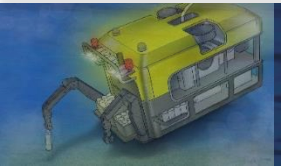
Greensea IQ
Intelligent Ocean Solutions

WOODS HOLE
OCEANOGRAPHIC
INSTITUTION

MROV
DeSSC Presentation

15-May-2025



mROV MEDIUM-CLASS DEEP SUBMERGENCE REMOTELY OPERATED VEHICLE

NSF NOAA

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Greensea IQ

Gateway to decades of scientific deep submergence service

A resource of existing proven and mature vehicles and subsystems

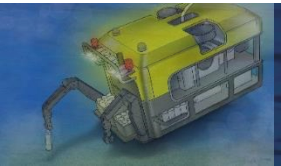
Insights into the operational needs

A deep reach into a multitude of scientific ROVs

Open architecture collaboration (OPENSEA software)

Requirements, standards, and documentation management for scaling and traceability.

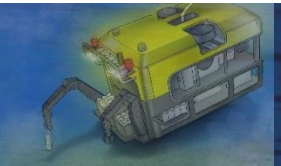
Systems Engineering expertise



What is MROV?

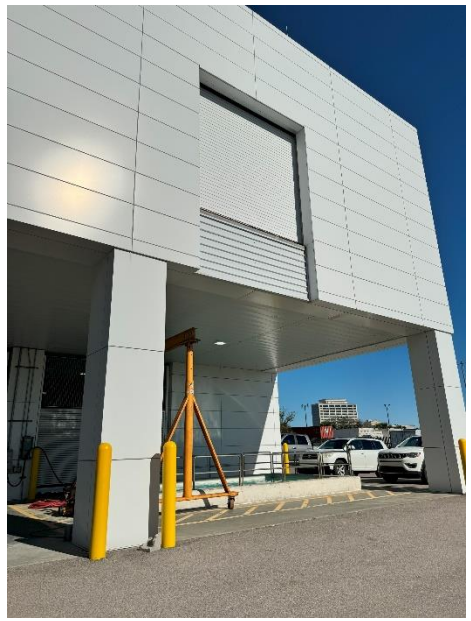
Goal: Expand access to the deep ocean for high impact science and research with the build of two medium-sized ROVs.

- Compatibility with NOAA vessels of opportunity, RCRVs and US ARF - Maximize use of shipboard equipment.
- Adaptable for current and future scientific equipment.
- Leverage proven designs: reusable and modular WHOI/GSIQ supplied components & off the shelf components
- Operational autonomy and scalability
- Standardization
- Component lifecycle management
- Democratizing deep sea research with an optimized system concept
  - Providing ~85% Jason capability in reduced footprint
  - Reducing operational costs
  - Remote operations
  - Reduced size and deck space
- Input from DSL, NDSF, mROV, Science Advisory Committee



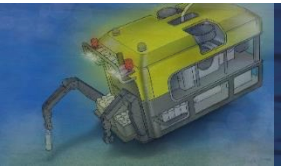
Current MROV Deliveries

- One vehicle will live at WHOI and be operated by the National Deep Submergence Facility (NDSF)
- One vehicle will live at University of Southern Mississippi (USM) and operated by a combination NOAA Ocean Exploration Cooperative Institute members

