L3HARRIS™

UNDERWATER TECHNOLOGIES ASSISTING ROBOTIC AUTONOMOUS SYSTEM

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Introduction

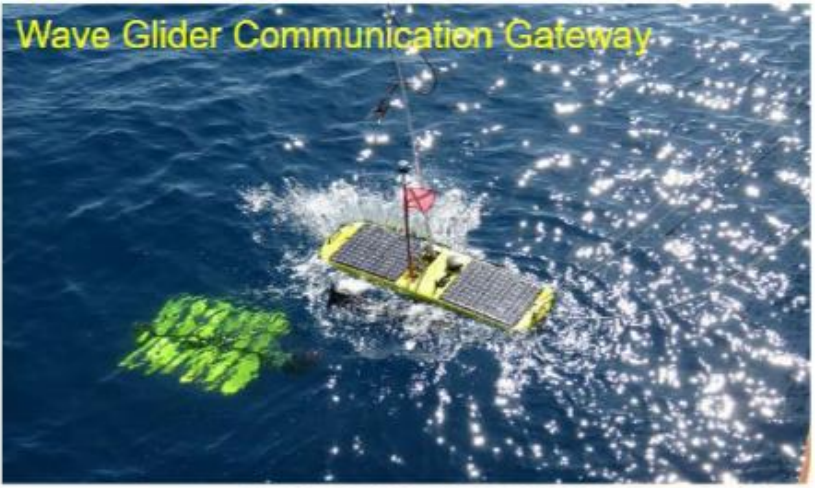
Australian Defence Department are seeking to achieve true autonomy for SEA 5012, to seek a integrated undersea surveillance capability, to allow this there are a number of key technologies that will need to be addressed

- Communications between RAS agents and remote C2 systems
- Application of Aluminum-Water (Al-H2O) Energy Modules
- Trusted Autonomy - Surface and underwater vehicles

SUT
Society for Underwater Technology

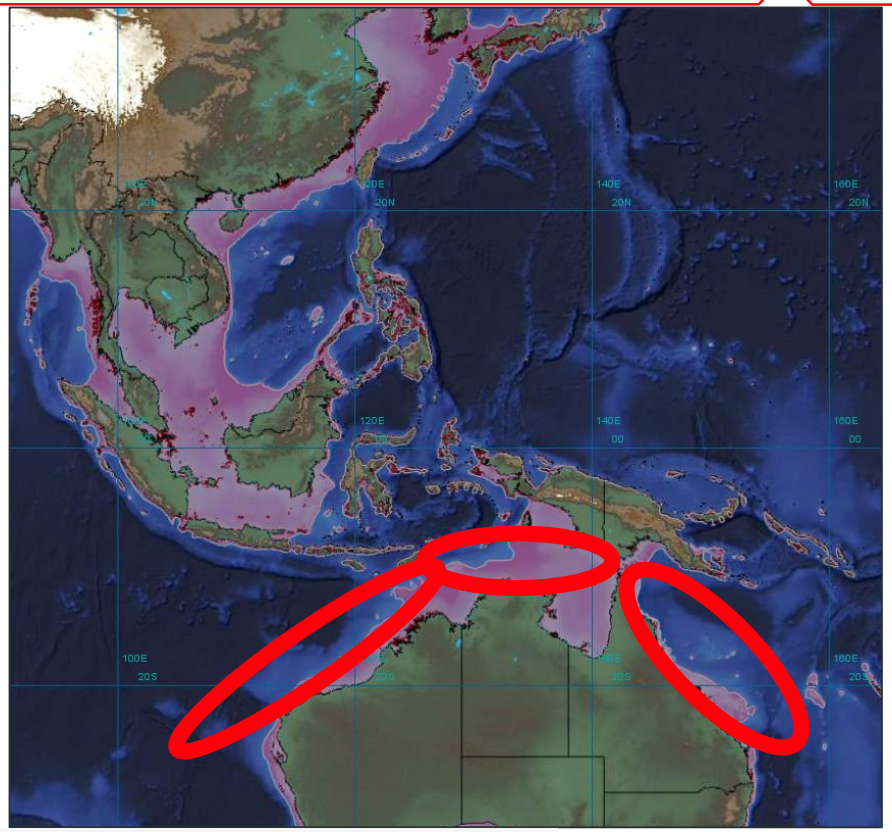
*Robotic Autonomous Systems (RAS).

Operational - Autonomous Surface vessels (Fremantle)

