



**ARCTIC DOMAIN
AWARENESS CENTER**
A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE



Advancing Arctic Domain Awareness via ...Using Unmanned Underwater Vehicles to Map Coastal Regions

A presentation by

Arctic Domain Awareness Center
University of Alaska Executive Director

In partnership with:



ADAC: Research for the Arctic Operator... For Today and For the Future

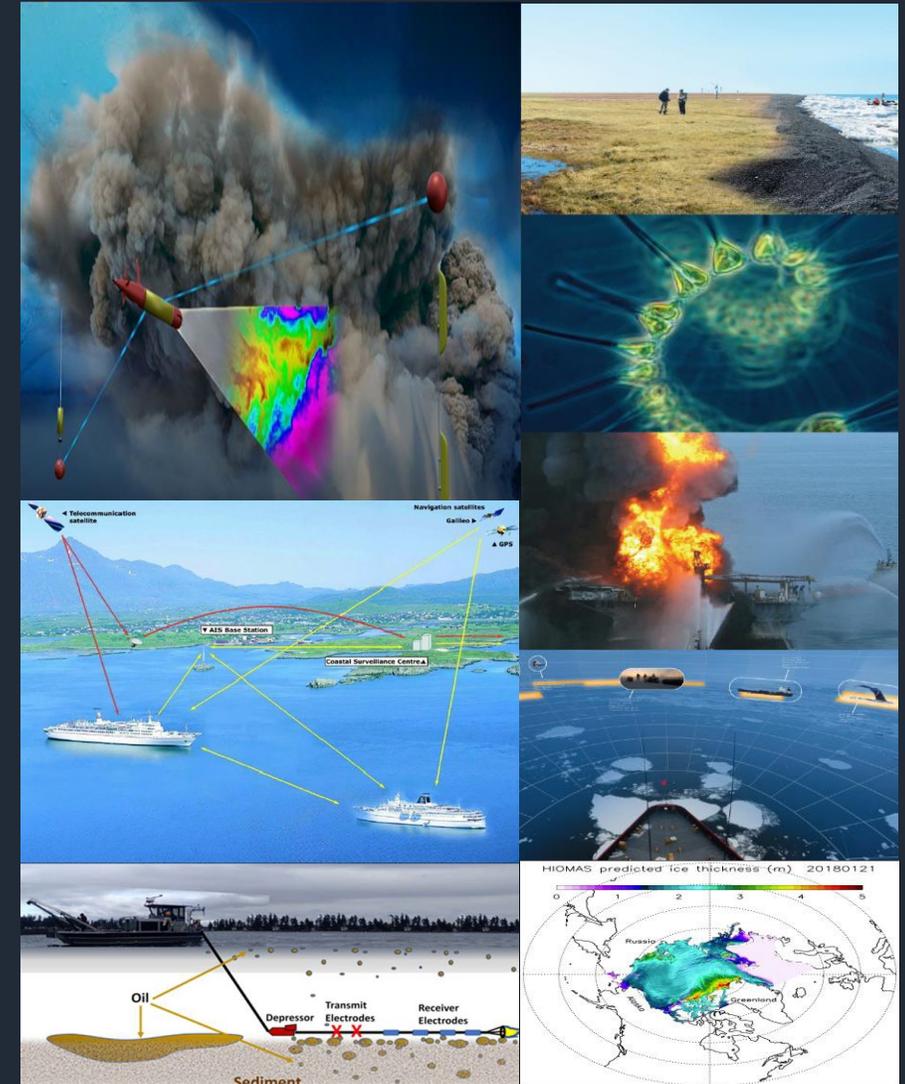


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A DHS Ctr of Excellence in Maritime Research at Univ of Alaska

ADAC advances Arctic Science in the following categories of research:

- Geophysical environmental modeling;
- Marine robotics;
- Decision support science;
- Biological & marine environmental science;
- Satellite support;
- Civil engineering;
- Big data analytics;
- Social science...to include gaining insights from rural Alaska and Arctic communities.



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University of Alaska's Arctic Domain Awareness Center...

- “Operator driven research” to support Arctic mission of the U.S. Coast Guard...
- ...and other U.S. federal maritime security and safety activities
- ...and to support the public good.