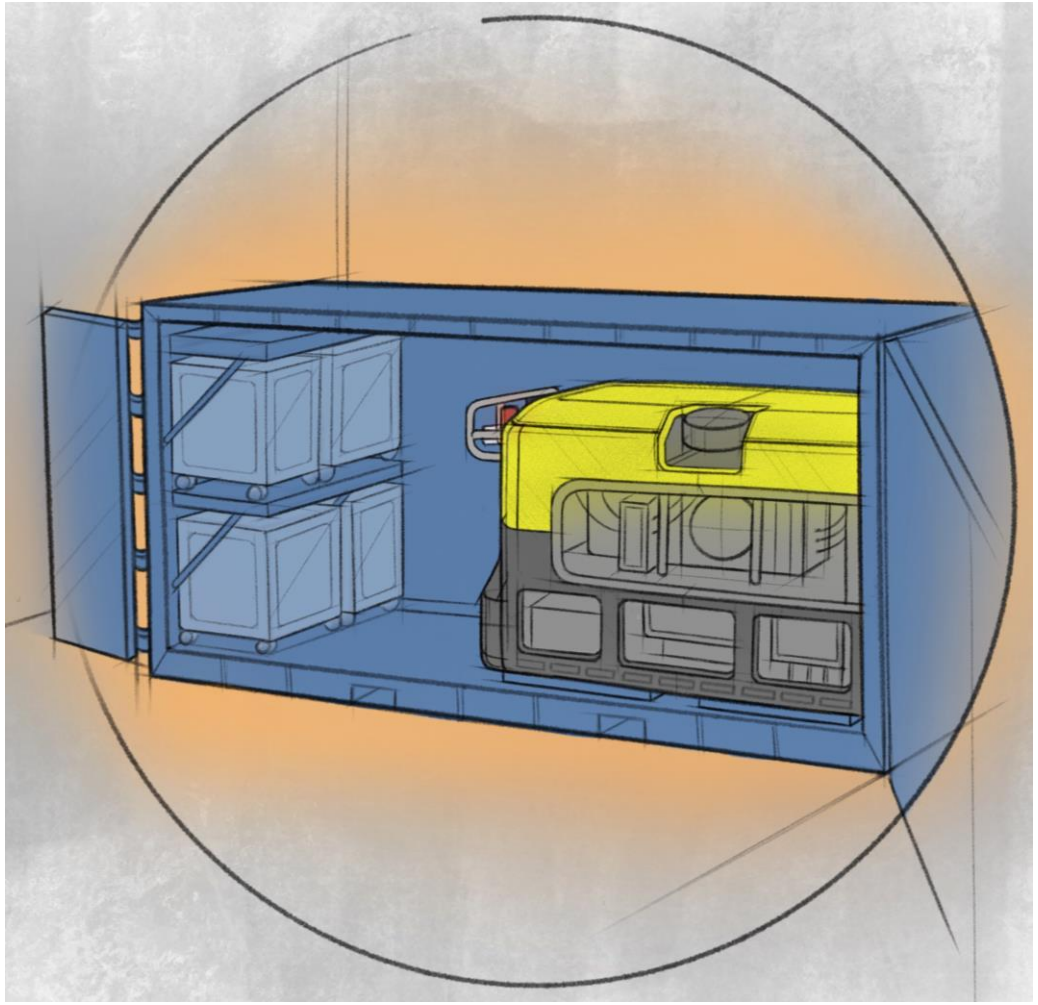


Operations Overview

Concept of Operations and LARS

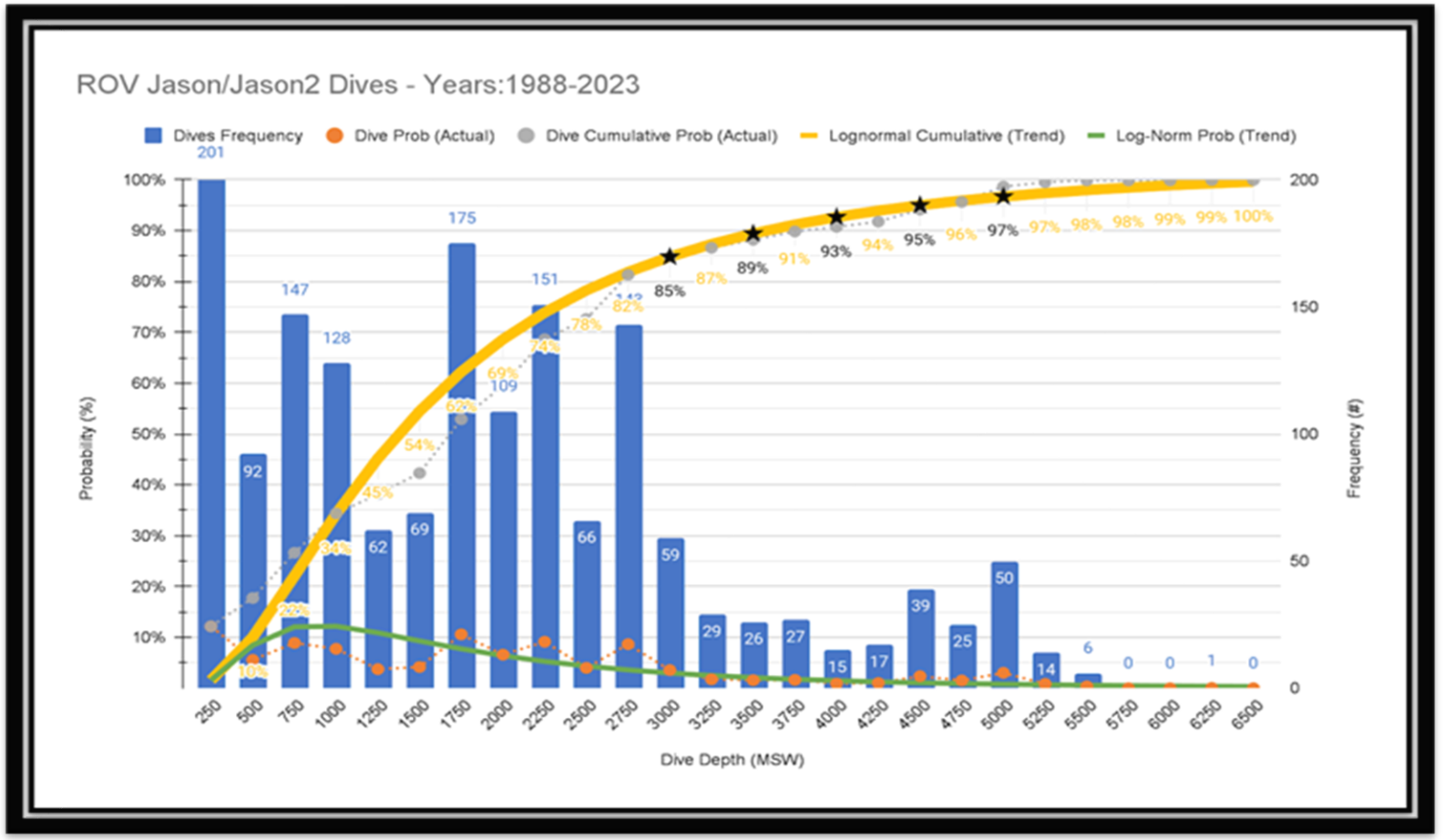


Operations Overview



- Mobilize in 2x20’ containers
  - Only (1) needs to be on board for ops (tool/power/server van)
  - Docking head will mobilize from containers
- Single body ops via .681 UNOLS standard OEM vessel provided cables and winches
- Designed to reduce overall system footprint.
- Designed for remote operations and monitoring
- Utilize ships labs for mobile pilot console, vehicle control system and A/V system.
- *Crawl/Walk/Run* approach to sustainable remote operations.