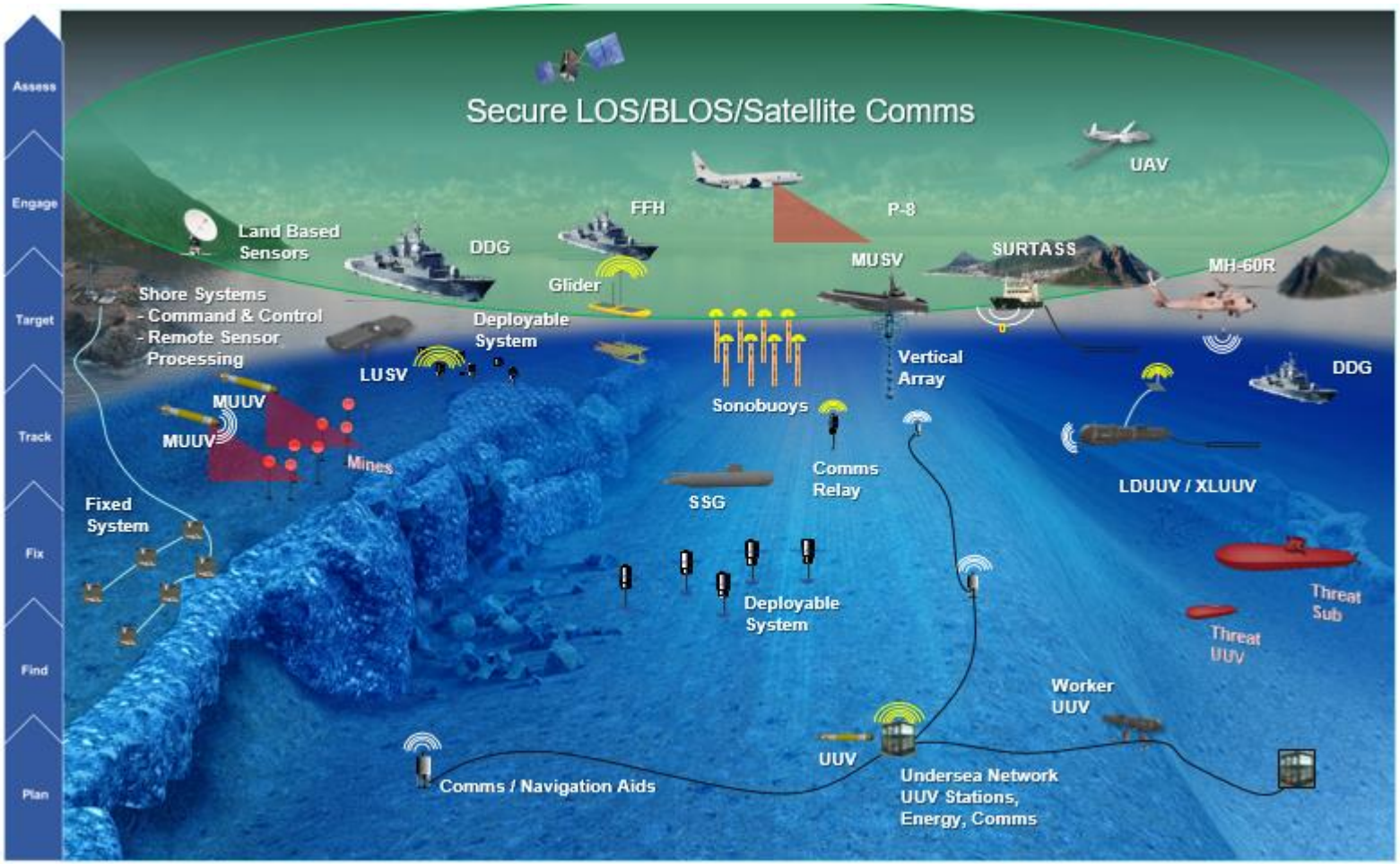


SEA5012 – Integrated Undersea Surveillance System

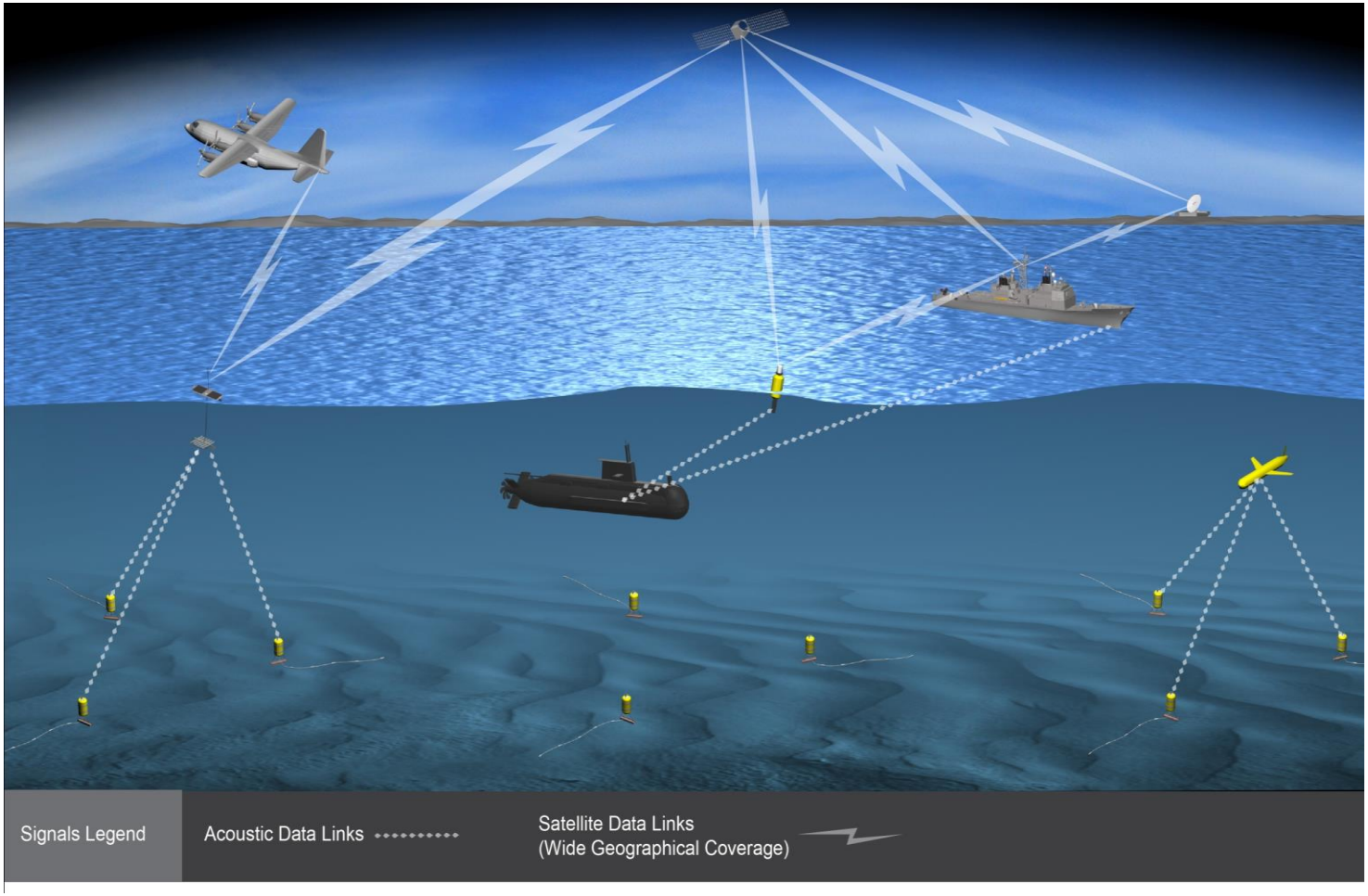
- Australia's vast maritime expanse is critical for trade, natural resources and a wide range of activities supported by Navy.
- Situational awareness of the undersea domain is essential to protecting these interests.
- 5012 is seeking a fully integrated sensor systems and networks will provide persistent coverage over wide expanses of ocean over long periods of time



> 'Protecting Australia's large exclusive economic zone requires understanding of the maritime environment under our control, sustained presence, and adapting to new technological developments that could increasingly complicate our ability to keep Australian interests safe in the Maritime domain.'
>
> **— Force Structure Plan, 2020**


Assess
Engage
Target
Track
Fix
Find
Plan
Secure LOS/BLOS/Satellite Comms
UAV
Land Based Sensors
DDG
FFH
P-8
Glider
MUSV
SURTASS
MH-60R
Shore Systems
- Command & Control
- Remote Sensor Processing
Deployable System
LUSV
Vertical Array
Sonobuoys
DDG
MUUV
MUUV
Mines
Comms Relay
LDUUV / XLUUV
Fixed System
SSG
Deployable System
Threat Sub
Threat UUV
Worker UUV
UUV
Comms / Navigation Aids
Undersea Network
UUV Stations,
Energy, Comms

