Navy Hybrid Ultra Large Airship (HULA) program

Peter Lobner, 21 December 2020

1. Origin of the Navy's HULA program (2001 – 2003)

The Joint Chiefs of Staff (J-4 Mobility Division) began an investigation into the military utility of hybrid airships in 2001. In June 2002, J-4 engaged Naval Air Systems Command (NAVAIR) to support this effort. In response, NAVAIR formed their Advanced Development Program Office (ADPO) – Airship Concepts, which directly supported J-4 and led the Navy's Hybrid Ultra Large Airship (HULA) program.

Author Chuck Meyers reported that the J-4 support tasks included:

- A technical verification of the J-4-funded "SkyCat-1000 Engineering Study"
    - The SkyCat-1000 hybrid airship was designed and proposed to the Department of Defense (DoD) by the UK firm Advanced Technologies Group (ATG).
    - The engineering study examined a notional 1000 ton payload hybrid platform from a technical perspective as well as operationally in intra- and inter-theater airlift scenarios.
- Conceptual design of hybrid airships:
    - A 30 to 50 ton Hybrid Airship Multi-Role (HAMR), which also would serve as a "proof of concept" model for much larger airships.
    - 500 ton Hybrid Ultra Large Airship (HULA).
- Investigations of airship survivability and technical risks
- Development of military concept of operations (CONOPS) for hybrid airships
- Exploration of commercial applications

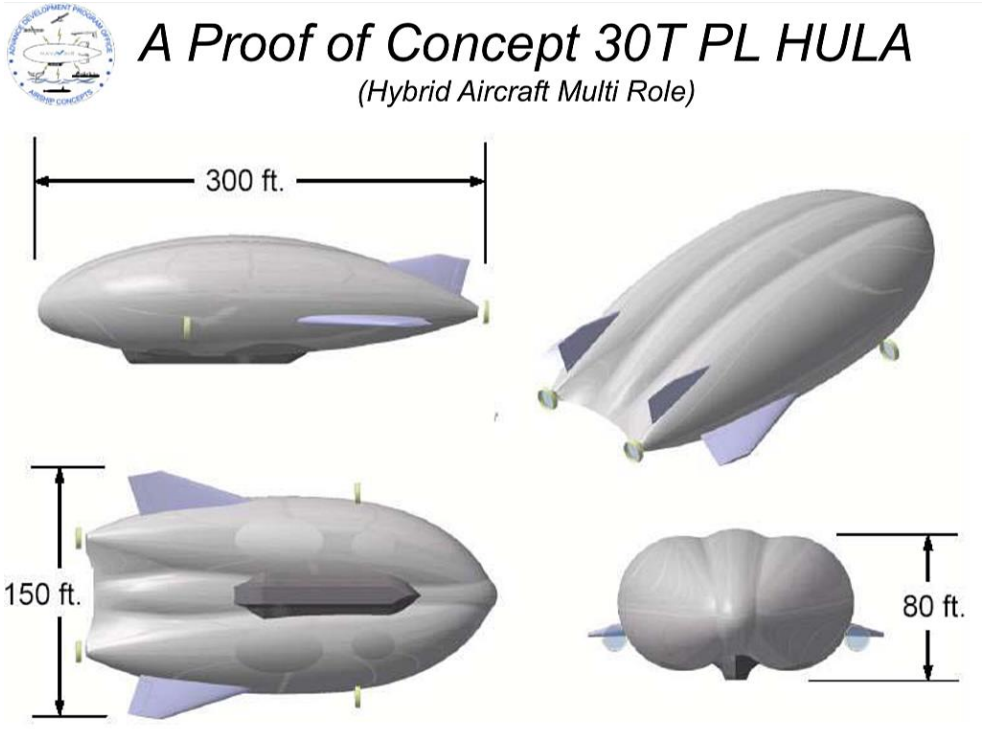
The following naval mission were identified:

- HULA heavy-lift missions:
    - Carry loads up to 500 tons (454 metric tons) over distances of more than 5,000 miles (8,047 km) at 60-90 knots, cruising at altitudes from just off the surface to 10,000 feet (3,048 m).
    - Insert forces inland from the continental US or from an advanced sea base
- HAMR medium-lift missions:
    - Extended range littoral and ocean patrols, with unmanned aerial systems (UAS) aboard to provide an over-the-horizon close-up look at targets of interest; also perform anti-submarine warfare (ASW) and anti-mine warfare.
    - Resupply naval forces afloat (Advanced Sea Base Connector)
    - Insert forces inland from an advanced sea base
    - Employ large aperture, low-frequency three-dimensional radar for force protection against cruise missiles and surface threats such as fast boats
    - Sea Power 21 implementation of network centric / ForceNet ISR (Intelligence, Surveillance, Reconnaissance) elements
    - Insert special operations forces elements

The 30 to 50 ton hybrid airship design concept developed by ADPO and the J-4 study team is shown in the following diagrams. This design concept was very similar to the ATG SkyCat-20. Based on their 2002 – 2003 engagement with J-4, NAVAIR concluded that the technical risk was low to moderate for a 30 to 50 ton hybrid airship.

In May 2003, NAVAIR (Patuxent River, MD) announced its plans to host an “industry day” conference on 5 June 2003 to discuss the HULA program and hybrid airship technologies with interested companies. At that time, the envisioned product of the HULA program was a range of hybrid airships with 30 to 1,000 ton payload

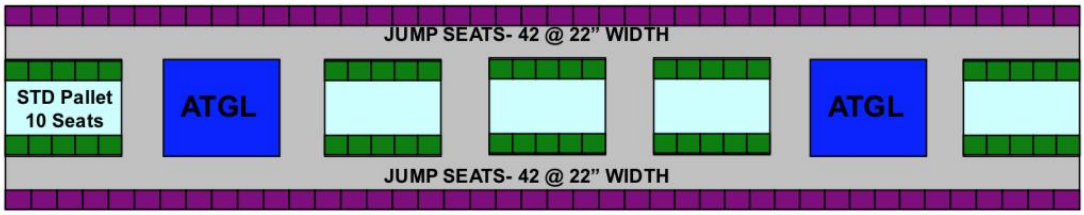
capacities, able to transport outsized cargo between areas that lacked prepared reception facilities, and able to operate from water.



Source, both graphics: NAVAIR ADPO – Airship Concepts (2009)

HULA 30ton MILITARY PASSENGER LAYOUTS
(NOTIONAL)

LONG/MEDIUM RANGE – 134 PAX MAXIMUM



Source: NAVAIR ADPO – Airship Concepts (2009)

NAVAIR planned to fund up to four contractors will up to $2.5 million each to produce and demonstrate their individual designs with a subscale model that would fly within one year of contract award (to occur in FY2004). In addition, the selected contractors were expected to produce conceptual designs of 30 and 500 ton HULAs for which the data from their flying model was applicable.

This industry day was cancelled when plans were announced to transfer the HULA project from NAVAIR to the Defense Advanced Research Projects Agency (DARPA) later in 2003.

2. DARPA assumes the lead with Project WALRUS (2003 – 2006)

Under DARPA, HULA became known as the WALRUS Global Reach Air Vehicle Program, or simply Project WALRUS. DARPA convened an industry day in March 2004 to discuss its proposed WALRUS hybrid heavy-lift airship program with interested industry teams.