Dive Depth



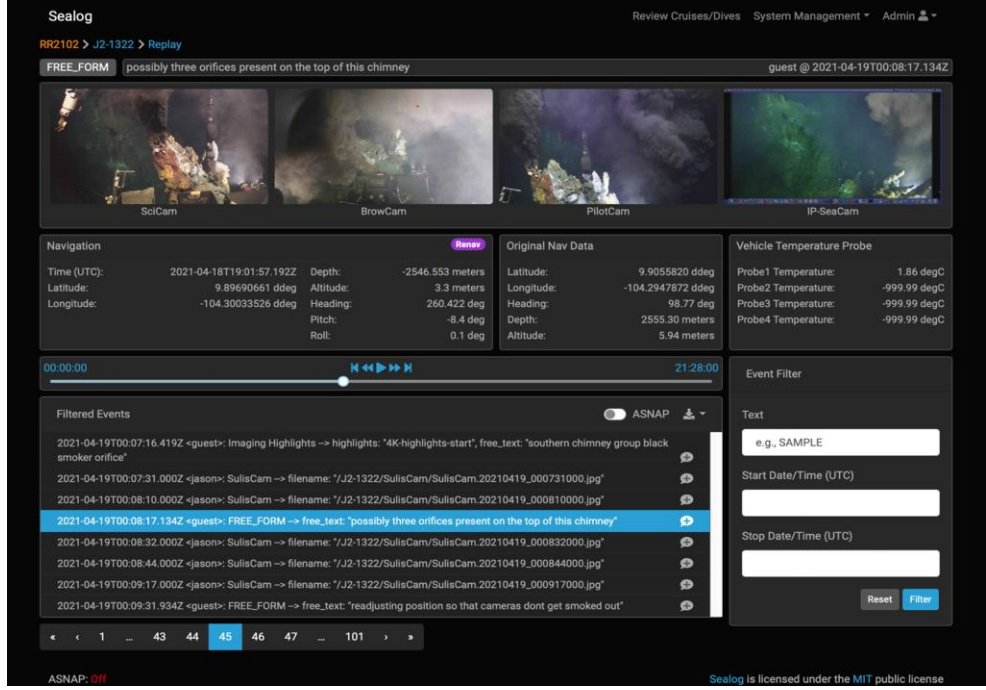
4000m depth rating can accomplish 93% of ROV Jason work depth.

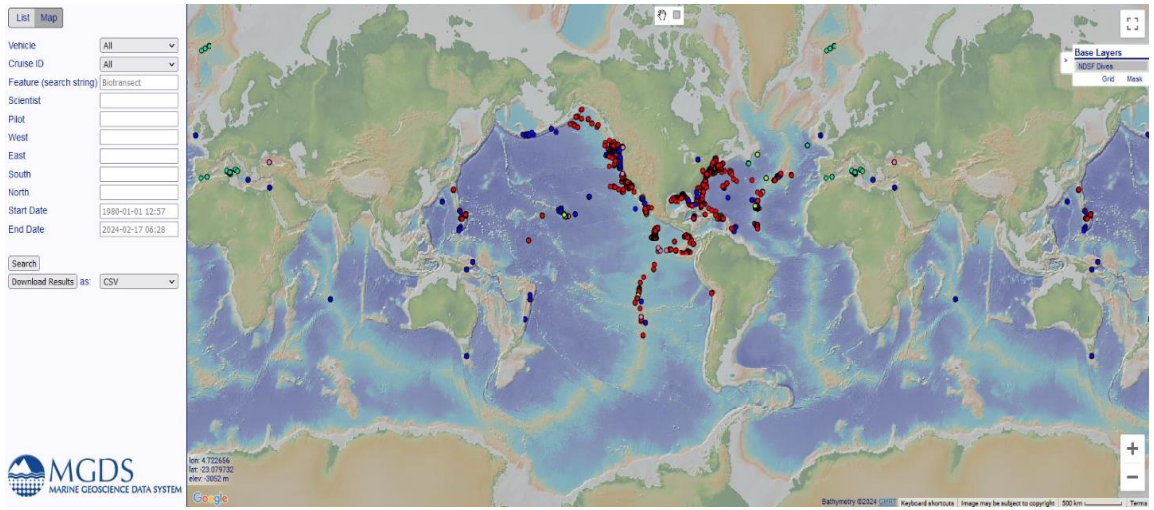
Software and Data Systems

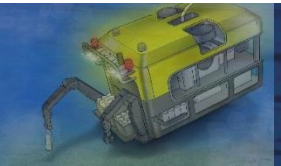
Data Systems Overview

The data package is a collection of real-time automated vehicle and navigation logs, raw data collections, user events, vehicle video, video stills, and post-processed products.