Meet our customers



Courtesy NASA.gov



Courtesy The Arctic Institute



Courtesy Defense news.com



Courtesy The Alaska Eskimo Whaling Commission

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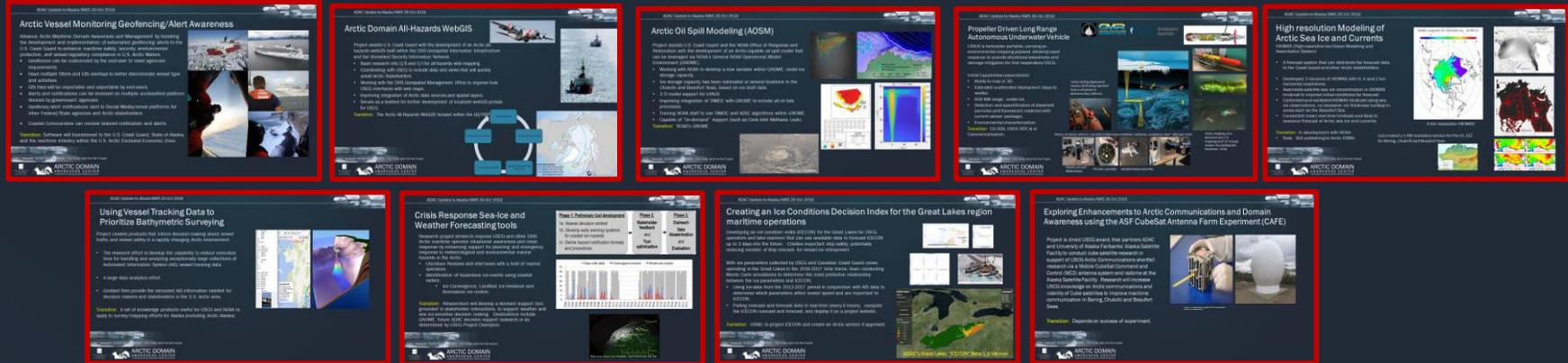
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ADAC's strategic approach Advance S&T, Convene and Educate

1. Lead Arctic focused Science and technology research



2. Convening experts via Arctic focused workshops to create new understandings and solve problems



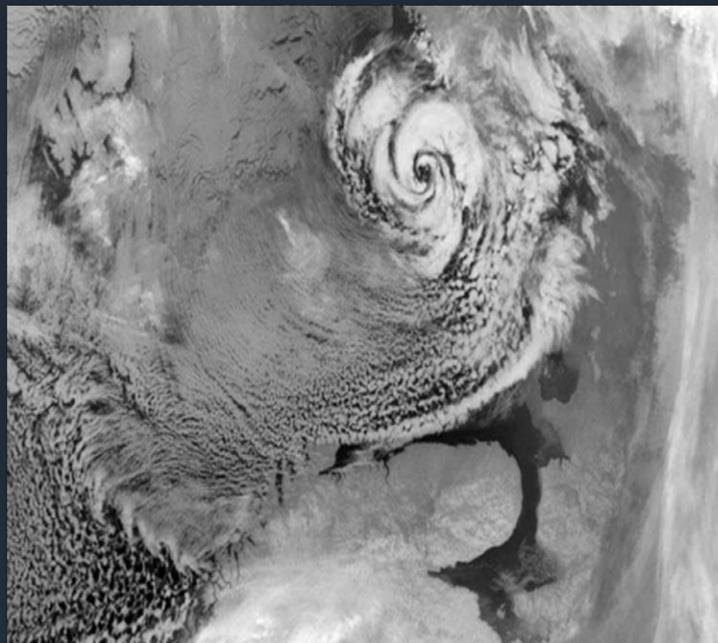
3. Conduct educational Programs



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(Some) of the Challenges faced by the maritime operator

- Weather
- Illumination
- Distances
- Sea ice (its more complicated than one may think)
- Logistics
- Infrastructure
- Communications
- Bathymetry (what's below the waves?)



A polar low northeast of Scandinavia in the Barents Sea.
Credit: Erik Kolstad/Ticker

Helping the operator...means improving the...

- Ability to locate people who need help
- Ability to locating people who are doing illegal activities
- Ability to suitably respond to disasters
- Ability to identify threats and risks to our interests

Accordingly...ADAC's

- S&T Solutions
- Knowledge Products
- Convening experts
- Educate

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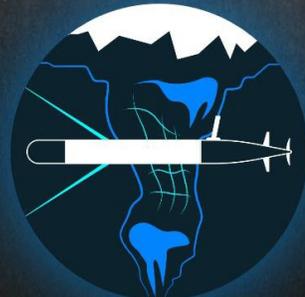


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ADAC's Current S&T Research Projects



ICECON



LRAUV



ASIP



Arctic GIS



Geofencing



Arctic Copepods



Arctic Mussels



AMSM



MIPM



ARCTICE

Note: In final stages for 2 new projects:

1. UAS for remote monitoring
2. Polar Communications and connectivity Assessment



ADAC's Recently Completed S&T

HIOMAS SIWF AOSM AIS-PAC

ADAC's Prior Completed or Concluded S&T

CBONS AIFC Arctic Sensors IHIF MMA
(page coming soon) *(page coming soon)* *(page coming soon)* *(page coming soon)* *(page coming soon)*

CubeSat Arctic Storm Surge Chemical Isotope Analysis Smart-Cam
(page coming soon) *(page coming soon)* *(page coming soon)*



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Propeller Driven Long Range Autonomous Underwater Vehicle

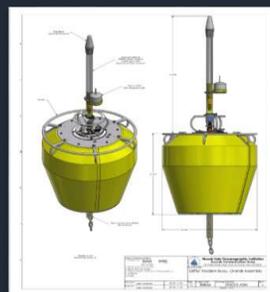


Project Description:

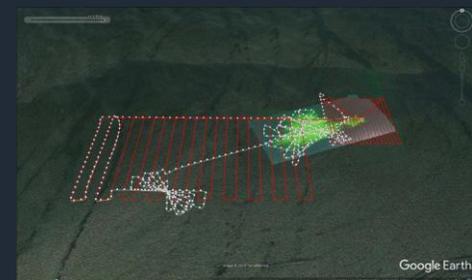
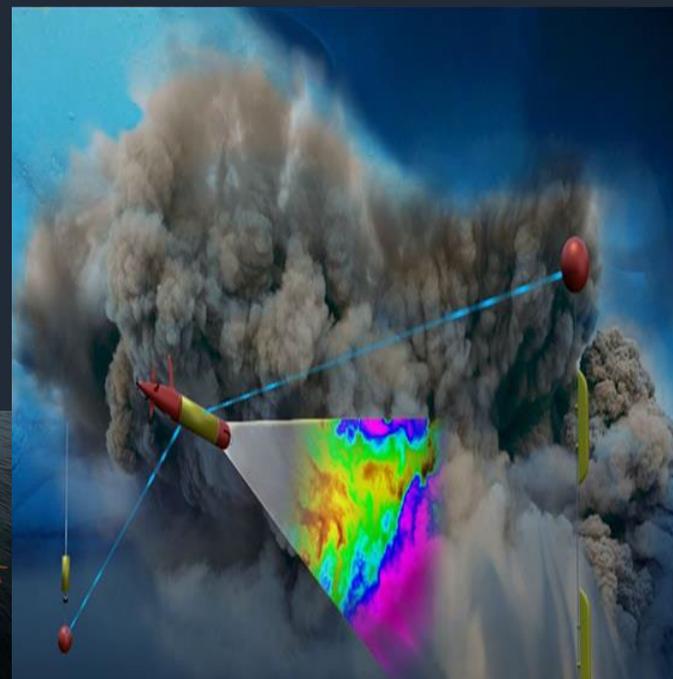
LRAUV is helicopter portable, carrying an environmental mapping payload which allows rapid response to provide situational awareness and damage mitigation for first responders/USCG.

Initial Capabilities (expandable):

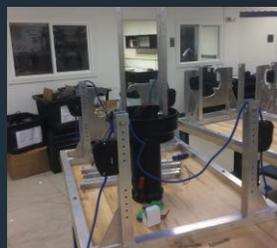
- Ability to map in 3D.
- Extended unattended deployment (days to weeks).
- 600 KM range...under ice.
- Detection and quantification of dissolved particles and fluorescent material (with current sensor package).
- Environmental characterization.



Tethys testing deployment January 2018 being operated from a cell phone in Monterey Bay California



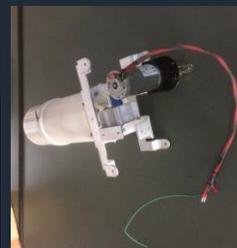
Photos of LRAUV, fabrication at MBARI



Vehicle cart and Nbell/chassis



Thruster assembly Variable Ballast Assembly



Plume mapping auto detection and mapping Buzzard Bay MA, (Prototype) November 2016 and Actual vehicle, Monterey Bay 2018



Addressing a Challenge: Mapping Coastal Arctic Regions

- **Well known...**Arctic is Poorly charted (roughly 10-12% to modern standards).
 - **Current charting methods provide superb accuracy.**
 - **However,** Large scale charting of the Arctic remains a challenge:
 - Limits of current surface methods due to short season, rough weather
 - Costs are a significant factor
 - COVID's impact to 2020
 - **USVs, are potentially useful...**but impacted by ice and rough weather
- **LRAUV: A potential solution?**
 - **Counters** Rough Weather & Ice cover.
 - **Long Duration**
 - **Communicate** with command and control via ice buoys
 - **New Mapping Sonar and INS upgrades** provide opportunity
 - **Is it precise enough?**
 - How precise does it need to be?
 - Interim practical vs Survey of record?

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ADAC Project LRAUV: Primary mission: Under-Ice Mapping of Oil Spills and Environmental Hazards

- **Project Principal Investigator(s):** PI Dr. Jim Bellingham (WHOI), PI/PM Amy Kukulya (WHOI), Co-PI Brett Hobson (MBARI)
- **Project Organizations:** Woods Hole Oceanographic Institution, Monterey Bay Aquarium Research Institute
- **Supporting Team:** Daniel Gomez-Ibanez, Sean Whelan, Noa Yoder, Amanda Besaw, Brian Kieft, Ben Raanan, Ryan Govostes
- **USCG Project Champion:** CAPT Kirsten Trego, HQ USCG MER
- **Project Advocates:** Dr. Robyn Conmy, EPA USEPA/NRMRL/RTEB, USCG Research and Development Center, Dr. Jay Choy BSEE/Oil Spill Preparedness Division, Dr. Lisa Dipinto, NOAA, Office of Restoration and Response.