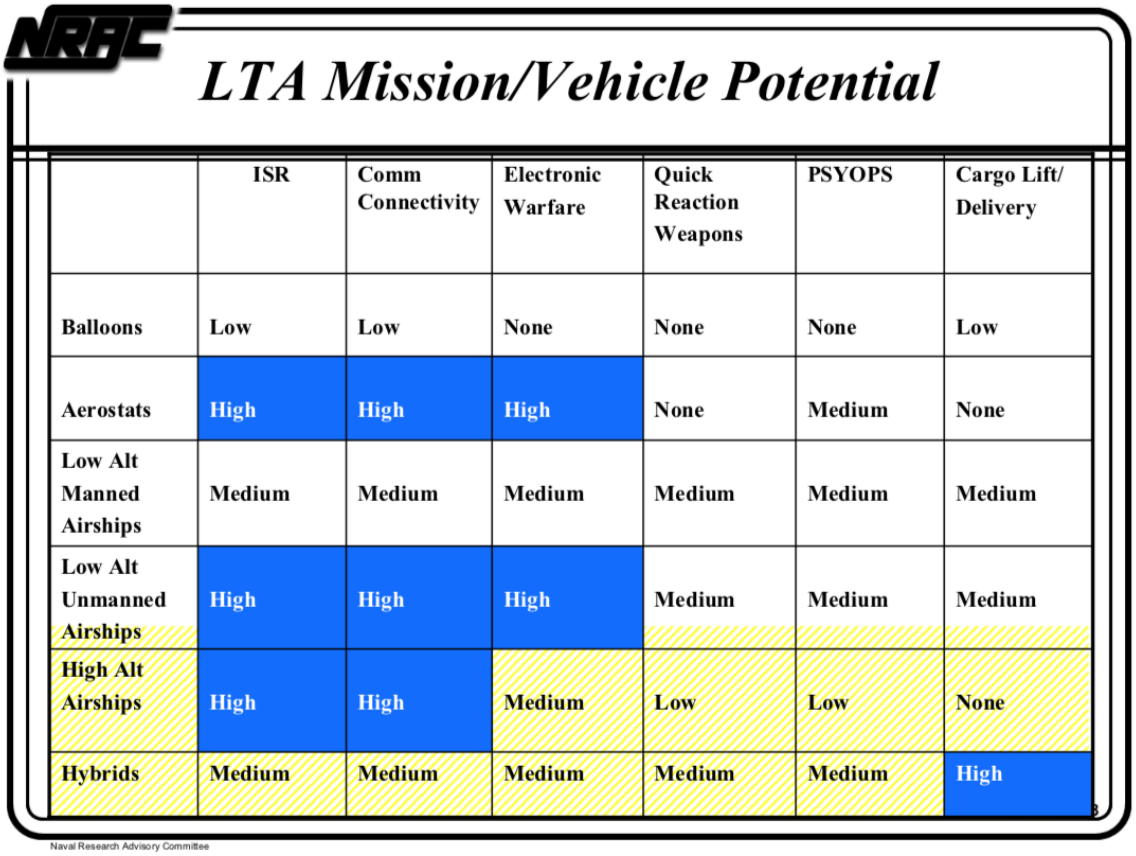
Project WALRUS continued under DARPA leadership from mid-2003 until the project was terminated in mid-2006, after completion of Phase I. By that time, Project WALRUS had produced one flying hybrid airship prototype, the Lockheed Martin P-791, which successfully demonstrated the practicality of a hybrid airship and its flight controls, vectored propulsors and air cushion landing system (ACLS). This demonstration helped reduce NAVAIR's perception of

technical risk for a 30 to 50 ton hybrid airship to “Low”. For more information, see my separate article on Project WALRUS.

After the termination of Project WALRUS, the Navy’s interest in lighter-than-air craft, including heavy lift hybrid airships, remained under the auspices of the NAVAIR ADPO - Airship Concepts. However, the Navy did not have any active LTA program of its own at that time.

3. NRAC LTA Assessment (2005 – 2006)

In 2005, before the termination of Project WALRUS, the Naval Research Advisory Committee (NRAC) was tasked to “assess applications of LTA technology for the full spectrum of Sea Power 21 missions and for providing capabilities to meet new GWOT” (global war on terrorism). This NRAC assessment evaluated a range of LTA vehicles against a set of mission requirements and developed the following ranking of potential naval LTA vehicle applications.