- The MROV data package will be built to NDSF data package standards.
- Focus on data access to the community
- Standardized content across vehicles
- Broadening access and improving discoverability
- Making data access faster/more robust







mROV MEDIUM-CLASS DEEP SUBMERGENCE REMOTELY OPERATED VEHICLE

Greensea IQ MROV Software Product

Goal: Allow users in any role to remotely and locally perform missions using MROV and its hardware suite by providing a robust vehicle control and navigation solution.

OPENSEA Library

- Provides mature and common software utilities
- Published API
- *libopensea* is the core of all software Greensea develops
- Access to OPENSEA networking

OPENSEA Applications

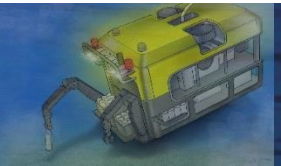
- Modular software applications
- Publish/subscribe network bus
- Published APIs/ICDs
- Extendable, flexible, severable

Collaborator Applications

- Collaborators develop and add their own applications
- Collaborators retain their own IP

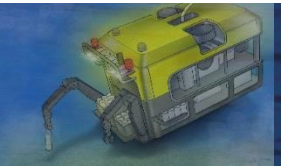
Cross Platform

- Edge processing
- Desktop applications

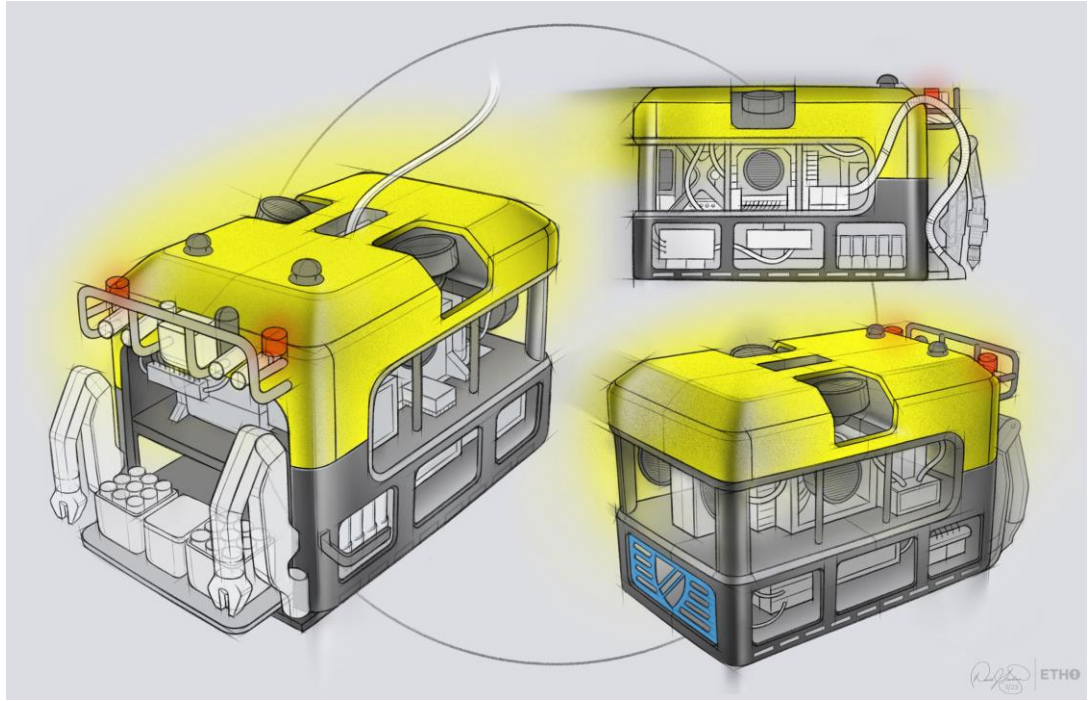


Vehicle Configuration

System design | Selected Sensors



Configuration Overview



MROV Concept Image 2024

- Cameras: Pilot, Brow & Science 4k cameras
- (2) 7-DOF manipulators (TBD - Kraft/Schilling)
- Removable tool sled (TBD - weight savings)
- ESS or Trelleborg foam
- Main junction boxes & science junction boxes with cutoff valves
- Hydraulic basket
- 6 bi-directional flow control valves
  - Adjustable pressure to 2500psi
- No swing arms

Core Component Selection

mROV

Greensea IQ Intelligent Ocean Solutions

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Payloads, Sensors, & Technical Details

*Preliminary design—pending finalization.

General Specifications

Depth	4000m
Size	Roughly 93"Lx62"Wx83"H
Weight*	7000lbs
Speed	.5m/s fore/aft, .2m/s lat, .5m/s vert

