

Persistence and Modularity as Key Design Effects for Marine Autonomous Systems

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Three fundamental challenges of the coming decade:

- In the military domain: life risk in military operations
- In the civil domain: labour availability and cost
- In both domains: persistent, reliable, flexible, cost-efficient presence

The Military Imperative to De-Crew

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Josh Wallick, PMP, SPC • 1st

GET (autonomous) SHIP DONE!

1w •

If the Moskva has to sink to make the A2AD threat "real," how many American Sailors have to die to make it "real for us"? A carrier's worth? The race is on to unman the tactical edge. "We must not be misled to our own detriment to assume that the untried machine can displace the proved and tried horse." (Gen. John K. Herr, opposing the development of the tank, in 1938) <https://lnkd.in/g9pPjtDY>



Jason Strickland, Ph.D. • 2nd

Technical Director, Unmanned Surface Warfare

1w •

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The race is on. Make no mistake that the goal is anything less than an autonomous vessel capable of militarily useful operations. Be it strike, support, or picket ops. Remember you can either make things happen, watch things happen, or wonder what happened. Where are you?

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China Launches its First Autonomous Container Ship Service

- Autonomous advantage in cost efficiency vs crewed maritime assets
- More time efficient for long-term repetitive tasks than crewed assets
- Cost-efficient persistent multi-week presence

Persistence The ability to service a mission over uninterrupted multi-week durations

Modularity The ability to service a wide range of missions

What system characteristics tend to limit mission duration?

Limiting Factor	Mitigation
Reasonable crew absences	Remove crew from platform
Limited fuel capacity	Power platform using environmental energy sources
Biofouling accretion	<ul style="list-style-type: none">• Anti-fouling coatings• Autonomous return to base for cleaning• Operate platforms in pairs to cycle between mission area and home port to ensure regular cleaning cycle
System reliability	<ul style="list-style-type: none">• Reduce system complexity• Apply proven high-reliability commercial systems
Unauthorised intervention (e.g. capture)	<ul style="list-style-type: none">• Onboard sensors identify threat craft and alert operator• Operator provides a response capability which deploys in case of threat to autonomous platform

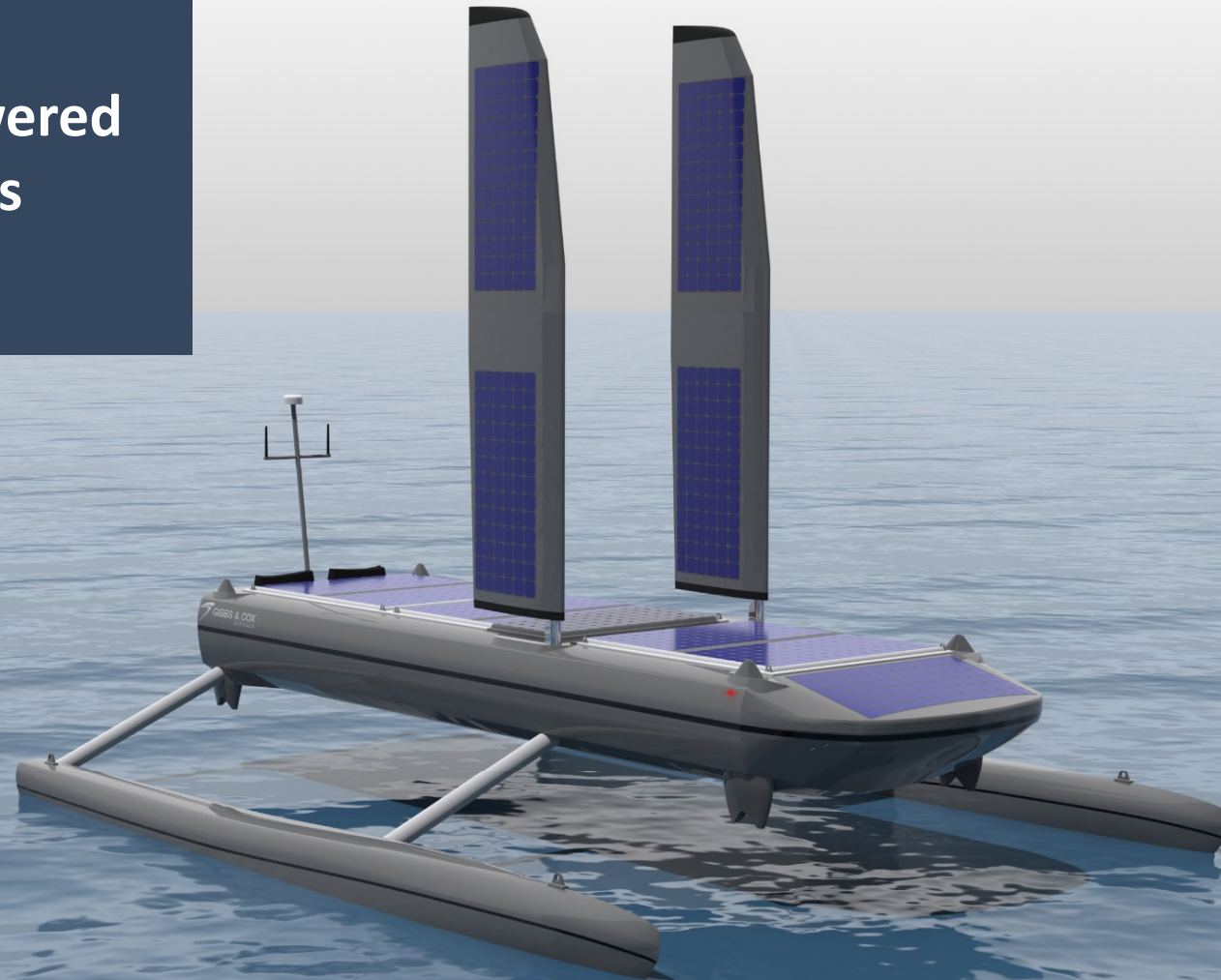
What system characteristics tend to increase adaptability?