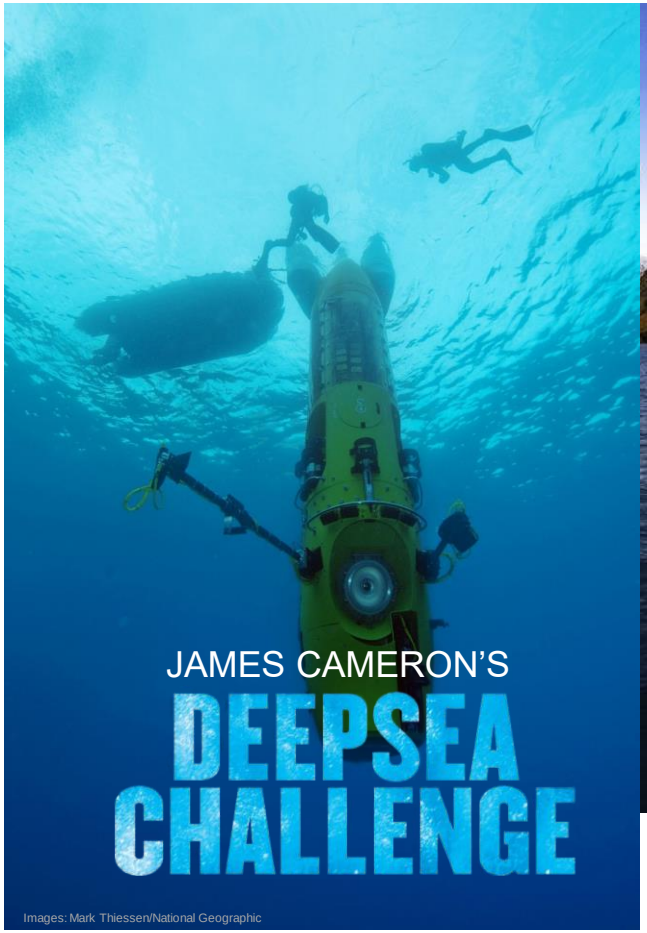
Australian Developed Comms at Speed and Depth



Developed by L3Harris, in the late 90's (Nautronix), HAIL is still in use on the Collins Submarines today to allow communication between Submarines and surface ships within the RAN and USN

MASQ (Multichannel Acoustic Signalling QoS) is the next generation in underwater communications includes, higher speeds, Networking and resilience to noise and interference.

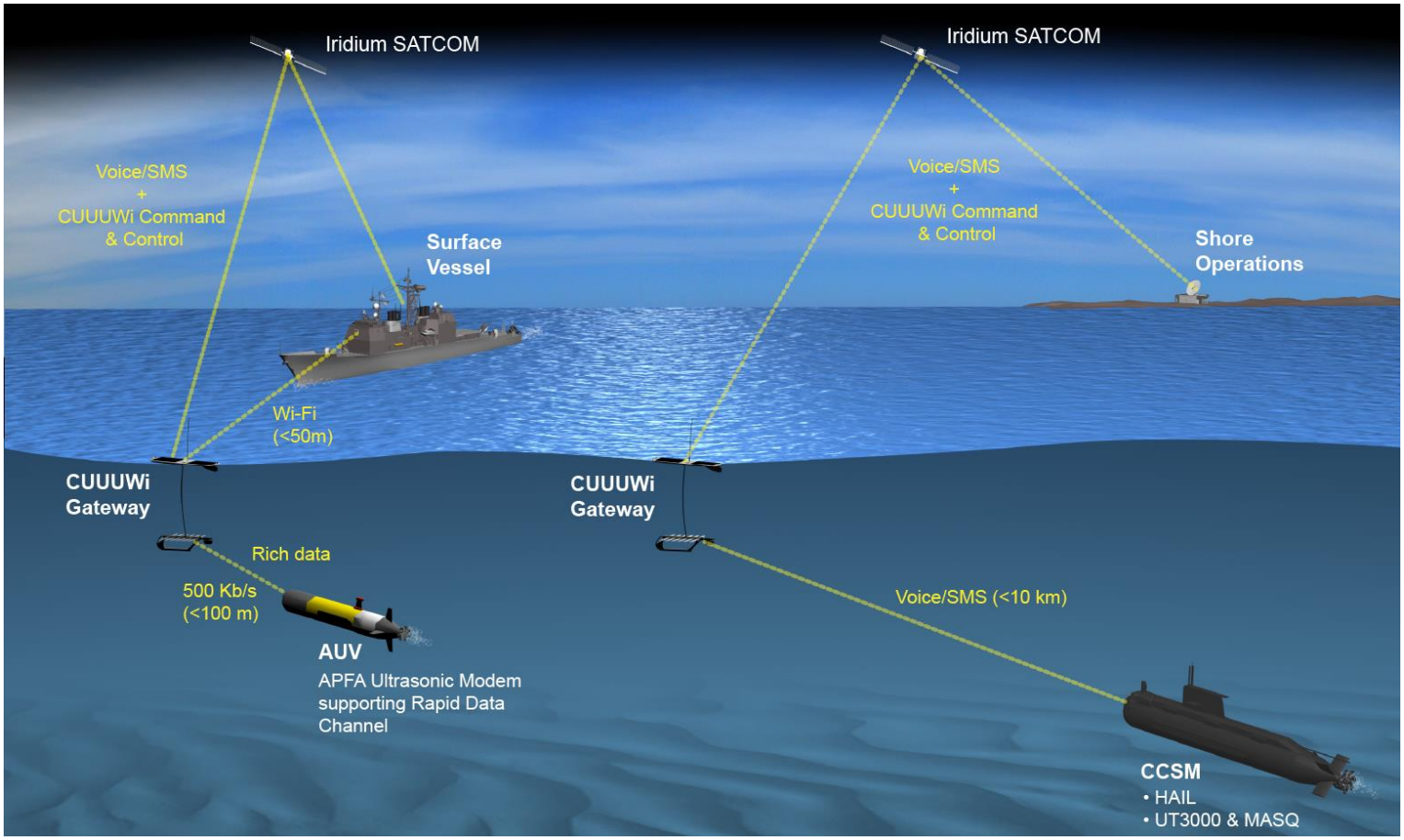
Operating in Deep Ocean Applications



L3Harris MASQ GPM300 acoustic modems were used on the James Cameron Deep Sea Challenge to get to the bottom of the Mariana Trench, enabling the world's deepest tweet at 11km below sea level.

