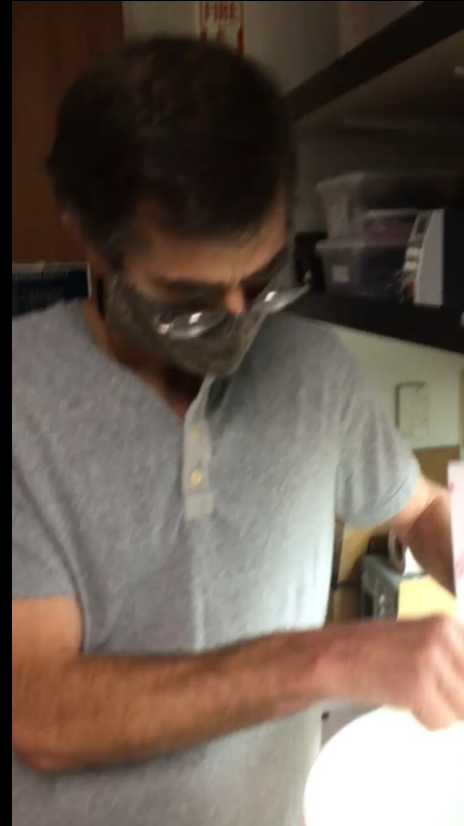
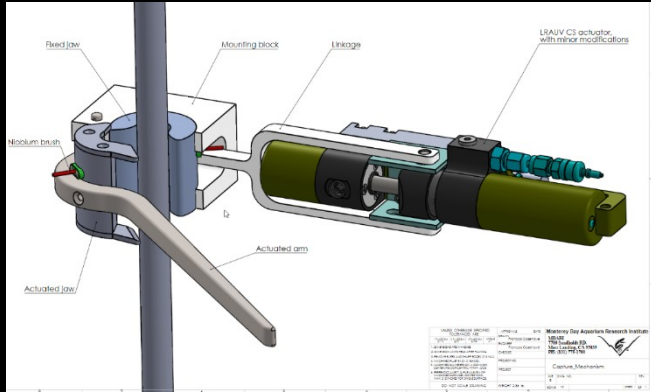
MBARI project #902106

Niobicon Based AUV Docking Development

- We've proposed to build and test a few prototypes 2021



Early Progress



Questions for Sea Tests:

- Can we reliably home to a cable with a Benthos DAT?
 - Offshore USBL homing and guidance testing underway now at WHOI
 - Can we reliably detect and capture a cable?
 - Test tank tests with prototype capture device at the surface (2D)
 - Repeat test tank tests at depth (3D motion)
 - Can we transfer power to the AUV through a niobium system?
 - Lab tests with prototype NB power transfer system
 - Test tank tests with AUV deployable NB power transfer system
 - Add simulated ocean motion to tests
 - Does it work in the real environment?
 - Offshore homing, latching and power transfer tests
-

Time to upgrade from our dumb modem on a rope

Requirements for a new test mooring (1/2):

- Need a mooring system to support the AUV Docking development at a relatively calm location
 - 70m of water, docking at 8m above seafloor
- The system shall have a docking section and acoustic homing beacon
 - Some lateral compliance is required to lessen the impact of capture
 - $\frac{3}{4}$ " diameter, 6' long NB power transfer section
 - Benthos MF acoustic modem
- Must be able to quantify homing and docking performance
 - Shall be equipped with a video camera and light(s)
 - Would be nice to see these data on shore in real-time, but transfer to shore of recent data is required
- Must be able to transfer power
 - 24 volts/16 amps (400 watts) to the AUV battery system for at least 5 minutes
 - Control and Monitor voltage and current at 20 kHz, would be nice to get data in real-time, but near-real-time file transfer of recent data is required
 - Would be nice if power transfer could continue for 10 hours, once per week
- Must be able to communicate with the AUV while underwater and at the dock
 - Benthos MF Acoustic comms is OK at the dock, but there shall be an Ethernet port for communications to the AUV while it is docked using some kind of data transfer system in the future.