Characteristic	Application
Physical payload modularity	Payload cassette allows a range of mission pack volumes using a common width against a defined cassette interface
Physical payload capacity	Payload cassette providing generous volume and weight capacity limits
Diverse payload combinations	Payload cassette provides ability to mix and match mission packs to provide best combination of capabilities
Minimal physical constraints on payload	Payload access to allow deployables to both sea and sky
Convenient payload exchange	Straightforward physical interface to payload cassette, with single power/data connector and minimum fastening points for fast changes
Platform equipment modularity	Propulsors mounted in exchangeable rotary cassettes. Batteries mounted in hot-swap racks.
Software modularity	Open, modular autonomy solution allows rapid development of new functions. Open interface between autonomy and mission packs allows modular development of mission packs.
Maximum power capacity	Maximise power to mission packs to allow widest range of missions
Maximum performance	Maximise speed-range performance to allow widest range of missions

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EMAPS

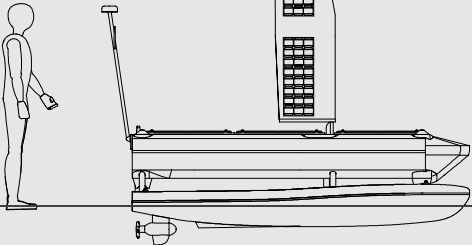
Environmentally-powered
Modular Autonomous
Platform System