Sensors and Sampling Payload

CTD	Seabird SBE 49 FastCAT
Sound Velocity	Valeport miniSVS
Oxygen Sensor	Aanderaa Optode
Temp Probe	WHOI-NDSF Design
Magnetometer	APS 22-bit 3-Axis Fluxgate
Additional Payload Cap.	300lbs wet weight

- Dual 7 function manipulator arms
- Extendable basket and aft payload bay
- Multi-chamber suction sampler
- Bio-boxes & push-cores
- Power, communication, and hydraulic ports for auxiliary sensor and sampling integration

Navigation

Hardware INS	IxBlue Rovins Nano
DVL	Nortek 500
Heading Reference	Fiberpro FG150
Backup AHRS	Sparton M2
USBL Transponder	Sonardyne WMT6
Depth Sensor	Paroscientific
Altimeter	Kongsberg 1107
Surface Recovery	Xeos Nemo-X

Lighting and Imaging

Imaging Sonar	Blueprint Oculus MD750d
4k Camera	Insite Pacific Mini Zeus 4k
HD/SD Cameras	DSPL Multi Seacam
Pan & Tilts	ROS Accu-Positioner
Scaling Lasers	SubC Imagining Mantaray
Lights	DSPL SLS-7200

Propulsion

Mission specific thruster configuration
Sub-Atlantic (FET) Brushless 5kW thrusters (qty7-9)

Software

Greensea IQ (GSIQ) OPENSEA® Software Platform

- OPENSEA Library.
- OPENSEA Applications
- Collaborator Applications
- Cross platform compatible

Data

National Deep Submergence Facility Standard Data Package
Utilizing relational databases to generate data package.
Communications managed using abstracted Publish/Subscribe protocol using LCM. Can accommodate ROS/DDS bridge.

Remote Operations

GSIQ long range Standoff Command & Control (SAFE C2) technology.
Remote performance monitoring and control experience.
Remote video, audio, and pilot control.

Shipping

The entire system will ship in (2) 20' shipping containers.

Over boarding

The system will utilize shipboard equipment whenever possible such as the winch, cable, and A-frame.

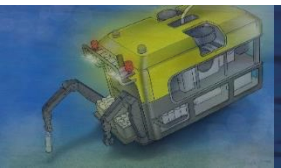
- Deploys on .681" UNOLS EOM cable (up to 10km)
- Custom docking head to increase safety and reduce deck personnel during L&R.