Requirements (2/2)

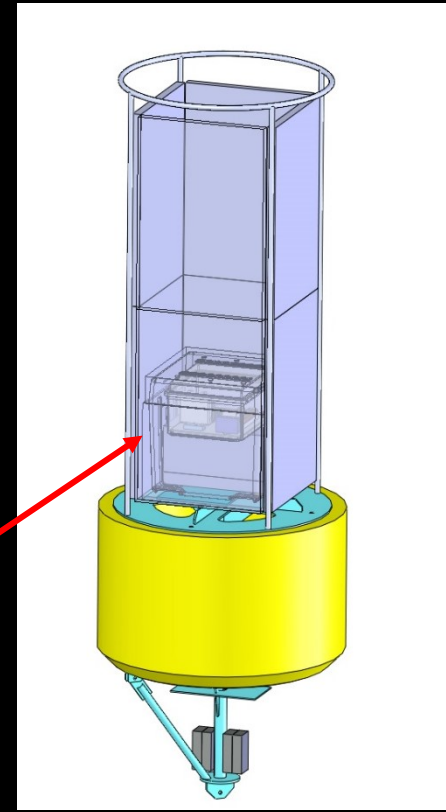
- The power and control system shall have web access
- The system shall be deployable from the Paragon
- The system shall use as many existing parts as possible
 - Buoy, anchor, subsea housing, cable
- The system shall be reliable for a six-month deployment, possibly through winter storms
- We expect to perform a system upgrade/redesign during 2022 for longer deployments. That system could be larger, and should be more robust with greater long-term reliability.

Subsystems – Top Down

- Radio telemetry to shore
- Power generation and energy storage
- Buoy and misc. electronics
- Riser to buoy – Electro/Mechanical
- Subsurface float with electronics
- Niobium power transfer section
- Anchor and 7m riser

Buoy

- Use the MBARI Vertical Profiler (MVP) surface float
 - Old tower is being used on the WEC project
 - Build a new frame to hold solar panels, radio antennas, lifting eyes
 - Paint below waterline with antifouling paint
- Electronics installed in a Pelican 0370 plastic box
 - Heat sink and U/W connectors added
- Cradlepoint IBR 600C for cellular and WiFi
- CBW 10 power relay with temp/humidity
 - SPST 270VAC/30VDC, 15 amp
 - accessible via the web
- DSL modem between buoy and subsea Moxa IEX-408x
- Could add security camera and hub (Arlo is watching)
- Radar reflector, light, Spot tracker, Cell antenna



Power Generation and Energy Storage

- Even for short tests, significant storage is required
- COTS solution: GoalZero 6000
 - 6 kW-hr of Li-ion NMC, at 10.9v
 - 230 VAC/50hz, 2 kW cont. (possibly 120 VAC)
 - 12 VDC @ 30 amps
 - MPPT solar charging at 600 W
- (4) 100 W solar panels
- Remote monitoring with app
- Fits inside a Pelican 1610 with heat sink added
- GFI circuit breaker on AC output