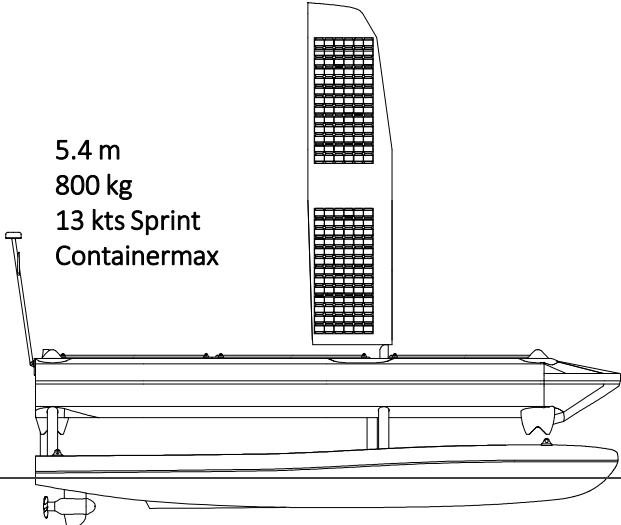
EMAPS Design Solution

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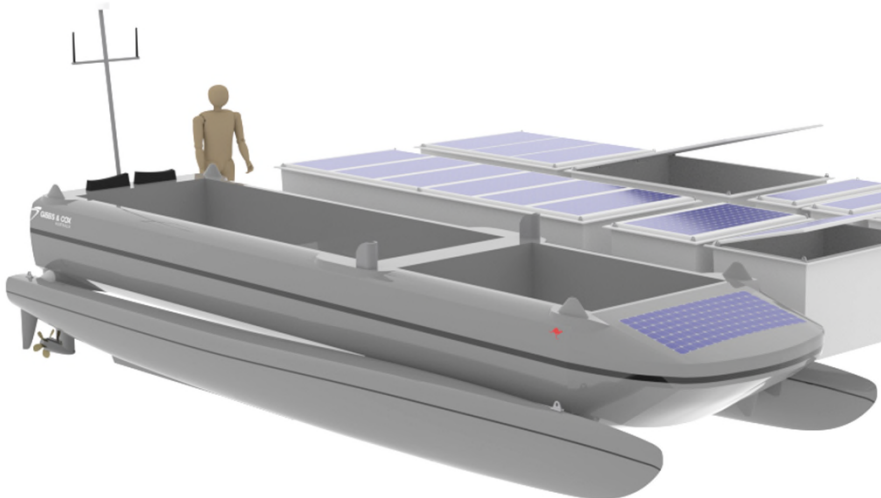
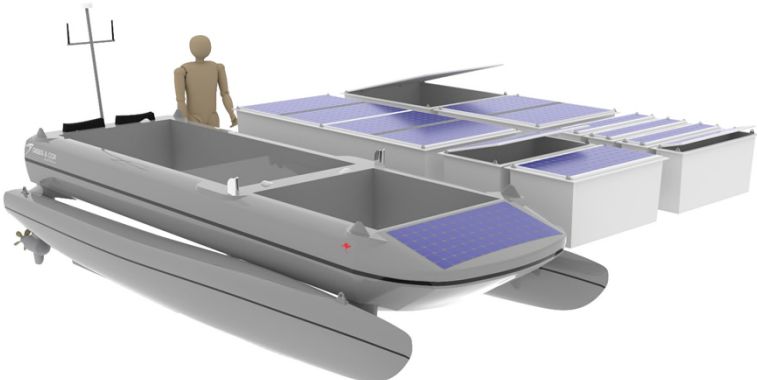
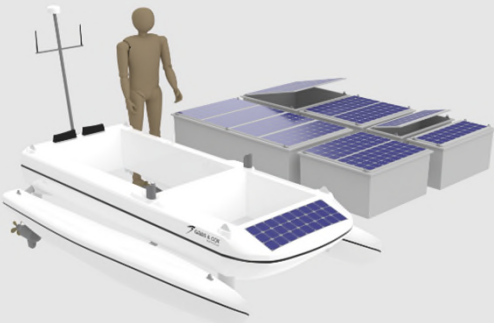
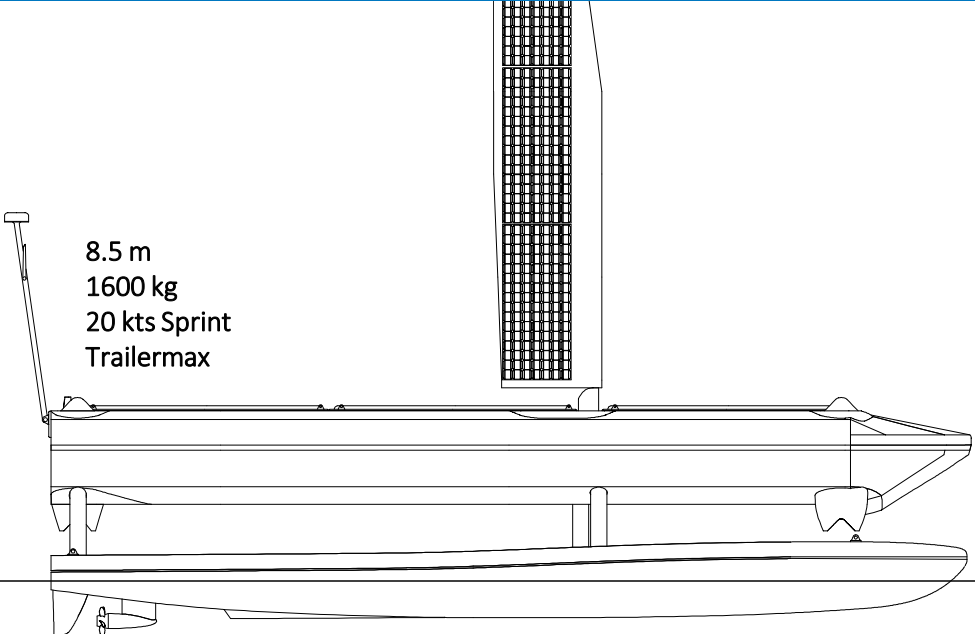
3.1 m
220 kg
14 kts Sprint



5.4 m
800 kg
13 kts Sprint
Containermax



8.5 m
1600 kg
20 kts Sprint
Trailermax



EMAPS Design Solution

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Sail System

- Single-element rigid wing sails
- Tandem sails maximise sail area within retraction and stacking geometry limits, and balance power with controllability
- Indefinite transit and sail-hydro-regeneration in median wind conditions
- Electro-mechanical trimming and retraction mechanisms
- Sails are retracted in severe wind conditions

Solar Array

- Substantial solar array on deck, mission pack hatch covers, and sails
- High efficiency flexible lightweight solar panels