And is fitted to the **Limiting Factor** two-man vessel that is currently operating in Australia

Communication from Seabed to Shore operations



CUUUWi

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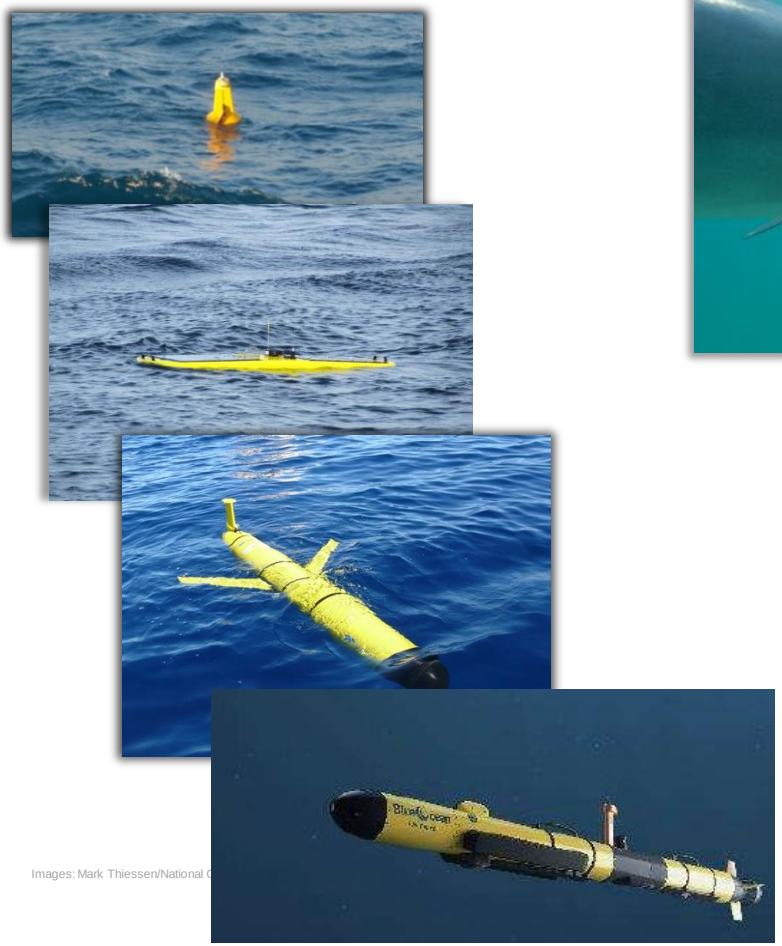
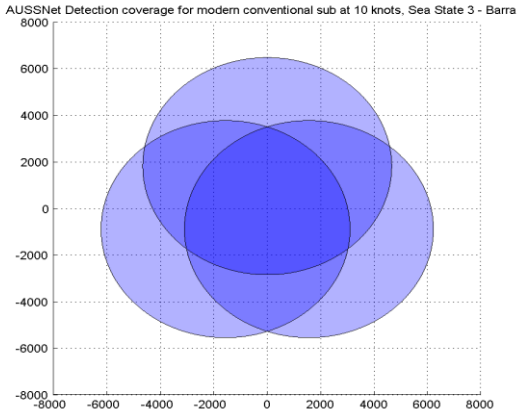
an acoustic communications /SATCOM gateway enabling voice and text-based data communication between submarines/under-water users and above-water mobile phone and SATCOM users.

Future Development – Open Integration Software Modem



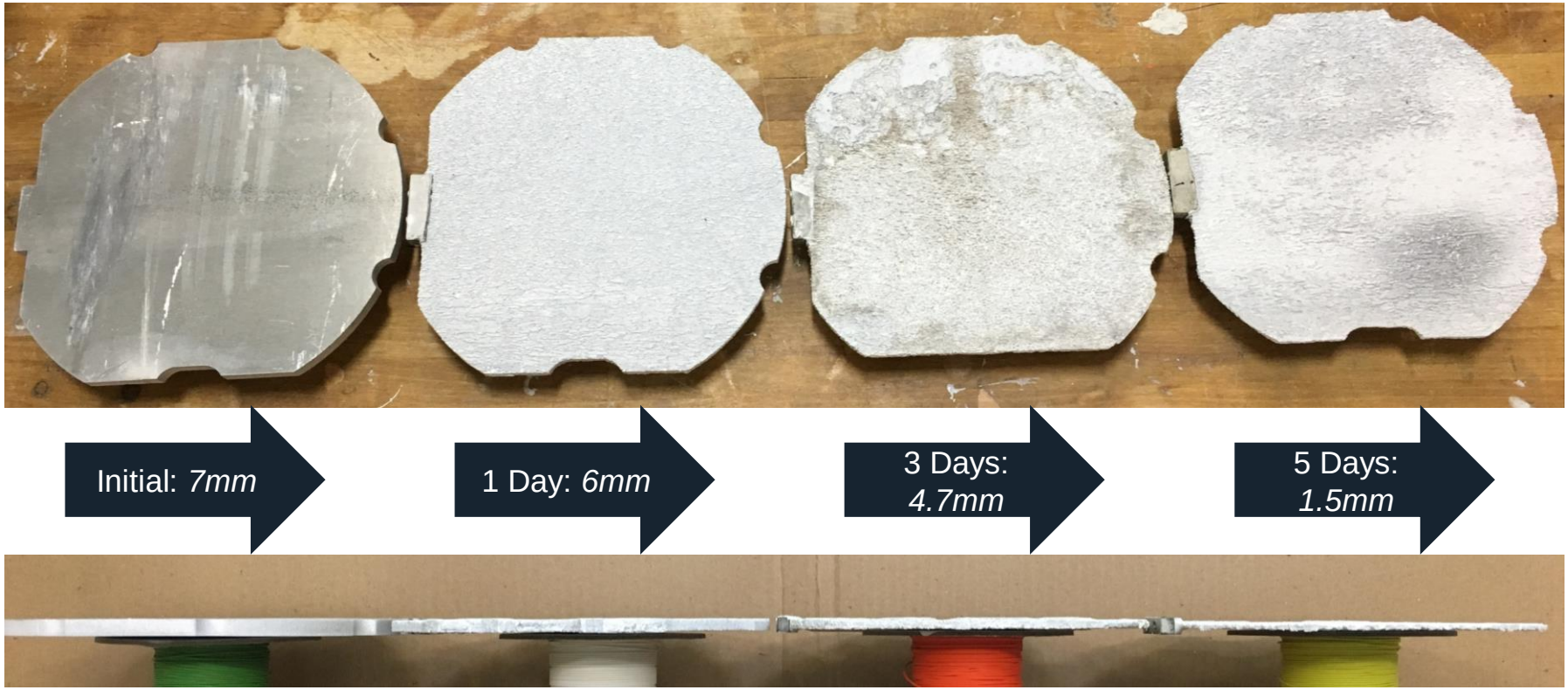
Images: Mark Thiessen/National G



Australian Investment continues to increase, range, bandwidth, reliability and to include stealth modes for the future projects, looking beyond acoustic signalling limits by alternate methods and technologies.

2022 will see the release of MASQ.OEM - Software Modem, allowing for easy integration into a variety of subsea systems, running on COTS based hardware.