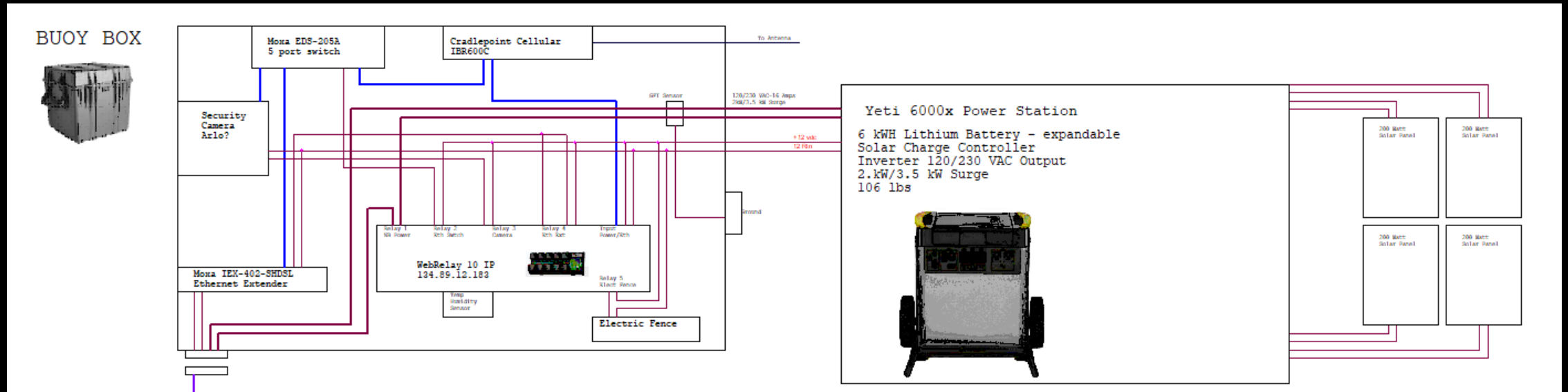


Other Options

- Other COTS solar/battery/inverter options
- Fuel Cell to reduce solar panel area
 - Adaptive Energy unit runs on propane
 - 350 watts – runs during battery charge
 - Burns ~1 lb of propane per kWh: ~4 lbs/week for LRAUV
 - 5.1 kg (11.2lbs) plus fuel
 - 600 hours runtime
 - Exchange fuel tank every month
 - 22 lbs of propane in a 13.5 lb tank provides 5.5 kWh/week
 - Start up fuel cell (~15 min) for docking and charging
 - Solar panels support continuous load (~6W)
- LRAUV Battery pack