Mission Pack Air Access

- Clear access to air at mission pack hatch lid enables potential aerial drone integration to mission pack

Lifting Points

- Lifting points on side hull bow and stern for on-water recovery
- Secondary lifting points integrated into stacking points on centre hull

Sail Supports

- Mechanical support to sails in retracted position

Efficient Slender Side Hulls

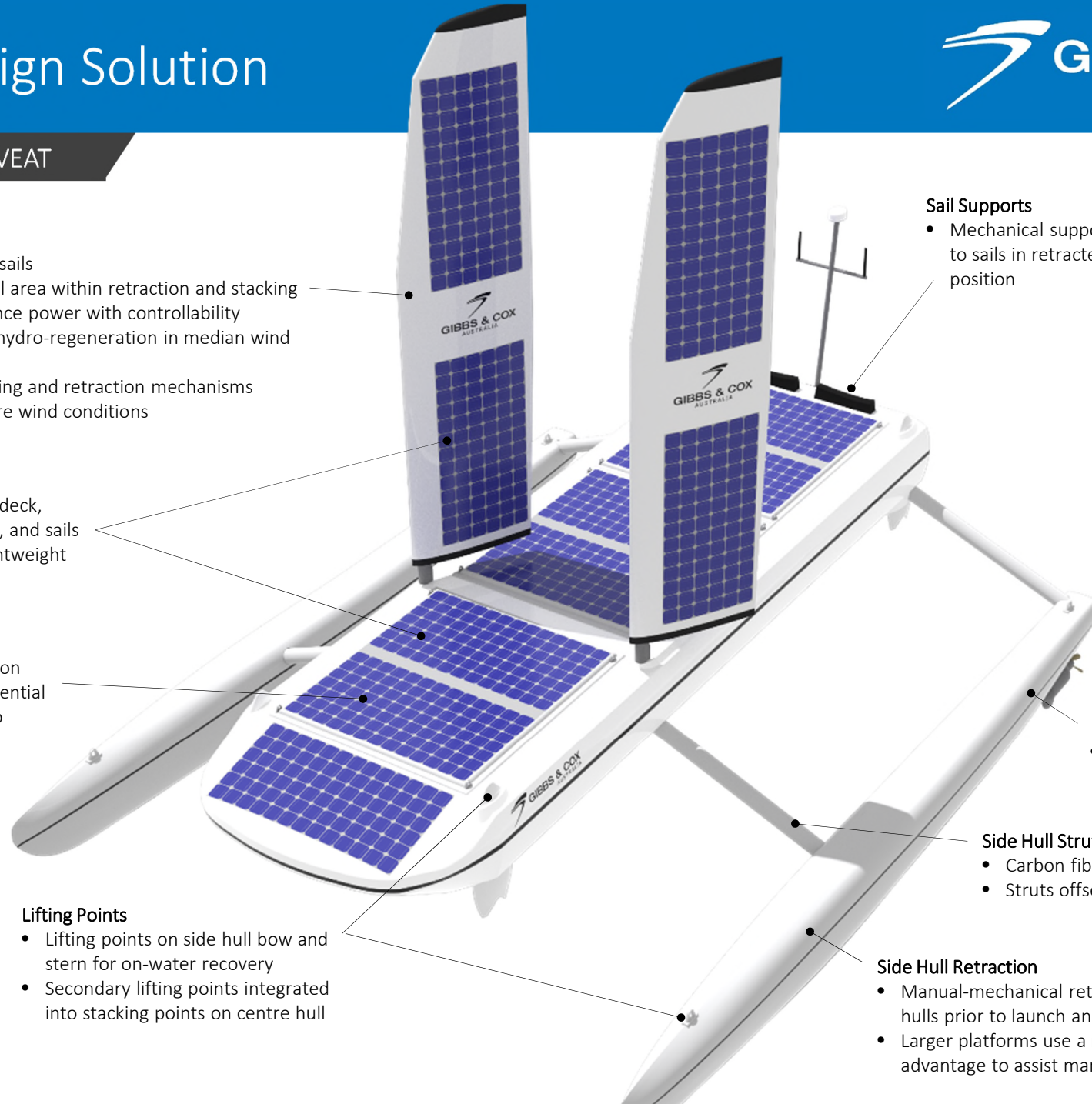
- Slender side hulls provide high hydrodynamic efficiency

Side Hull Struts

- Carbon fibre struts sleeved into main hull
- Struts offset to cross in retracted position

Side Hull Retraction

- Manual-mechanical retraction of side hulls prior to launch and after recovery
- Larger platforms use a mechanical advantage to assist manual retraction