Power - Al-H_2O Energy Modules



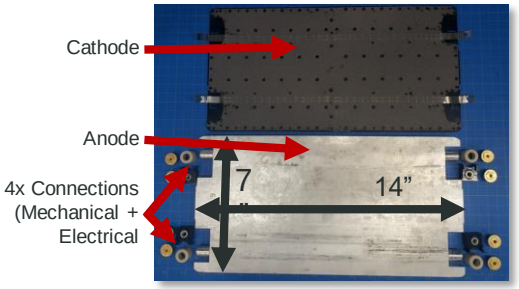
Attributes of Al-H_2O Energy Modules

- Primary battery (non-rechargeable)
- Simple, modular, scalable, and reconfigurable in "stacks"
  - Energy proportional to volume of aluminum
  - Increase anode thickness to increase energy + energy density
  - Power proportional to total surface area of aluminum
- Delivers power like a battery, but unlike a battery can be completely dormant with no self-discharge
  - Max power ceiling a function of operating conditions
  - Native output is low voltage, high current
- Pressure tolerant with no pressure encapsulation required
  - Energy density advantage increases with depth as competitors must use ever heavier / more cumbersome pressure vessels
- Can load follow and throttle once active (see right)
- Can hybridize with other battery types

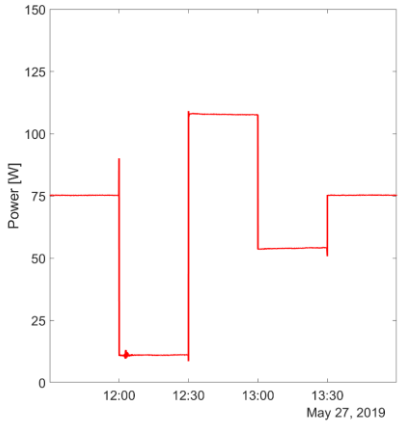
Reconfigurable Stacks

Simple Design

Minimal Components & Few Moving Parts



Load Following & Throttling



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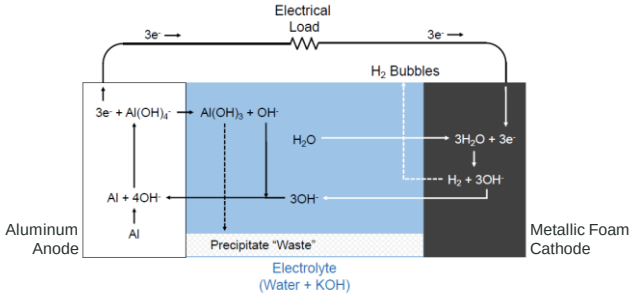
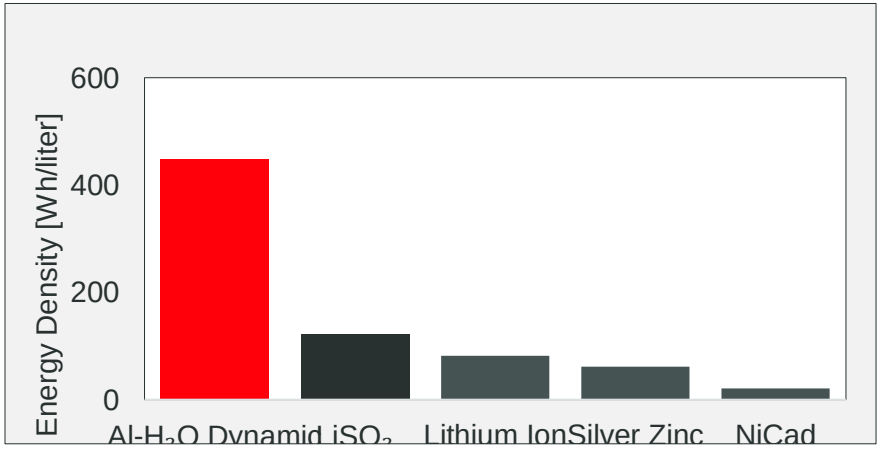
Why Use Aluminum as a Fuel?

- Unactivated systems inert and safe to transport via commercial means
  - "No hazards observed" in preliminary testing at U.S. Navy NSWC – Carderock
- Unrivaled system-level energy density in packaged state
- Cost is competitive or lower than other chemistries
- System-level performance and cost advantage increases with depth
- Works with any type of H_2O (salt, fresh, brackish, rain, urine)