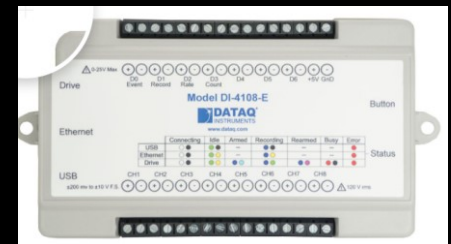


Buoy Electronics Overview

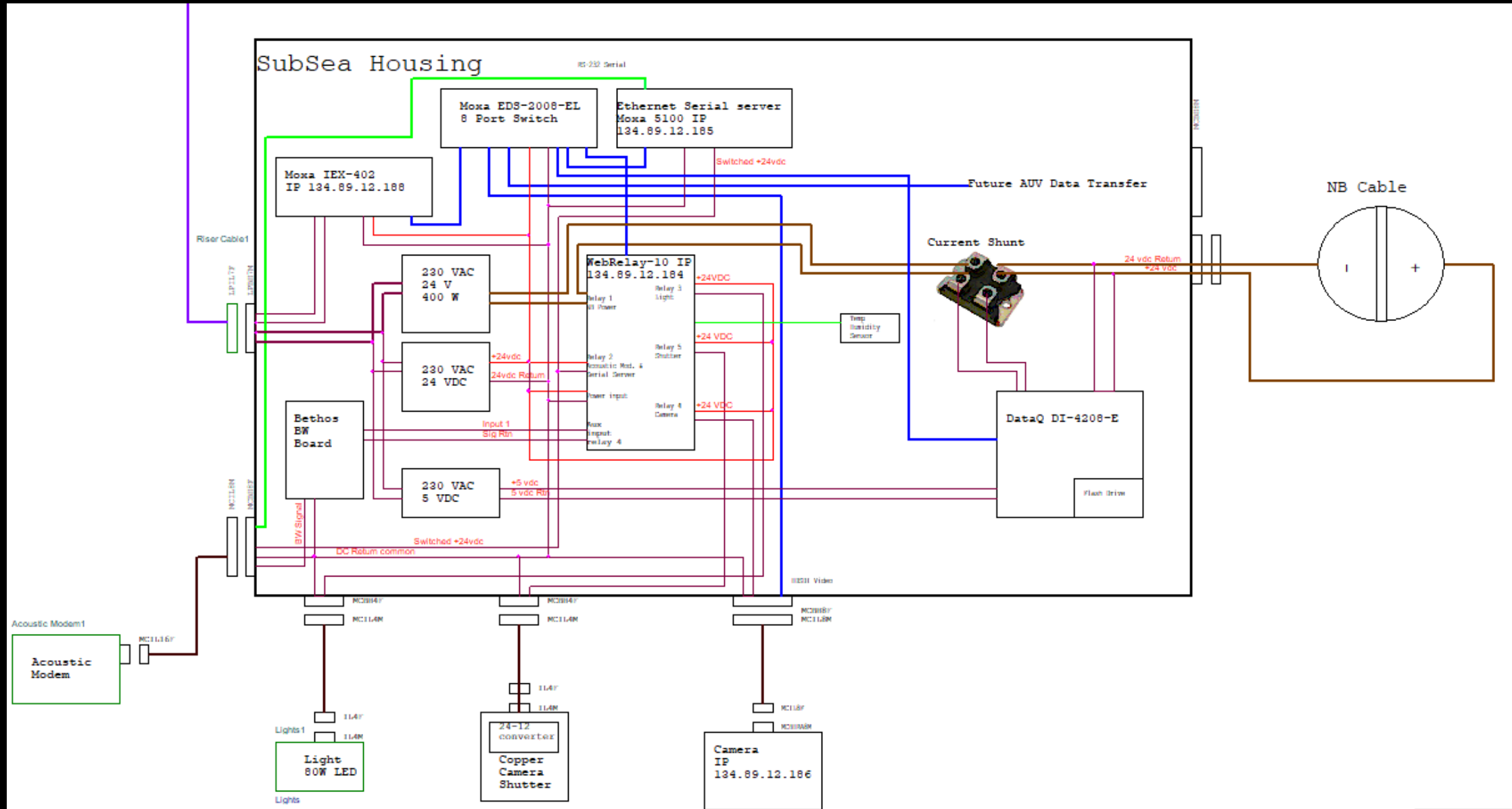


Subsurface Housing

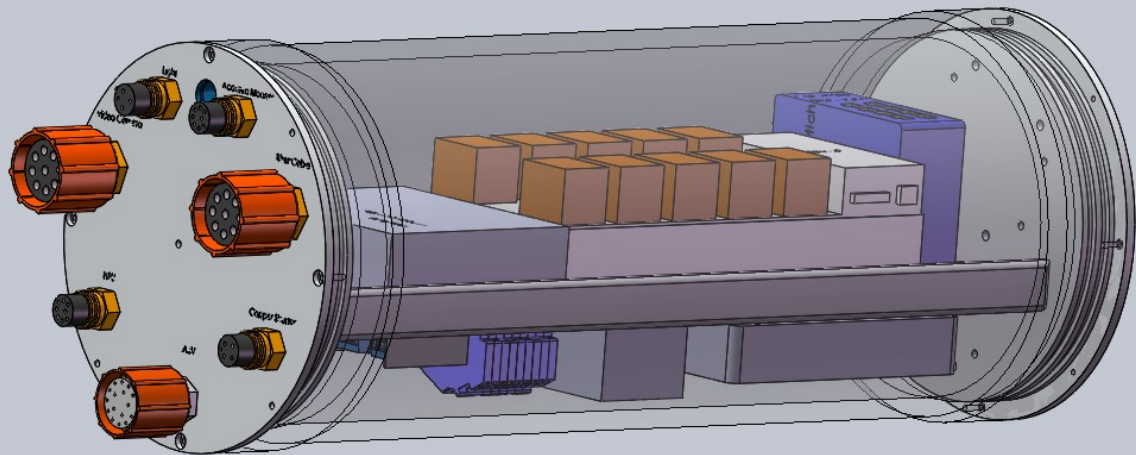
- Use existing Prevco Housing
- 230 VAC – 24 VDC with a 400W Vicor PFM+AIM
 - Initial power transfer tests will be to a resistive load dump on AUV
 - Change out to 48 VDC when updated LRAUV batteries are available
- WebRelay-10 for power control and temp/hum sensing
- DSL modem + 6 port Switch
- Benthos modem, Serial through Moxa terminal server
- IP camera with internal storage and network streaming with ~80W light
 - Copper shutter device to ensure a clean viewport for up to 6 month deployment
- DAQ, auto starts and logs charging voltage and current at 25 kHz to on-board memory that is accessible from shore.