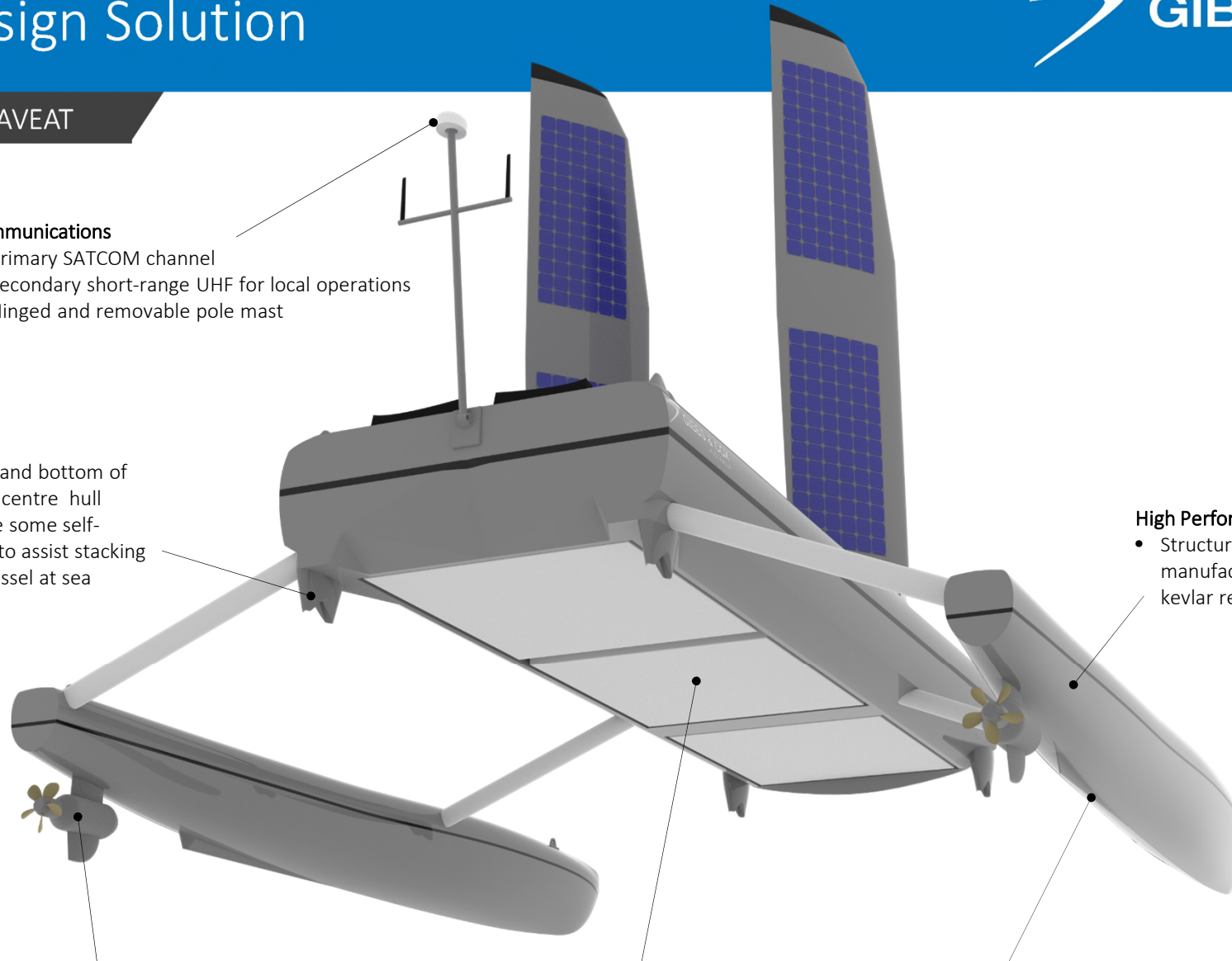
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Communications

- Primary SATCOM channel
- Secondary short-range UHF for local operations
- Hinged and removable pole mast

Stacking Hardpoints

- Hardpoints on top and bottom of each corner of the centre hull
- Hardpoints provide some self-locating tolerance to assist stacking aboard a parent vessel at sea



High Performance Structure

- Structural elements manufactured from kevlar reinforced epoxy

Propulsion

- Tandem electric pod propulsors
- Propulsors built into azimuthing cassettes, providing continuous 360 degree steering