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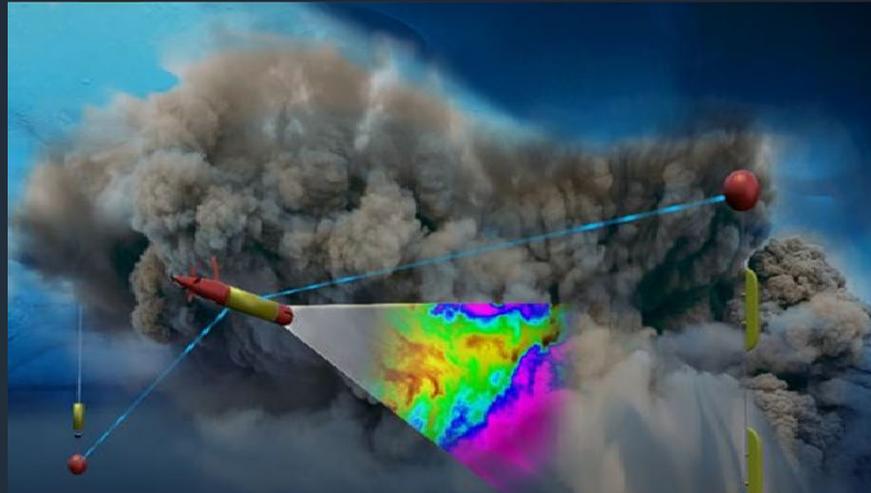
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 **MBARI**
Monterey Bay Aquarium
Research Institute

Woods Hole
Oceanographic
INSTITUTION

ADAC, WHOI & MBARI LRAUV: Description and Baseline

- **Baseline:** Currently, there is no USCG baseline for an AUV to meet the unique demands of Arctic operations that requires a minimal logistical footprint, a small operational team and oil detection and mapping capability.
- **Project Description:** Develop an Arctic-capable **long-range Autonomous Underwater Vehicle (AUV)** that is helicopter portable, carries an environmental **mapping** payload, allowing **rapid** response while providing situational **awareness** and damage **mitigation** for first responders/USCG.



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Project LRAUV: Relevance and Method

- **Relevance to DHS and USCG:** Project team characterizes the challenge as the 'last seat in the helicopter' problem:
 - If first responders are operating at the far end of their logistical support capability, the system must be able to fill that void.
- **Research Method:** Approach is to leverage an existing Long-Range AUV developed at MBARI (known as *Tethys*)...
 - Enhance the system to detect oil and operate under ice.
 - LRAUV offers extended ranges (one to three weeks) and can be operated by a team remotely and monitored by anyone, anywhere.



Long range autonomous capability: *Tethys* LRAUV

- Specs: 300-meter rated, 2.7 m long, 0.3 m (12") diameter, 110 kg dry weight.
- Propeller-driven: 0.5~1.2 m/s speed. Buoyancy engine enables neutral buoyancy and drift mode.
- Low-drag and low-power design: 15-day duration with 6 kWh rechargeable batteries, more than twice that with expendables.
- **Current Sensors:**
 - CTD, DO₂, **SeaOWL** fluorescence/backscatter and hydrocarbon detection, **Up/Down ADCP**, **Umodem**, **USBL array**, **Docking nose**, PAR
- **Now:**
 - **Multi-mission capability, mapping & inertial navigation payload**



CTD= Conductivity Temperature and Depth

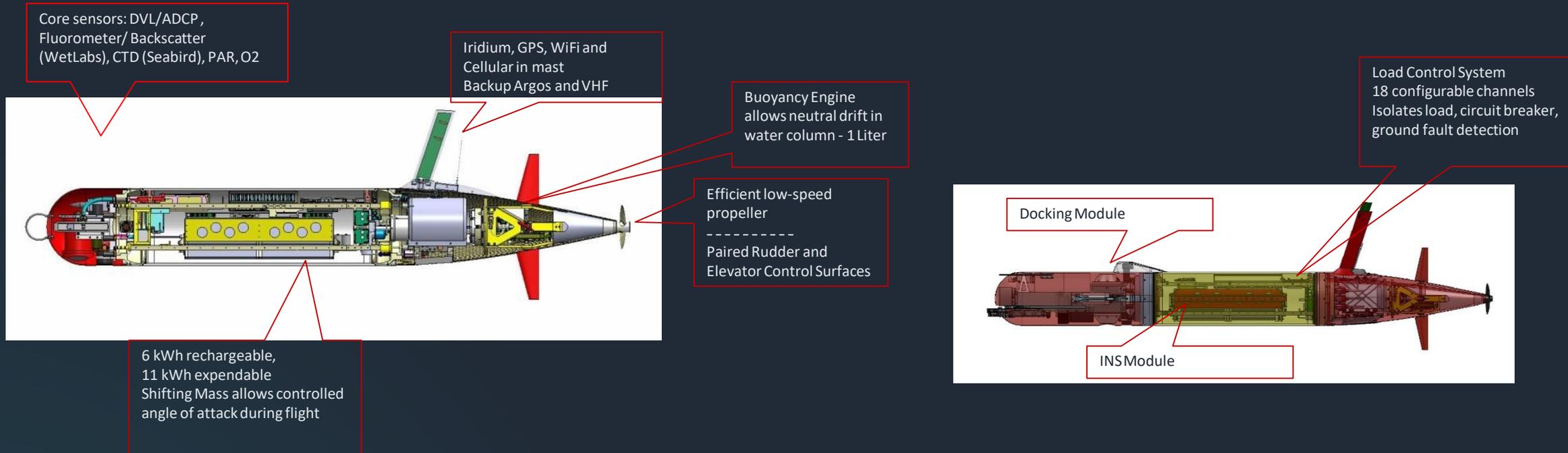
USBL=Ultra-short baseline acoustic positioning system