Subsea Can Electronics Overview



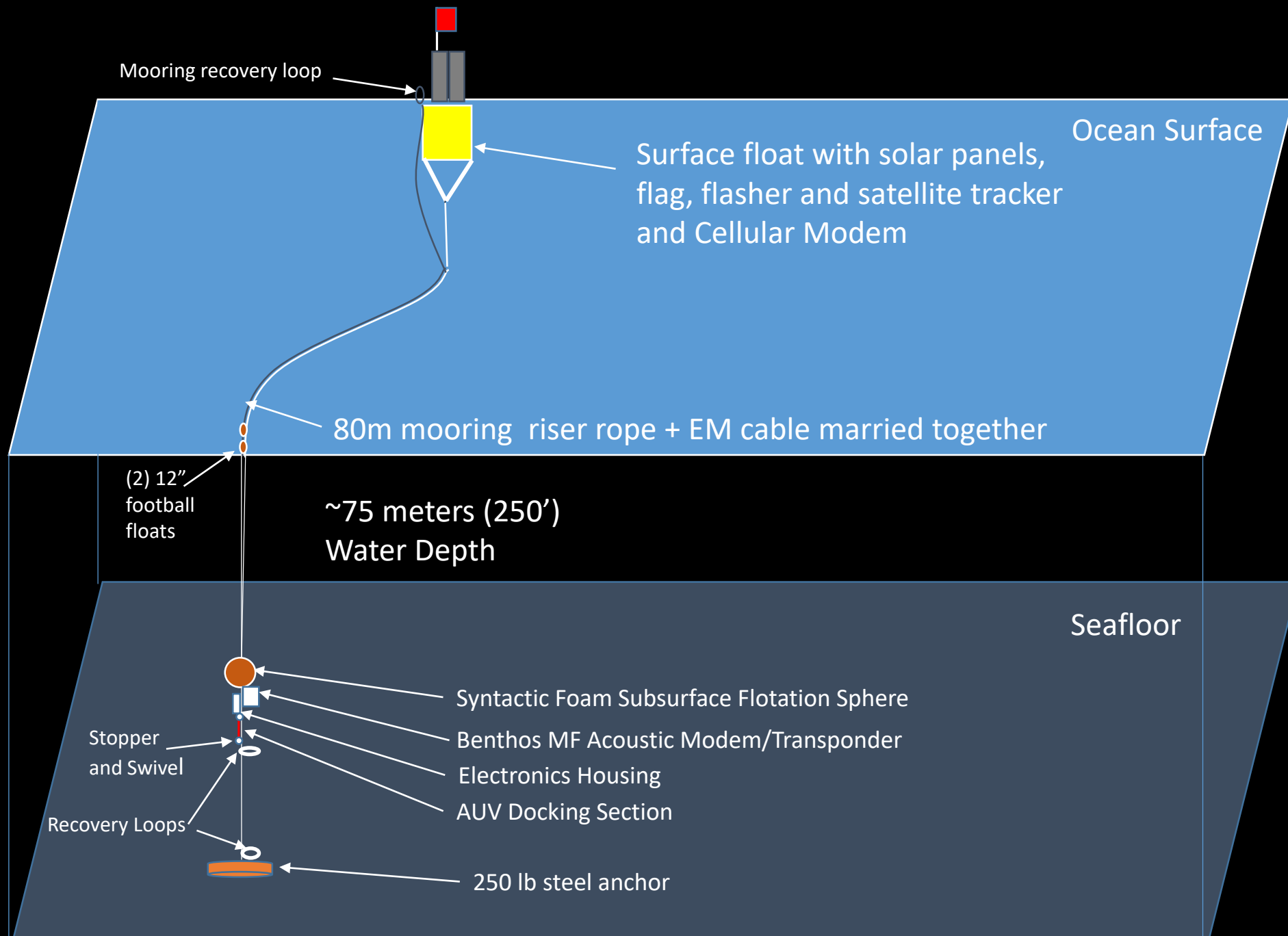
Sub-surface Housing



Components with power draw

Surface					Volts	current	Cont. power min	Cont. power max	Docking Power	Charging Power	cost
	Buoyancy	N/A	Synfoam	surplus buoy							
	Weather housing	N/A	Waterproof enclosure	Pelican 370			0		0		
	Energy storage	always on	battery pack	Yeti 6000x			0		0		
	Energy generation	always on	Solar panels, or generator	(4) 200W panels, compatible with mounting frame			0		0		2000
	Generate HV AC	always on	2kW sine inverter	Yeti 6000x			0		0		5000
	Safety interrupt	always on	120/230 AC GFI				0		0		35
	Cell modem and antenna	always on	ethernet link to shore and	Cradlepoint IBR600c	12	0.34	4.08	1.3872	4.08	4.08	550
	Webrelay	always on	Remote controlled relays, plus environment		12	0.086	1.032	0.088752	1.032	1.032	450
	DSL modem	switched power	Ethernet over TP to subse	Moxa IEX-402	12	0.388			4.656	4.656	700
	Ethernet switch	switched power		Moxa EDS-205A	12	0.18		2.16	2.16	2.16	100
	Buoy camera	Switched power	topside buoy camera, with	Arlo?	12	0.5		6	6		
	EM Mooring cable	N/A	7/20 cond.Cable, married	Rochester A276374			0		0	0	
	Strain Relief	N/A	PMI armored rods, or full BSR				0		0	0	
	U/W connetors	N/A	Riser cable (4 pin, 2 pin), Cell Antenna, Power in, Ground				0		0	0	
	Electric fence				12	0.1		1.2	1.2	1.2	
Subsurface							0		0	0	
	Pressure housing	N/A	Existing Prevco housing				0		0	0	
	DSL Modem + 6 port switch	switched power	(1) DSL modem in, (2) ter	Moxa IEX-402	24	0.196			4.704	4.704	700
	8 port switch			Moxa EDS-2008-EL	24	0.067			1.608	1.608	
	Payload AC/DC Power supply	switched power	400 watts/24 volt initially, I	Vicor PFM4414VB6M24D0CA0 plus	230	2				460	800
	Hotel AC/ 24 DC Power Supply	switched power							0	0	
	Hotel AC/ 12 DC Power Supply	switched power							0	0	
	Hotel AC/ 5 DC Power Supply	switched power							0	0	