Electrical/Telemetry

16.5kW total vehicle power budget
Moog Focal 914 multiplexer system
Science ports: 24Vdc, serial, Ethernet

Hydraulics

2500 PSI @ 2.5 GPM
1500 PSI @ 4.25 GPM
QTY: 5; Bi-Directional Flow Control Valves with Adjustable Pressure to 2500 PSI



mROV MEDIUM-CLASS DEEP SUBMERGENCE REMOTELY OPERATED VEHICLE

NSF NOAA

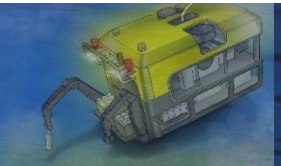
Over-the-Horizon (OTH) Operations

OTH/RO

Goal: equipping MROV with a robust and reliable method for long range remote operations that meets cybersecurity requirements.

- Bringing Greensea IQ's long range Standoff Command and Control (SAFE C2) technology for Remote Systems to the scientific community after years of deployment and use by the defense community.
- Provide a remote user UI management and control experience that mirrors as closely as possible the local ship operator experience, for all phases of the mROV mission
- Provides effective and accurate remote control by:
  - Utilizing bandwidth management and compression
  - Deploying configurable data prioritization schemes
  - Not protocol specific

Design Considerations Review



High Level Design Decision

Electrical

- 60 hz (vs 400hz) decision
- Electric propulsion: Forum (Sub-Atlantic) SPE-250 electric thrusters

Mechanical

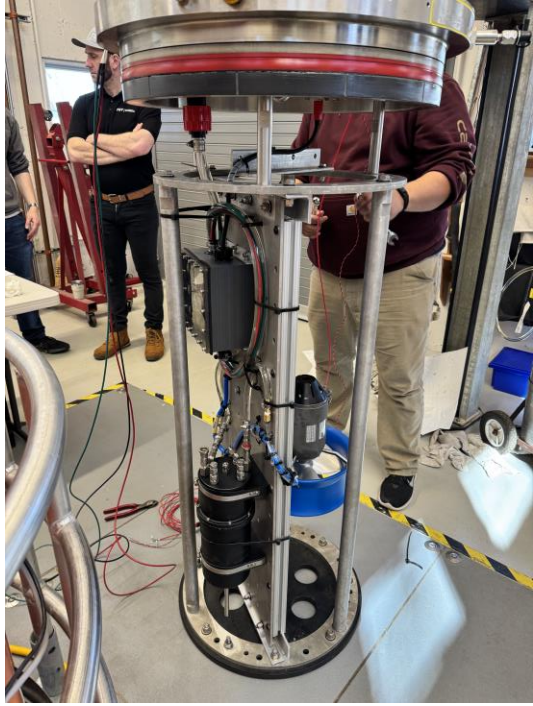
- 7900lb max air weight
- HPU - Forum SPE-250 brushless dc motor

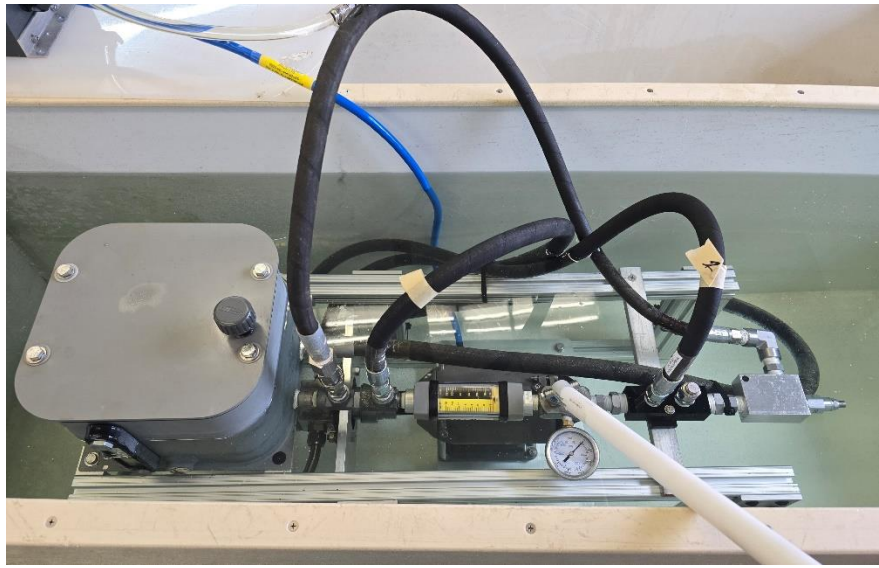
Software/Data

- Utilizing PostGres and SQL databases to pass system data from the GSIQ control software and data package systems.
- Communications managed using abstracted Publish/Subscribe protocol: will be using LCM but can accommodate ROS/DDS bridge as well.