DO₂=Dissolved Oxygen Sensor

ADCP=Acoustic Doppler Current Profiler: Measure water speed in overall column

PAR=Photosynthetically Active Radiation

Tethys LRAUV Overall Specifications



	Short Nose	With Mapping Module
Mass:	110 kg (240lb) dry weight	118 kg (260 lbs)
Size:	0.3m (12") diameter, 2.47m long	2.75 m long
Speed:	0.5 – 1.2 m/s plus hover	0.5 – 1.0 m/s plus hover
Energy/Endurance:	400 Ah energy, ~1.1 Ah/hr, ~3 km/hr .83 m/sec ~15 days, 1000 km	400 Ah energy, ~1.5 Ah/h See different modes below

Mode: 5-day RT transit out 120 km = 1800 W-hrs; 28 hours of survey= 2800 W-hrs;
13.5 days of slow science = 4600 W-hrs

300 A-hr useable at 15.3v=4600 W-hrs

LRAUV Current Sensors...a bit more detail

- Up/down 600 kHz ADCP (RDI Pathfinders)- water velocities, relative terrain navigation
- Licor Par for measuring photosynthetic artificial radiation
- SeaOwl Ecopuck-provides dissolved and droplet signals
- Seabird CTD with a dissolved oxygen probe
- WHOI Whisker Box for line capture docking
- WHOI DUSBL for homing/docking
- WHOI u modem for subsurface communication replaces need for LRAUV to surface to send data back to command control



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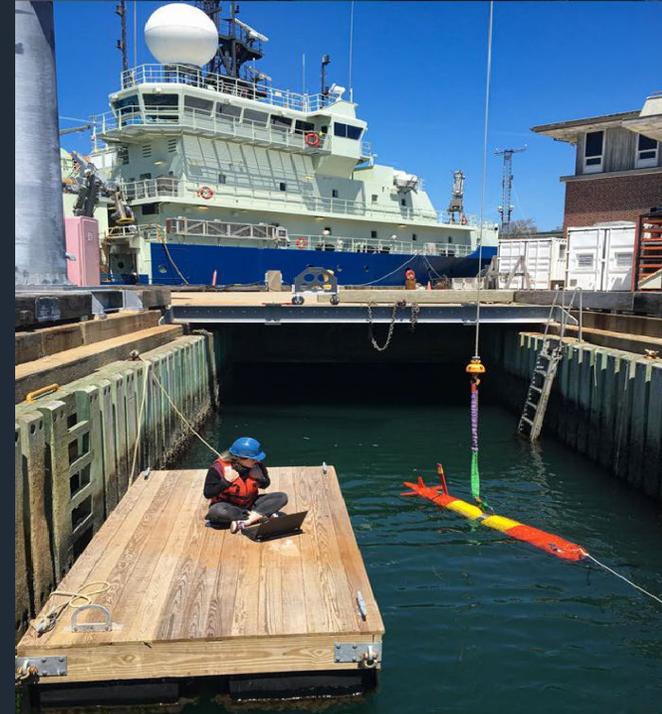
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ADAC WHOI and MBARI New LRAUV Kit For Program YR7

- Soundtrap self-contained soundscape sensor (can be strapped in nose)
- Inertial navigation (integration inside housing)
- Multibeam for mapping
- Multi-channel low frequency diversity array (have hardware, for 400 km range receive only navigation pings, works with **receiver**)
- Low-frequency **receiver** for long distance navigation (hundreds of kilometers)
- Chelsea UviLux- has a lower excitation (SeaOWL) wavelength, it gives you a clearer dissolved oil signal that can be discerned from natural humic DOM. (have sensor, integration lower priority, but compliments SeaOWL)
- Upgrade to CTD/DO: integrated system
- Backseat computer for more versatile control of sensor integration/new behaviors.