	ISR	Comm Connectivity	Electronic Warfare	Quick Reaction Weapons	PSYOPS	Cargo Lift/ Delivery
Balloons	Low	Low	None	None	None	Low
Aerostats	High	High	High	None	Medium	None
Low Alt Manned Airships	Medium	Medium	Medium	Medium	Medium	Medium
Low Alt Unmanned Airships	High	High	High	Medium	Medium	Medium
High Alt Airships	High	High	Medium	Low	Low	None
Hybrids	Medium	Medium	Medium	Medium	Medium	High

The blue boxes indicate high potential applications. The yellow cross-hash indicates types of LTA vehicles / applications with little of no operational experience (i.e., they were either in prototype stage, partially demonstrated, or existed only as conceptual designs).

Regarding heavy-lift hybrid airships, NRAC reported:

> "The uses of LTA vehicles to transport, load, and unload cargo from land or sea-based depots to an area close to the warfighter could be a unique role for LTA technology. If cargo can be loaded and unloaded efficiently, total turnaround time can be less than currently possible using conventional air, sea, or ground transport or any combination of these."
>
> "The goals pursued by the DARPA WALRUS program have potential for furthering LTA development. The ability of the LTA vehicle to travel at more than 70 knots, at altitudes of thousands of feet, coupled with its speed and highly survivable envelope, promises to make it very difficult for an enemy to target, attack, and destroy it, thus considerably reducing the difficulty of defending U.S. lines of communications."
>
> "When the WALRUS concept is demonstrated in 2009, the potential to carry loads of 40 tons at speeds greater than 70 knots, at distances of 2,000 nautical miles, and with the ability to land and takeoff in unimproved areas with minimal ground support will greatly enhance current LTA platform capabilities. And if the concept design can be scaled up to the goals of transporting a 500-ton payload to ranges of 12,000 nautical miles – the heavy-lift goal of providing direct logistics support from "fort to foxhole" may be realized."

NRAC identified the following technical challenges that must be overcome for heavy lift airships to serve as viable naval operational platforms.

- To achieve desired payload fractions over the ranges required, the LTA vehicle must achieve lift to drag (L/D) ratios of 25 to 30 at speeds greater than 70 knots. Currently, at these speeds, the

best L/D ratio demonstrated for traditional airships is only about 15-20.

- The ability to control internal buoyancy during flight without the need for extra ballast is critical to compensate for the large amounts of fuel that would be consumed, fuel that could roughly weigh as much as the vehicle payload.
- Heavy lift LTA vehicles must also be able to takeoff and land in a “heavy” or full load configuration without requiring the support of large ground crews.
- The development and demonstration of concepts for the structure and fabric remain critical issues. NRAC estimated that fabric technology development for a 500 ton (454 metric ton) HULA would require two years of research.
- Issues associated with takeoff, landing, loading, and unloading from ships such as the Marine Pre-Positioning Force (Future) (MPF(F)) must be carefully studied to determine the impacts on the airship and the ship.

Among their conclusions, NRAC noted:

- The Navy is behind the Marine Corps, Army and Air Force in the use of LTA vehicles for military missions.
- The highly ranked hybrid heavy lift cargo airship and the high altitude ISR / communications airship require significant investment but offer promise for greatly enhancing performance.
- Current LTA capabilities for heavy lift and high altitude ISR are being oversold.

NRAC recommendations related to heavy lift airships were:

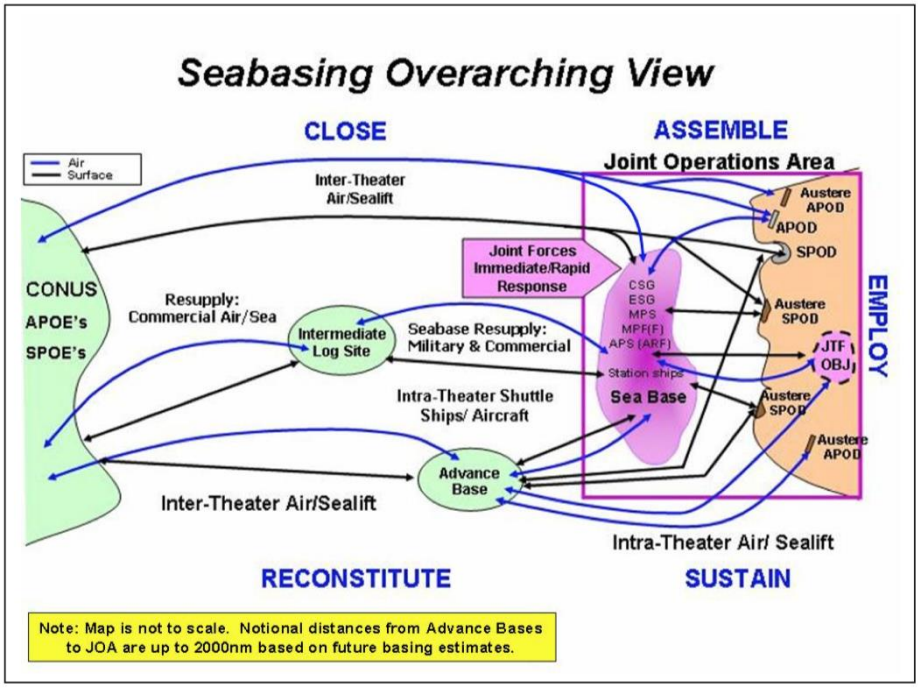
- The Navy should initiate a series of studies to look at operational concepts for transiting heavy-lift LTA vehicles to and from ships.
- The Navy should adopt a “wait-and-see” strategy with respect to the DARPA WALRUS program, until the prototype WALRUS LTA platform is developed and demonstrated.

- A series of system-level studies should be performed to confirm that the Navy's planned MPF(F) ships will be compatible with proposed heavy-lift airship concepts.
- Depending on the findings of the DARPA WALRUS program and Navy studies, the Navy should consider modifying a ship to serve as a platform for research on use of maritime platforms as bases for LTA heavy-lift vehicles, as well as for high-speed aerostats and unmanned airships.

4. Congressional Budget Office (CBO) Sea Basing Study (2007)

In their 2005 Joint Integrated Concept (JIC) document, the Joint Chiefs of Staff defined "seabasing" (or sea basing) as follows:

> "Seabasing is defined as the rapid deployment, assembly, command, projection, reconstitution, and re-employment of joint combat power from the sea, while providing continuous support, sustainment, and force protection to select expeditionary joint forces without reliance on land bases within the Joint Operations Area (JOA). These capabilities expand operational maneuver options, and facilitate assured access and entry from the sea."



Source: DoD, Seabasing JIC v1.0 (2005)

In 2007, the CBO published their assessment of sea basing alternatives for “employing” (deploying) one Marine Expeditionary Brigade (MEB), with about 2,000 personnel, and sustaining one MEB and one light Army brigade.

The CBO assessment included alternatives using heavy lift airships.

- For “employment and sustainment” of the invasion force, Alternative E4 involves developing and buying 46 hybrid heavy-lift airships (40 + 6 spares).
- For “sustainment-only”, Alternative S4 requires 8 airships (6 + 2 spares) to deliver 1,000 tons of cargo per day from an advance base 2,000 nm away. Triple the number of airships (17 vs. 6) would be needed to deliver comparable supplies directly from the continental US if an advance base was unavailable.

These hybrid airships were assumed to be similar in design to the concepts explored in DARPA’s Project WALRUS and by NAVAIR’s ADPO - Airship Concepts. The notional airships would carry more than 10 times the average payload of an Air Force C-17 cargo aircraft but would travel at only one-fourth the speed. The CBO noted that the hybrid airship design would reduce or eliminate the need for large transfers of stabilizing ballast during loading and unloading and would make the airship easier to handle on the ground. High winds could still present control problems during loading, transit, and unloading.