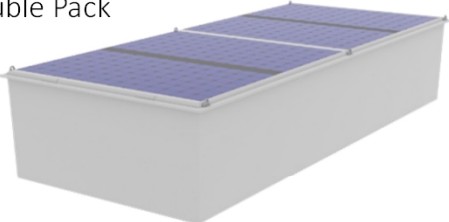
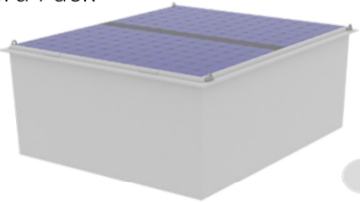
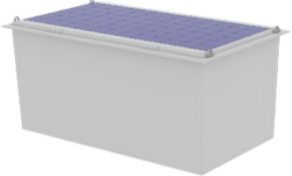
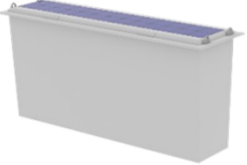
Mission Pack Water Access

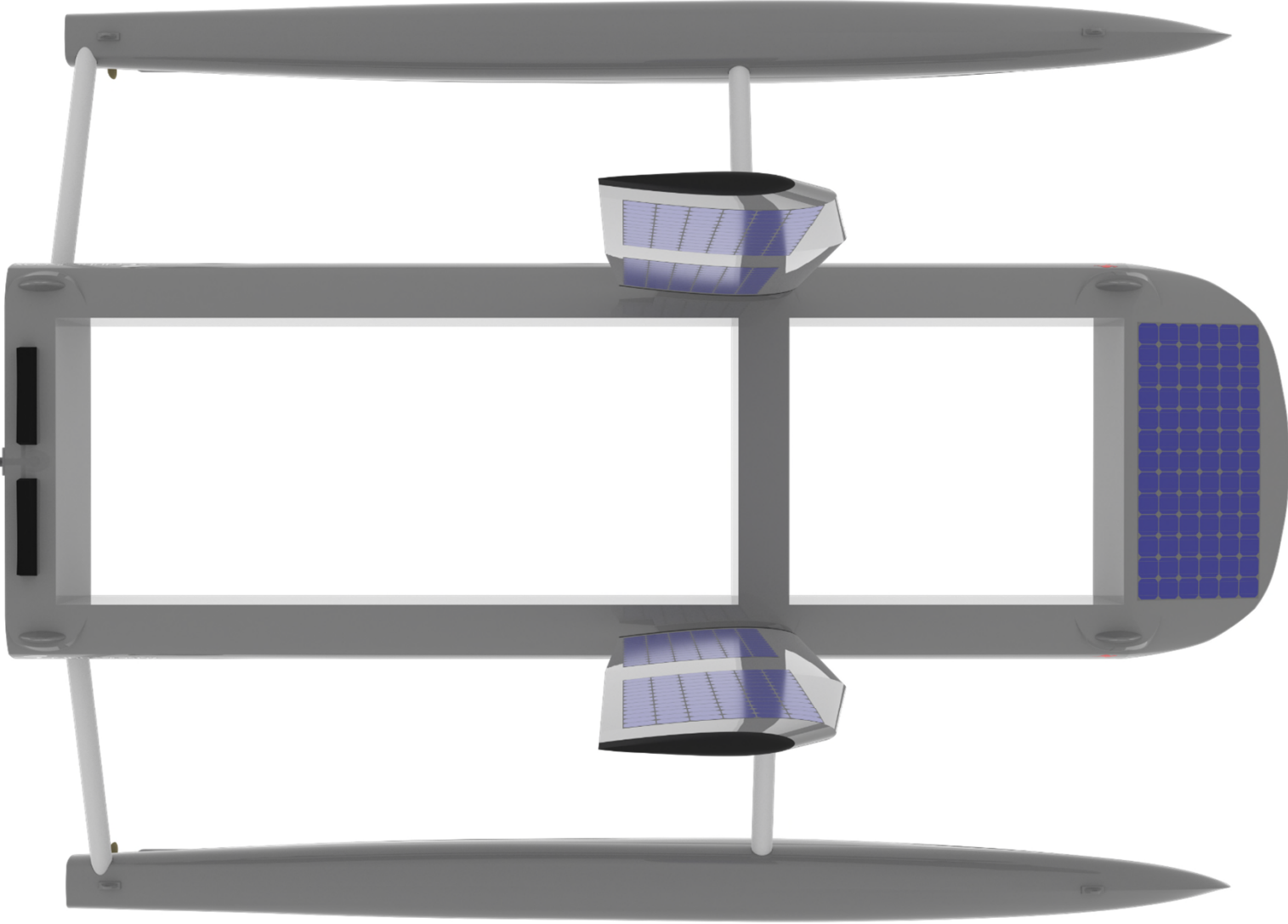
- Catamaran form provides clear access to water surface for mission pack deployables
- Mission packs expected to integrate AUVs, tows, dips, expendables, etc.