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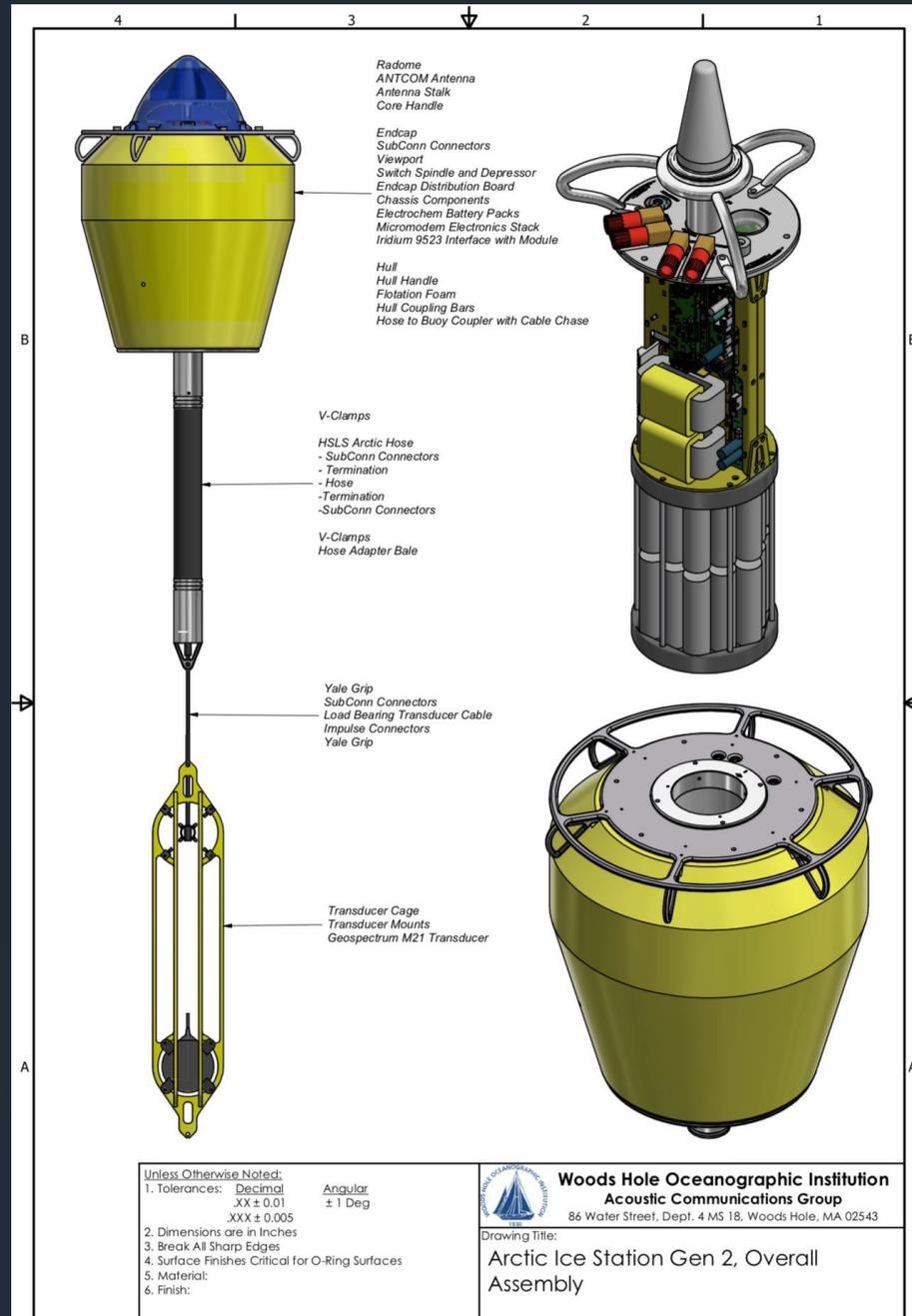
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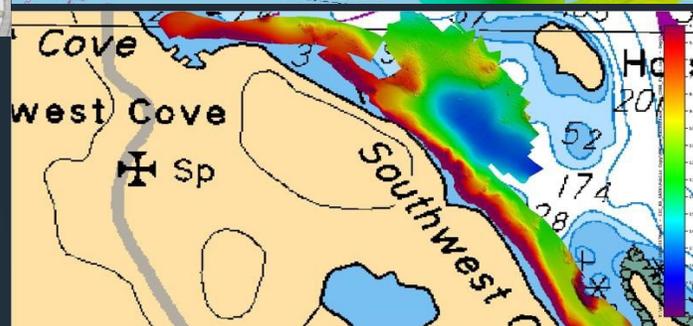