Vehicle Design and Development Underway

- Completed internal design review
- Electrical architecture complete and draft electrical design underway
- Propulsion - functional and pressure testing complete
  - Integrating control through GSIQ software
- Telemetry architecture underway (Focal 914)
- Component selection underway
- Topside user interface operational
- Functional OTH/RO test setup between Armstrong/GSIQ
- Started frame, chassis, and buoyancy designs
- Docking head out for bid soon



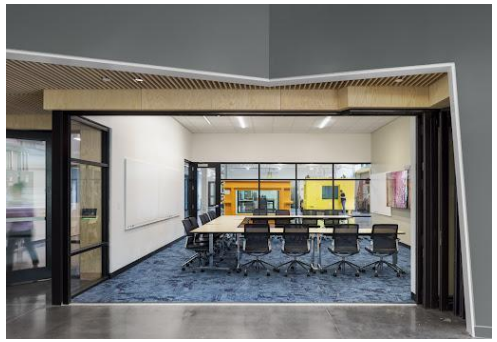


Built & Tested at WHOI

- Build - David Center for Ocean Innovation
  - High-profile research facilities
  - On-site machine shop
  - High bay workspace
  - Touchdown work areas and conference rooms
- Testing - Test Tanks and Waterfront
  - Deepwater dock access
  - Overhead lift test well
  - Pressure test facilities
  - Salt and freshwater test tanks

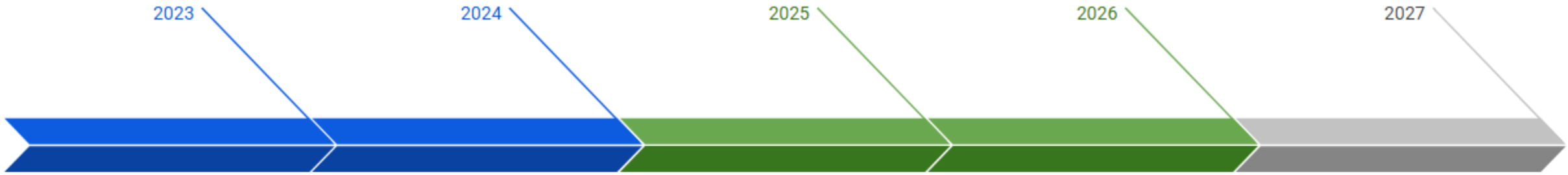




Path Forward

Timeline



Ideation

GSIQ/WHOI MROV White Paper Published.

Proposals

MROV proposals are submitted to the NSF and NOAA.

Proposals are awarded and funding authorized.

Project formally kicks off (requirements, systems eng)

Construction

Complete system design - design review complete

Build and integrate

Test early and often

Delivery

Complete tank and pierside testing.

NSF and NOAA Sea trials and Science Verification Cruises

Operation

RCRVs start operating

Ready for standard operations

Questions?!

Thank you!

Molly Curran – mcurran@whoi.edu
Andy Bowen – abowen@whoi.edu
Anna Michel – amichel@whoi.edu

And huge thanks to all the engineers on the mROV team, GSIQ team, engineers at DSL, ROV Jason team, PMs, admins, communications teams, mROV Science Advisory Committee, WHOI Project Management Advisory Committee, NSF, NOAA, MDBC, USM, URI, OECI… and many more.