	Webrelay	switched power	Webrelay 10 port SPST re	X-WR-10R12-IP	24	0.264			6.336	6.336	
	Ethernet/serial server	switched power	required to talk to the A-m	Moxa 5100	24	0.064			1.536	1.536	
	A-Modem	switched power	Benthos MF	Benthos M270-26	24	0.01			0.24	0.24	
	Camera	switched power	Bellamare IP Camera	Bellamare IP camera or WATEC 2400S	24	0.065			1.56	1.56	3500
	Light	switched power	80 W DSPL LED		24	3.5			84		
	Camera Shutter	switched power	MBARI copper sutter to minimize biofouling of camera port		12	0.1			1.2	1.2	
	Subsurface float	N/A	(2) FloTech 16" dia, 4km rated with aluminum skirt, 50 lbs buoyancy				0		0	0	
	U/W connectors	N/A					0		0		
	NB section with stoppers	N/A	2m long with swivel and lifting eye on the bottom, eye on top				0		0		
	Voltage/Current Sensing	switched power		DataQ DI-4108Q			0		0		
	Strain Relief										
Seafloor											
	Anchor	N/A	250 lb train wheel??								
	Strain relief	N/A	PMI armored rods, or full BSR								
	10m riser	N/A	Synthetic line								
							5.112	10.835952	120.312	490.312	\$13,835.00
							Cont. Power min	Cont. Power max	Docking Power	Charging Power	Cost

\\atlas\projectLibrary\707976_EPBuoyPrototypeAndTesting\Docking\Documents\Datasheets



Mooring Launch and Recovery

1. Launch:

1. Lift buoy into the water, stream riser, subsurface float, dock and lower riser out on the surface, then release anchor – stand back.

2. Recovery:

1. Grab recovery loop from top of buoy and begin lift with the capstan, separating the EM cable from line.
2. Remove football floats and stop at subsurface float.
3. With a boat hook, reach down below dock and attach davit lift to loop below AUV Dock and take up the strain.
4. Remove the rest of the mooring and tie in a new lift line back to the capstan and transfer the load.
5. Recover lower 7m riser until anchor is at the surface.
6. Recover anchor with davit