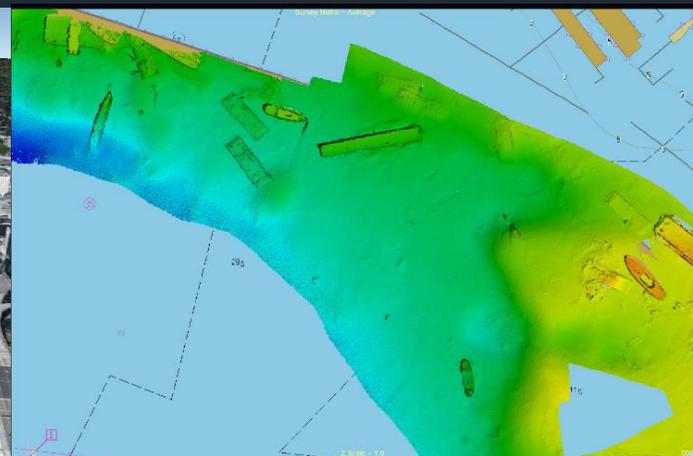
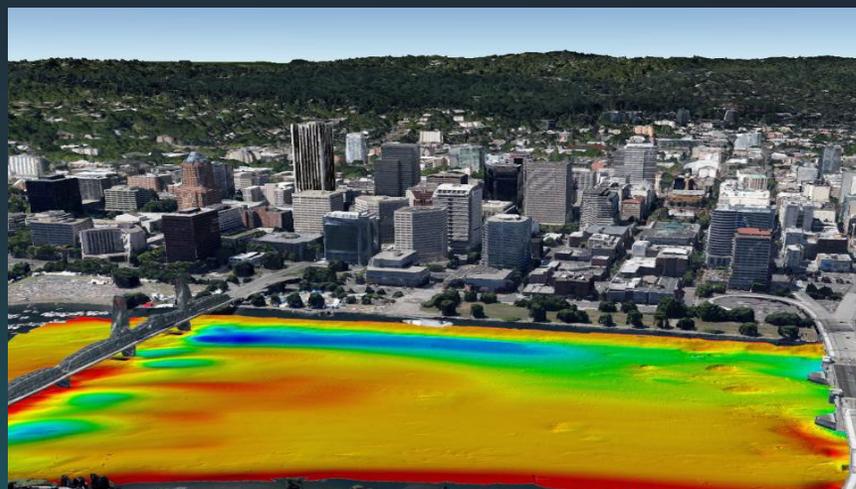
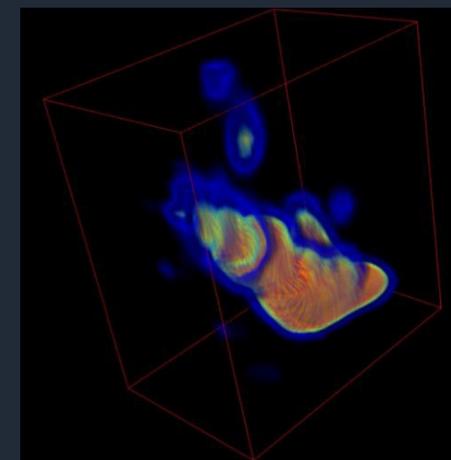
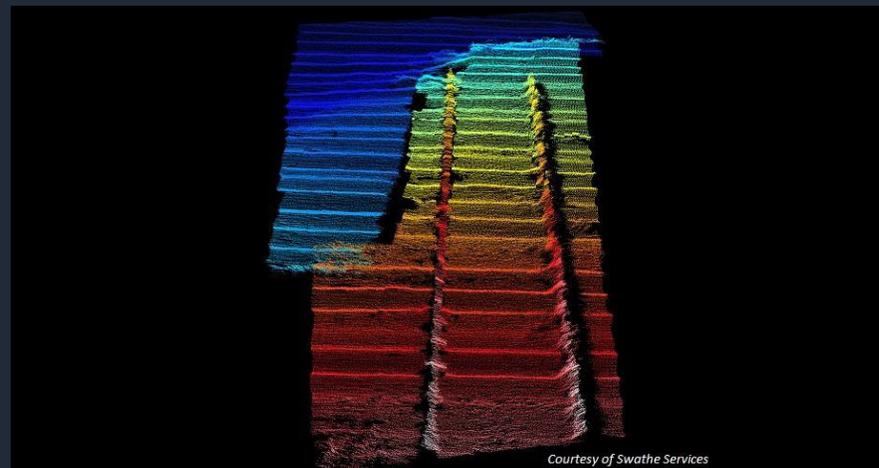
LRAUV's Arctic Buoys...