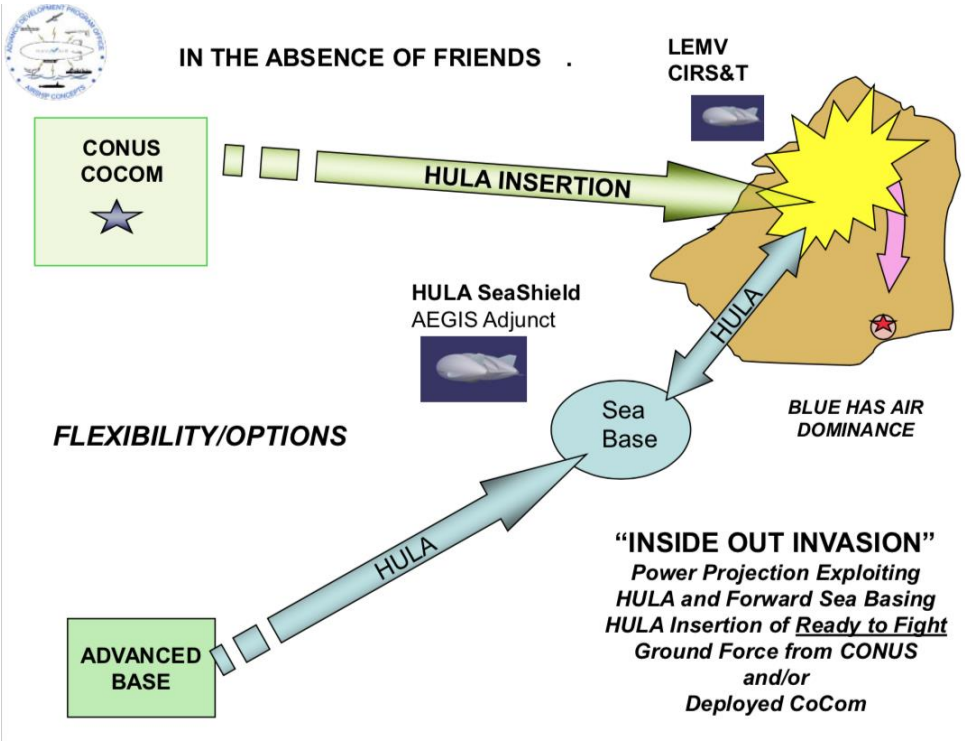
Particular advantages of using hybrid heavy-lift airships in sea basing roles include:

- Ability to deploy one MEB in 7 days, several days to weeks faster than all other alternatives
- Ability to reach 90% of the world’s land area (total land area with ground elevation no greater than 5,000 ft MSL), much greater than all other alternatives except airdrop (for sustainment only)
- Lower cost than several alternatives, including new rotocraft

The CBO acknowledged that Navy or Air Force defense-suppression operations would be needed to neutralize or destroy defensive systems in the landing area before the arrival of the invasion force.

5. NAVAIR 2009 briefing

In Sept 2009, Steve Huett, the Director of NAVAIR's ADPO - Airship Concepts, gave a presentation titled "Hybrid Aircraft: Envisioned Military Relevance," explaining how hybrid heavy-lift airships expand strategic and tactical options for inserting and supporting Joint Combat Forces in combat zones. The following diagram shows a proposed CONOPS for using heavy-lift hybrid airships for "employment and sustainment" of an invasion force in spite of an adversary's anti-access measures and without involving a third-party nation.