Wide Beam

- Extended side hulls provide a wide beam to mitigate capsize risk in survival weather conditions

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Mission Pack Class
Double Pack 
Standard Pack 
Half Pack 
Quarter Pack 



Mission Pack Combinations

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Mission	Slot	Mission Packs	Effect
UUV Ops	Aft	UUV Host Launch / Recovery Pack (Double Mission Pack)	Additional battery capacity increases power assurance for continuous UUV operations.
	Mid		
	Fwd	Extension Battery	
ASW Ops A	Aft	20 mm Class Acoustic Towed Array / Winch Pack	EMAPS performs ASW surveillance and supports crewed vessel in ASW prosecution. Active dipping sonar and passive towed array provides multi-static sonar when teaming with crewed ASW asset. EMAPS deploys sonobuoys under remote operator command.
	Mid	Sonobuoy Canister Array Pack	
	Fwd	Active/Passive Sonar Dipper / Winch Pack	
ASW Ops B	Aft	CTD Sonde / Winch Pack	EMAPS performs ASW surveillance and supports crewed vessel in ASW prosecution using dipping sonar. EMAPS deploys sonobuoys under remote operator command. EMAPS deploys CTD Sonde to collect real-time local oceanographic data, enhancing knowledge of local sonar conditions.
	Mid	Sonobuoy Canister Array Pack	
	Fwd	Active/Passive Sonar Dipper / Winch Pack	
Surface Surveillance	Aft	Optical / IR Camera Array on Mast	EMAPS performs persistent surface surveillance using optical and IR cameras mounted on the platform and on a tethered drone operating on cyclical short-duration max altitude horizon search flights.
	Mid	Extension Battery	
	Fwd	Tethered Drone Pack	
Shore Surveillance	Aft	Autonomous Drone Pack	EMAPS supports over-the-beach aerial reconnaissance, shoreline surveillance, aerial marine asset survey, or synthetic aperture radar geo-survey, using tandem autonomous drones operating on a loop. Duty cycle is dictated by drone recharge time.
	Mid	Extension Battery	
	Fwd	Autonomous Drone Pack	
Marine Science A	Aft	Water Sampler Dipper / Winch Pack	EMAPS autonomously collects hydrographic data, water composition data, and water samples in support of marine science and ocean health monitoring.
	Mid	Chemical Sampler Dipper / Winch Pack	
	Fwd	CTD Sonde / Winch Pack	
Marine Science B	Aft	Hydrophone Dipper / Winch Pack	EMAPS autonomously collects hydrographic data and underwater acoustic data in support of marine science and ocean health monitoring.
	Mid	Extension Battery	
	Fwd	CTD Sonde / Winch Pack	

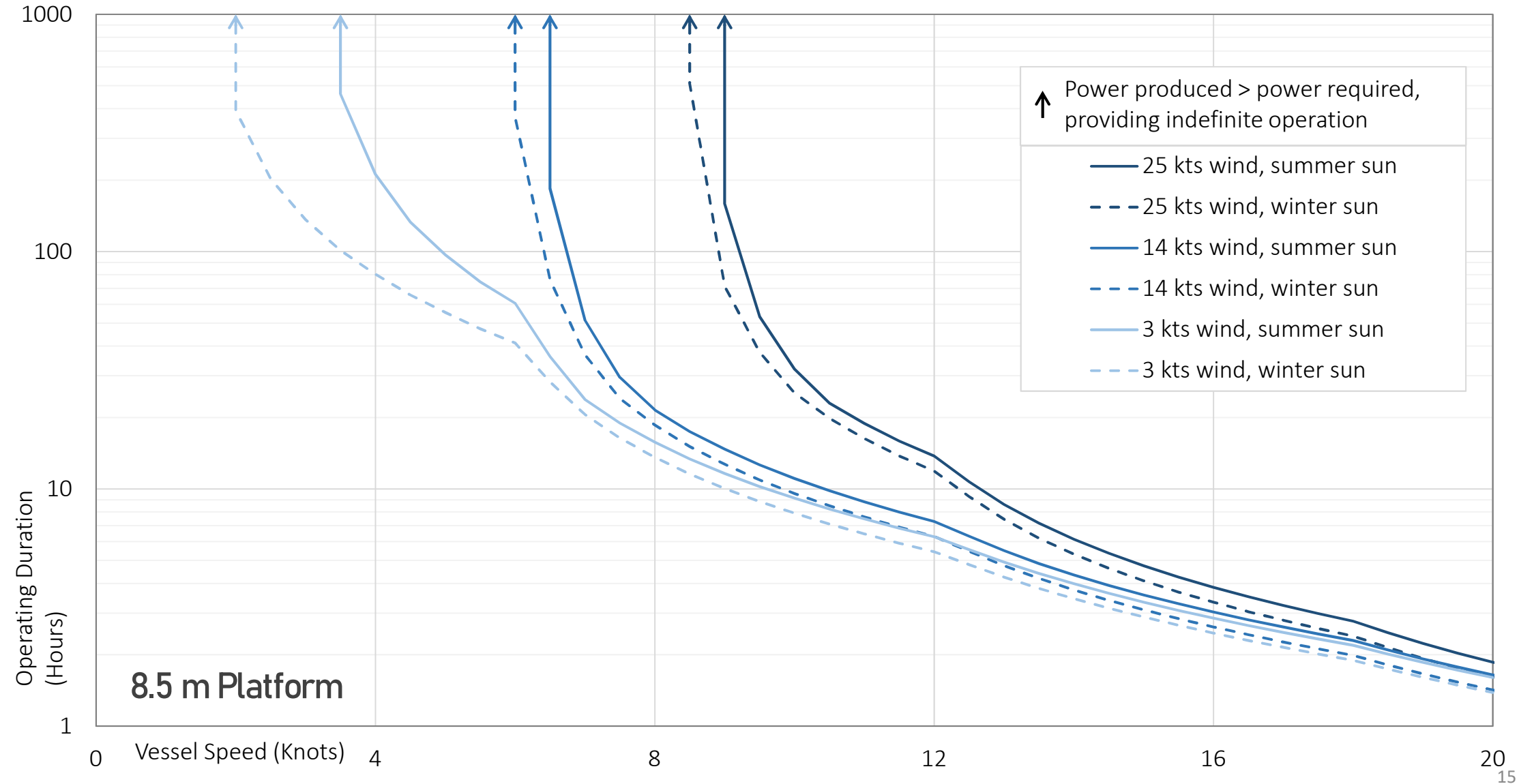
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- EMAPS enabled by Leidos' advanced autonomy capabilities
- Vehicle-agnostic solution adaptable to diverse platform topologies
- Modular, open architecture designed to support third parties rapidly integrating innovative technologies
- Multi-layer autonomy solution capable of advanced functions including sense and avoid, advanced collaborative autonomy, and a range of special mission functions