- Can be configured to be HF or LF
- Have disposable primary battery packs for 12-14 day duration.
- Enable Under ice/broken ice communication from the below water column to shoreside command and control
- LRAUV can tether on attached cable extending through the ice



LRAUV's new Multibeam Sonar & Inertial Nav System

1. Sonar: Norbit WBMS (60W 10-28VDC, 110-240VAC)
2. Inertial Nav: Ixblue Phins C3 INS



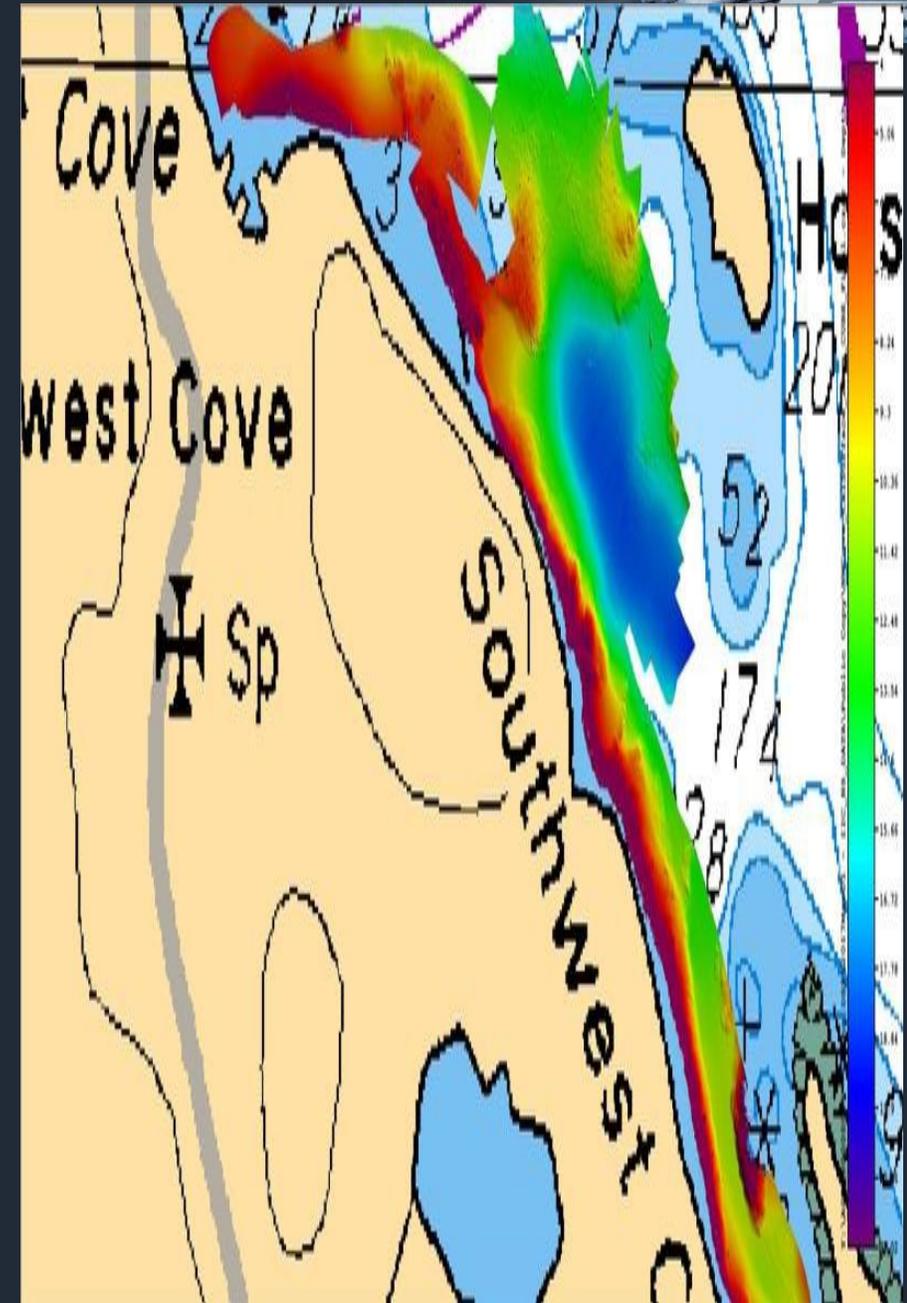
ADAC and Project Team working to achieve LRAUV sonar to be:

- Low power
- Easy to digest data and evaluate
- Compact
- Low cost
- Able (and easy) to flip up or down for bottom mapping or ice keel mapping

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LRAUV...may prove a useful option for remote location mapping, particularly ice-covered regions

- As a supplement to its core mission of oil spill detection
- Is potentially suitable to conduct surveys of poorly charted regions
- LRAUV is anticipated to be capable for “practical standards” of mapping with Norbit MBS and INS system by end of Program Year 8
 - What tests/evaluations are needed to investigate this potential?
 - Would the mapping community be willing to consider and potentially invest (or at least advocate) for this construct?



ADAC...steadily advancing to provide operator driven S&T research

- ADAC's efforts...can help to **reduce risk, improve safety, increase awareness, increase decision precision.**
- ADAC will continue to seek **research that addresses shortfalls** and gaps as the priority.
- ADAC will seek to **leverage prior investments** to find suitable futures as practically as possible
- ADAC will **prosecute approved investigation** to develop, and transition **...in order to field capability.**
- **We believe in our mission...and sincerely strive to deliver...and are profoundly appreciative of our partnership with WHOI and MBARI for LRAUV**



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Monterey Bay Aquarium
Research Institute

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Ready for Questions & Discussion

...Thank you for your attention!



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