Using aluminum to directly generate electricity

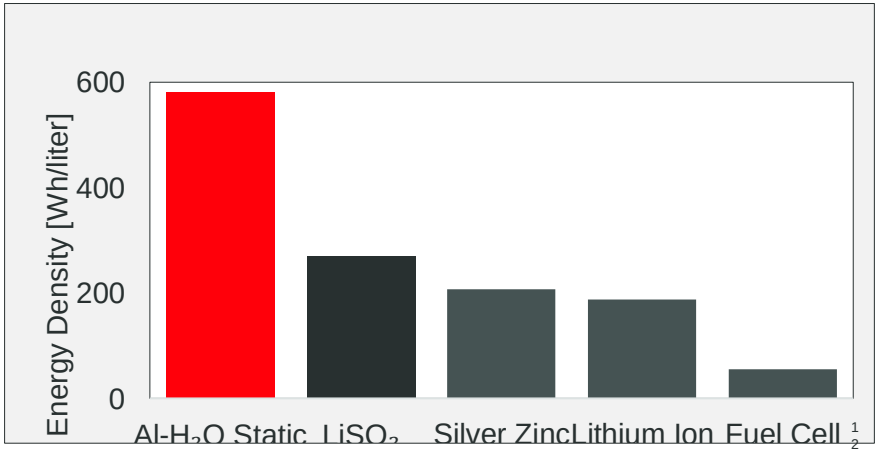


Neutrally Buoyant Vehicle Modules System Level Performance

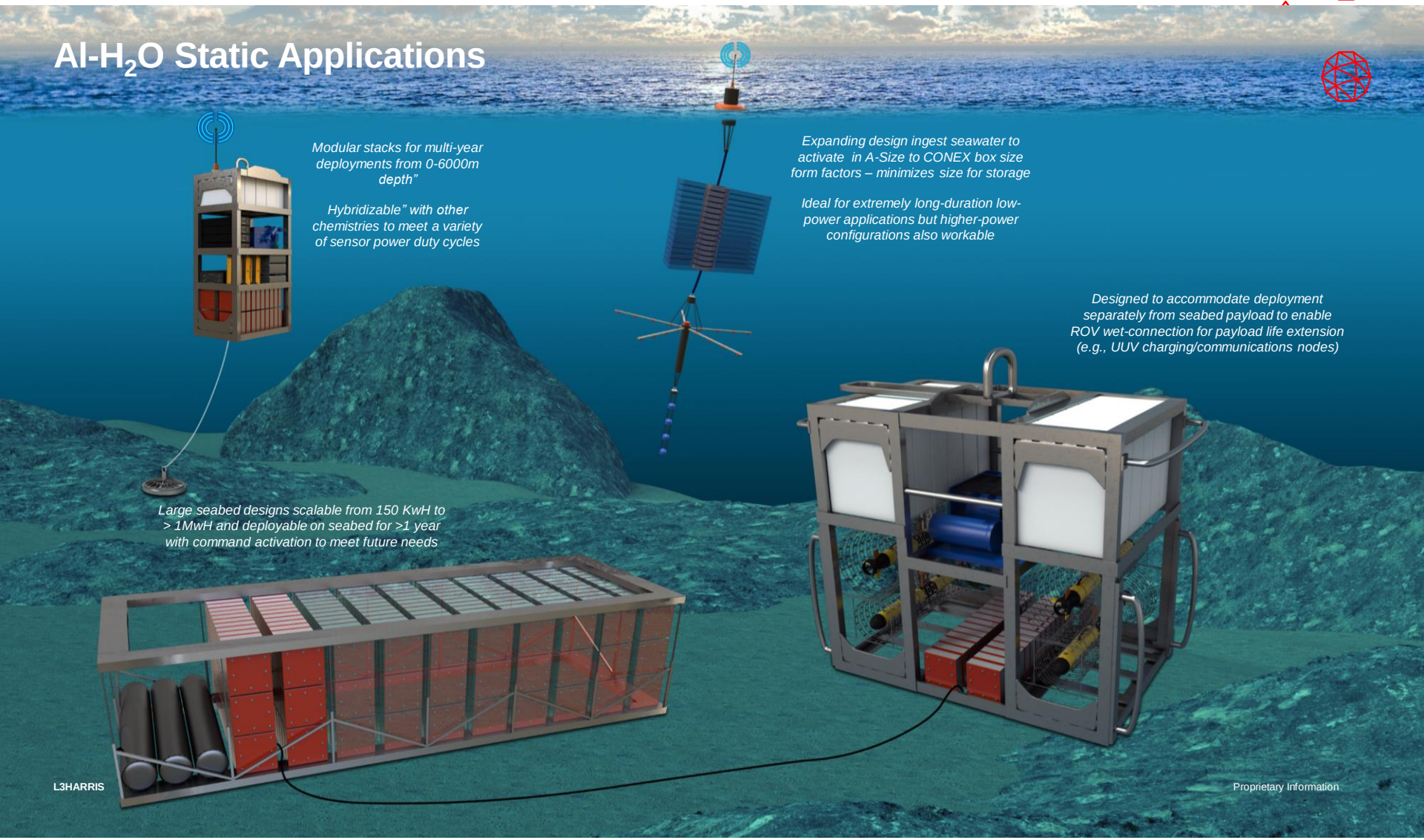


Negatively Buoyant Subsea Energy Modules System Level Performance

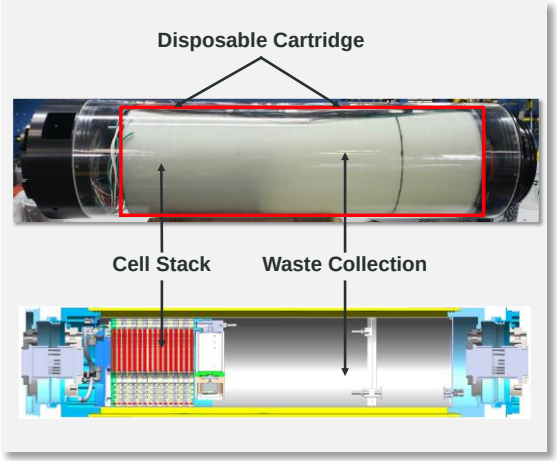
Depth Tolerant to >6000m



Al-H_2O Static Applications



Dynamic (UUV) Energy Modules – Two Variants In Development



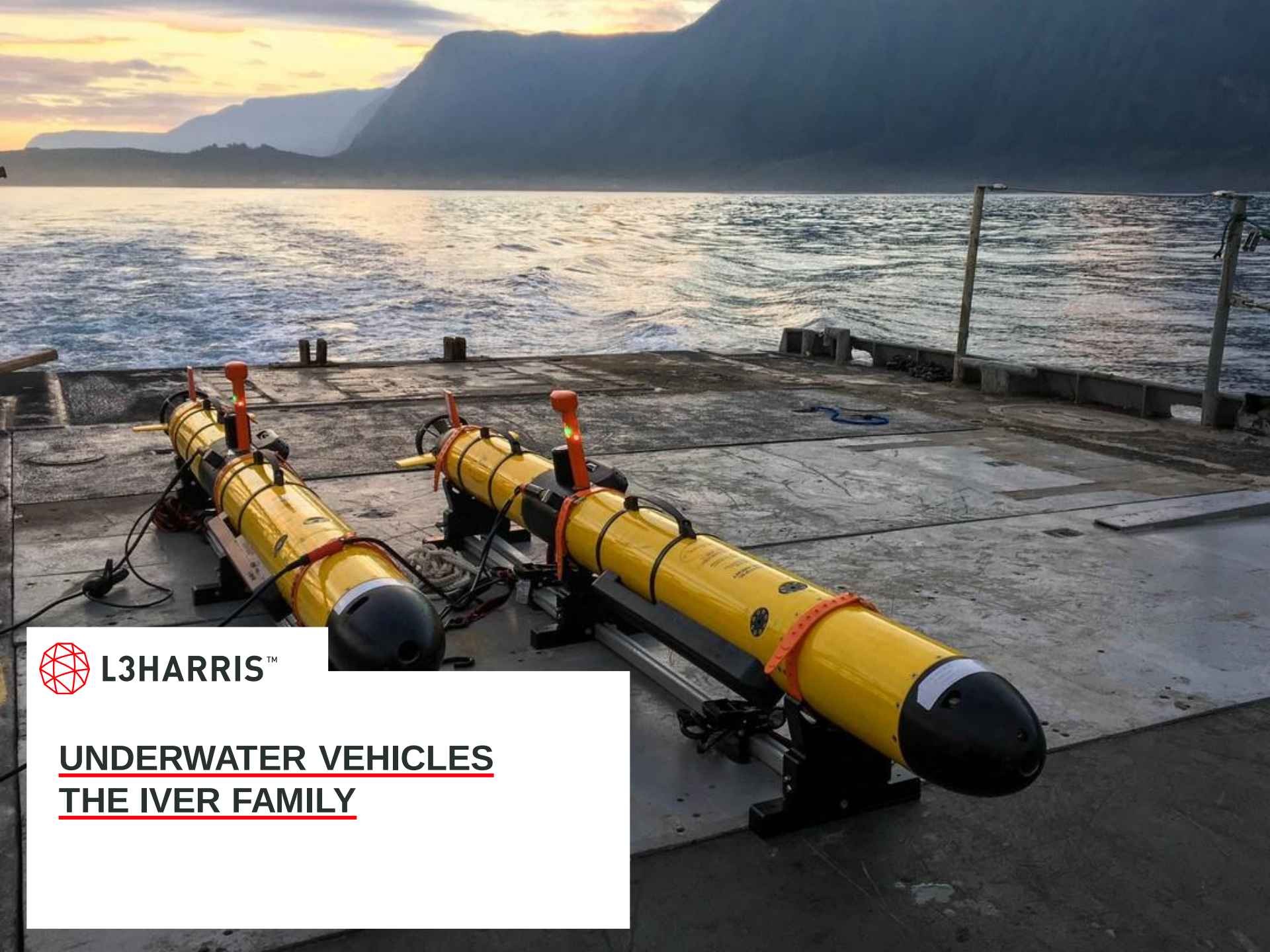
WASTE ON BOARD (WOB) – 200 Wh/L

- Stores inert waste products onboard – no signature
- At TRL 6+ today– made first commercial sale in CY20
- Simple system expedites TRL 7 and reduces cost vs. WJ
- Executed record duration demo in Q2 CY20 on IVER 4
  - Delivered 4.3 kWh to IVER 4 on 45hr, 138km mission in CY20
  - Supported 100% of vehicle load for 43% of the mission – with most exceptions relating to short duration sensor bursts
  - IVER's rechargeable battery depleted 32% of capacity

WASTE JETTISONING (WJ) – 350-600 Wh/L

- Achieves OWP's highest energy density (for vehicle systems) by periodically jettisoning inert waste product
- Native buoyancy management
- TRL 7 expected by end of Q2 CY21 on US contract focused on optimization and Remus 100 integration

Proven ability to support extended mission durations – modular/scalable to larger UUV size classes