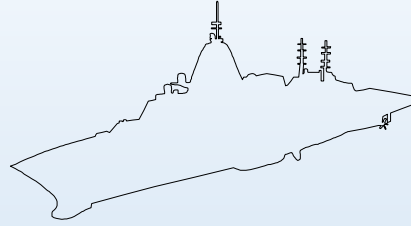


Speed-Range Performance

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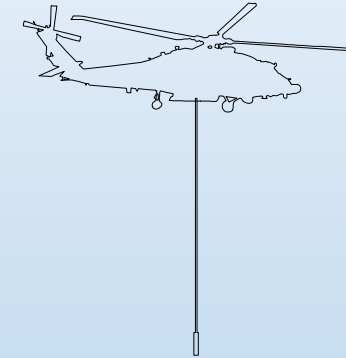


Hunter Class Frigate

- Hull Mounted Sonar
- Towed Low-Frequency Active Sonar
- Towed Line Array Passive Sonar
- Twin Lightweight Torpedo Launchers

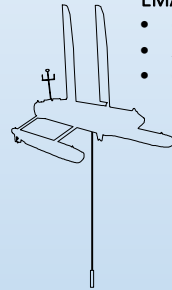
MH-60R ASW Aircraft

- AN/APS-153 Multi-Mode Radar
- AN/AQS-22 airborne low-frequency sonar
- Twin Mk 54 Lightweight Torpedos



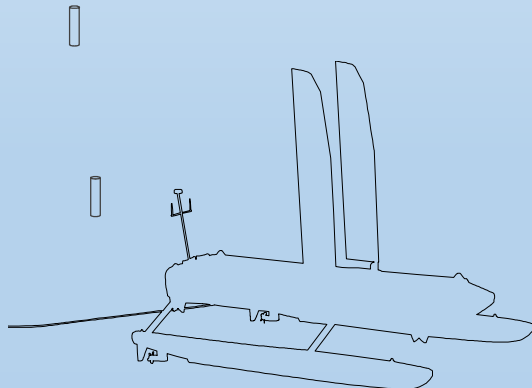
EMAPS 2

- CTD Sonde / Winch Pack
- Sonobuoy Canister Array Pack
- Compact Active / Passive Dipping Sonar



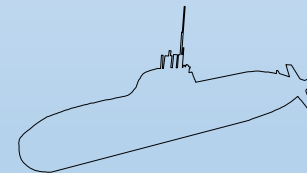
Sonobuoy Picket

Laid by EMAPS 1 on transit to far side of search area



EMAPS 1

- 20 mm Class Towed Line Array Sonar
- Sonobuoy Canister Array Pack
- Compact Active / Passive Dipping Sonar



Threat Submarine

- Multiple sonar systems
- Submarine-launched anti-ship missiles
- Heavyweight torpedos