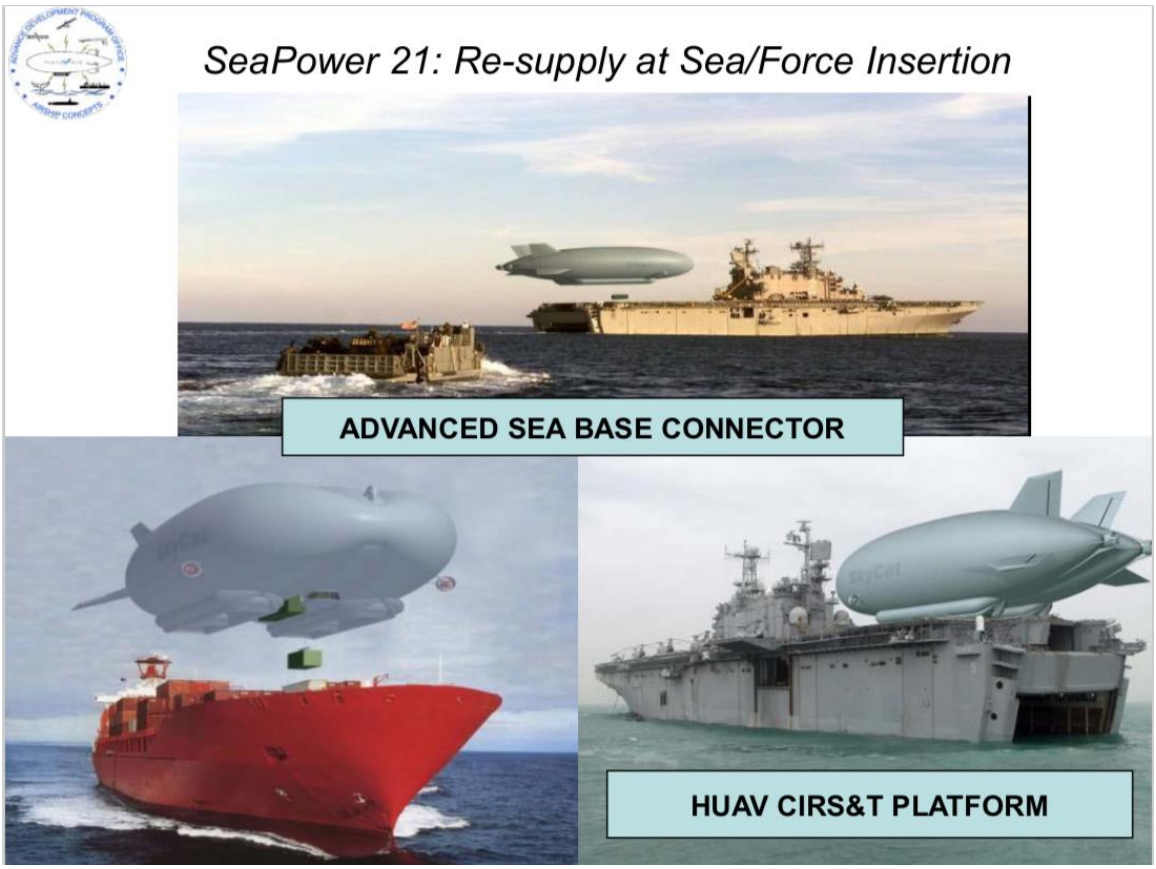


Concept of operations for HULA invasion support.
Source: NAVAIR ADPO – Airship Concepts (2009)

The military forces arrive by HULA deployed directly from the continental US and/or from an advanced base via Navy ships at sea that serve as a temporary sea base. The Navy's forces at sea are protected by a HULA / HAMR "SeaShield" airship that is monitoring

for threats such as cruise missiles, aircraft and surface ships. In-theater ISR support is provided by a HULA / HAMR "LEMV CIRS&T" airship. In a prolonged conflict, the sea base is resupplied by HULA flying from the advanced base.

As of late 2020, the Navy has not funded HULA development and testing to confirm the operational practicality of using hybrid heavy-lift airships in the roles envisioned in the 2007 CBO sea basing study or the 2009 NAVAIR ADPO presentation.



Examples of sea base roles for hybrid heavy-lift airships.
Source: NAVAIR ADPO – Airship Concepts (2009)

6. For more information:

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