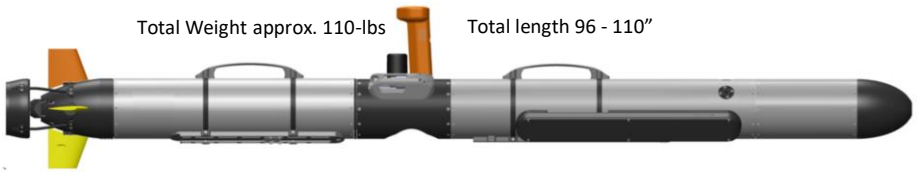


L3HARRIS™

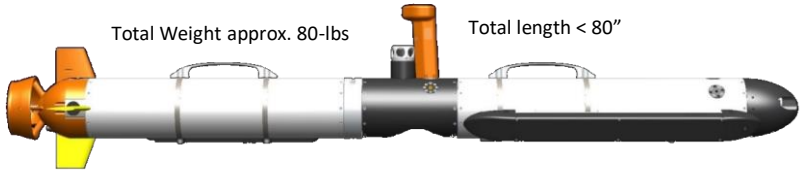
UNDERWATER VEHICLES
THE IVER FAMILY

2021 Iver UUV Family of Vehicles

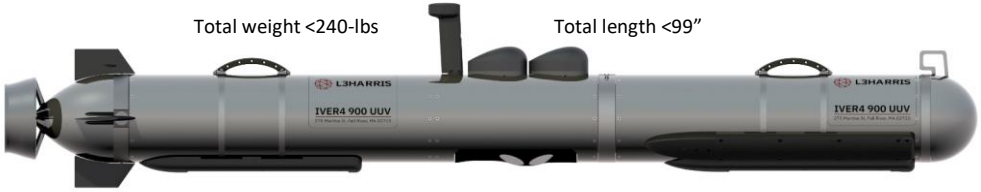
- **Iver3-580:**
  - 100-200m Depth-Rating
  - Open-System
  - Flexible Payload Configurations
  - 780-Wh (Li-ion) Approx. 6-8 hrs duration



- **Iver4-580:**
  - 300m Depth-Rating
  - Sealed Swappable Tail Sections
  - Fixed forward-section and payloads
  - 780-Wh (Li-ion) 6hrs / 2000-Wh (Li-ion) Option



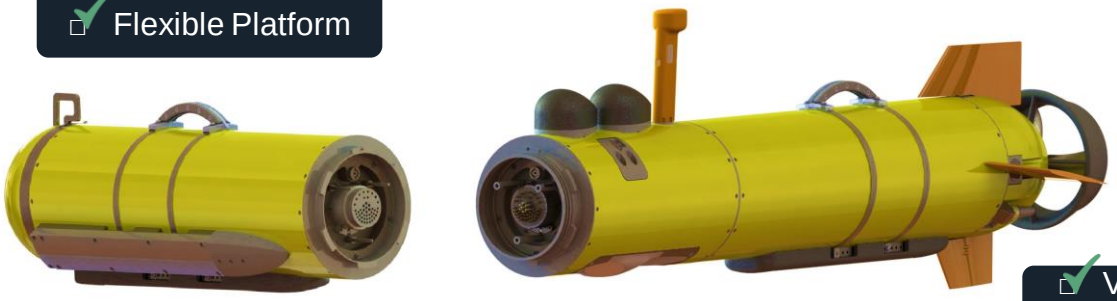
- **Iver4-900:**
  - 300-m Depth-Rating
  - Sealed Swappable Sections
  - Multiple Battery Chemistries
  - 2-4 kWh (NiMH, Alkaline, Li-ion) 18 – 30hrs
  - Flexible-payloads



IVER4-900 - 4th Generation Autonomous System Key Features

- ✓ Operational Depth Rating 300m
- ✓ <10” Diameter
- ✓ Sensitive Information Storage
- ✓ <230 Pounds

- ✓ <99” Length
- ✓ Flexible Platform



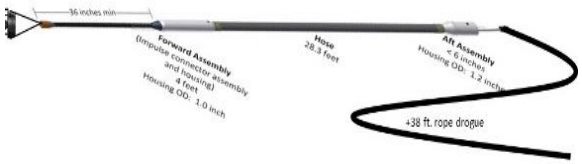
- ✓ 18+ Hour Mission or 40+ Hours with Lithium Ion Option
- ✓ Variety in Power Sources
- ✓ Ability to Integrate 3rd Party Sensors, Autonomy Software

L3Harris selected for the U.S. Navy’s Next Generation Small-Class Maritime Expeditionary Mine Countermeasures Unmanned Undersea Vehicle (MEMUUV) program.

FLEXIBILITY IN PLATFORM CONFIGURATION

TOWED PAYLOAD OPTIONS

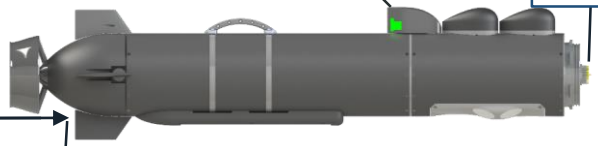
Towed Magnetometer



Passive Acoustic Array

User Defined Towed Payload

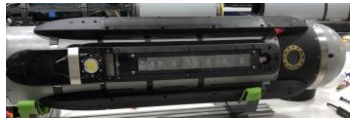
AFT SECTION



FORWARD SECTION PAYLOAD OPTIONS

User Payload + Battery Options

EdgeTech 2205B + Battery



Camera & Sonar + Battery

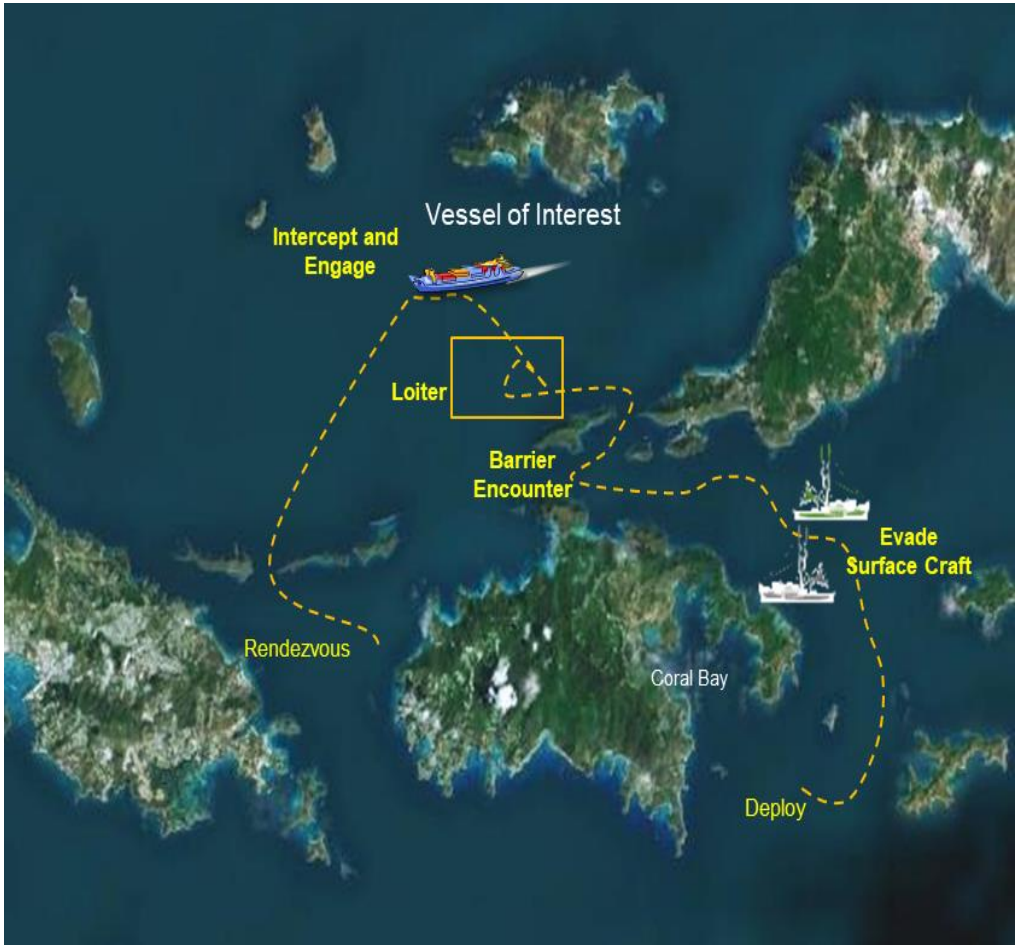
Unique, Bi-directional GigE communications & power simplify payload integration and field swap

FWD and AFT common interface for swappable payloads in minutes

Adaptive Mission Autonomy – Trusted ?

Operational Challenge and Objectives

Develop adaptive mission level autonomy in order to effectively perform complex maritime missions in denied areas using autonomous vehicles equipped and empower by mission technologies built upon ontological models which adapt to changing needs and threats.



Current autonomy solutions are not suitable for extended periods of time without human intervention and any pre-mission plan will not anticipate all future possibilities.

Adaptive Mission Autonomy (AMA) technology seeks investments and emerging technologies to enable unmanned systems to anticipate and dynamically respond to changing mission objectives, operating environments and adversary counter actions.

2

Questions, Contact Details and thank you!

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Society for Underwater Technology

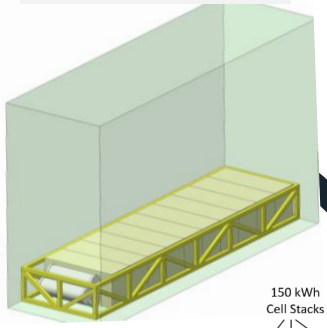
sut.org.au

Backup

Large Form Factor Energy Module

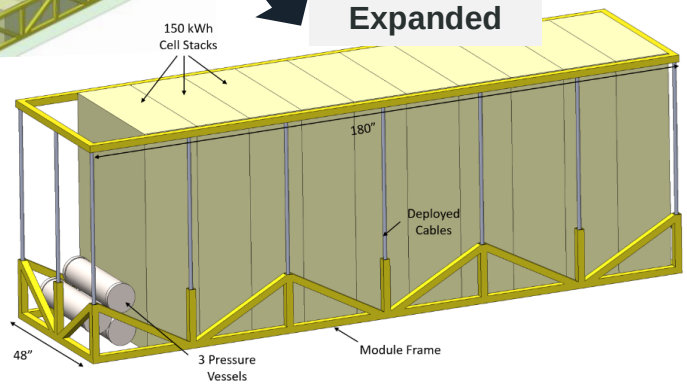
- Developed large module for deep seabed sensors capable of delivering 150 kWh, 70 W at 6000m, 1 ºC
  - Tested to simulated 6000m ocean depth in pressure tank – full discharge at 1 ºC as proof of concept
  - Configured to link 10 modules in parallel to provide 1.5 MWh, 700 W seabed power – single module shown at right
- Simple design: minimal components, few moving parts
  - Designed to store compressed and expand on seabed; compressed size of single module: 180” L, 48” W, 18”H
  - Can deploy in dormant state and activate on command, including staggered startup of cells to extend lifespan
- Deployment via XL UUV or vessel of opportunity with ability to wet connect into existing seabed infrastructure
- Power output tailorable on setup and via use of buffers

Single Module Compressed



SPECIFICATION	OBJECTIVE
Capacity	1.5 MWh
Operating Temp.	-1.5 to 15 °C
Nominal Voltage	48.0 VDC
Operating Power	450 - 1200 W
Average Power	700 W
Depth Rating	6000 m
Dry Weight	5,300 lbs
Wet Weight	3,000 lbs
Stored Size	48”W x 180” L x 19” H

Expanded



At-sea testing at 800m planned for CY21