Hybrid Airships for Lift: A New Paradigm

Hybrid airships can fill a gap in the current military airlift system. But first, the Department of Defense must examine misconceptions about their safety and operational challenges.

By Major Zachery B. Jiron, USAF

The U.S. military's mobility platforms provide the basis for the Nation's global reach and power projection across the full range of military operations. However, as the Department of Defense (DOD) enters the second decade of the 21st century, it faces daunting challenges in fulfilling current and future mobility requirements. Budget cuts will force DOD to make difficult decisions in determining what combination of mobility assets across all of the services meets its logistics requirements.

These decisions may prove to be more critical in supporting a future joint operating environment that requires flexible lift platforms to accomplish point-of-need cargo delivery to the warfighter. All viable options for future transportation modes must be carefully evaluated, including the development of a hybrid airship for lift.[1]

Even though airships are currently demonstrating military utility and value in a number of applications, including intelligence, surveillance, and reconnaissance, border patrol, and communications platforms, considerable resistance is still encountered when the use of a hybrid airship for military lift is proposed. When presented as a transportation option, pragmatic assessment of hybrid airship use is hampered by stovepiped mobility analysis and narrow thinking or misconceptions about the operational challenges that face hybrid airships in a military environment.

Understanding the Potential of Hybrid Airships

With their ability to efficiently transport a large range of payloads across strategic distances to austere locations, hybrid airships have the potential to fill a gap in the current mobility system. These vehicles offer promising advantages to the future transportation distribution network because they are more economical to operate than fixed- and rotary-wing aircraft and do not require the complex, costly infrastructure currently needed for air and sea transportation modes.

Although airplanes and sealift vessels are proven transport modes, they must always terminate at an airport or seaport, and those rarely coincide with point-of-need destinations. Hybrid airships offer the potential to deliver supplies directly to users, avoiding the complications inherent in multimodal port operations. From combat cargo lift to humanitarian assistance and disaster relief operations to civilian cargo delivery in austere environments, hybrid airship technology is now poised to transform the transportation landscape. The fusion of more than a century of technological advances has shifted hybrid airship development from the realm of future concept to a realistic near-term production possibility.

However, while military logisticians are beginning to realize the potential lift capabilities of the hybrid airship, misinformed opinions on the challenges of using airships continue to plague rational analysis of the topic. A balanced assessment of the airship's potential use for military lift is not possible unless military personnel detach airlift from traditional paradigms of current analysis and understand that hybrid airships have the potential to be a separate-but-equal transportation mode.

As stated by Dr. Robert Boyd, the hybrid lift portfolio senior program manager for Lockheed Martin Aeronautics Advanced Development Programs, the hybrid airship "is not well characterized by either airplane-derived or airship-derived relations . . . . The implicit sensitivity to both speed and size sets this type of vehicle apart from

[1] Detailed operational concepts (including land and water operations) and engineering principles for cargo hybrid airships have been well established in a number of research efforts beyond the scope of this analysis. It is assumed that the reader is aware of the overarching principles in design and employment of the vehicle and also possesses a basic understanding of the advantages and challenges involved when considering the vehicle for lift. A thorough overview is available in "Back to the Future: Airships and the Revolution in Strategic Airlift," a 2005 study conducted by Colonel Walter O. Gordon, USAFR, and Colonel Chuck Holland, USAF (Ret.), and published in the *Air Force Journal of Logistics*, Fall–Winter 2005, pp.48−62. (www.aflma.hq.af.mil/shared/media/document/AFD–100120–037.pdf)

other flight vehicles, yielding unique design constraints and objectives."[2]

Among U.S. military personnel, notions about the perceived operational disadvantages of employing hybrid airships for lift are rooted in a cursory selection of historical airship disasters and a well-intentioned but flawed understanding of the topic. These misinformed preconceptions allow decisionmakers to summarily dismiss the idea. Therefore, to address the viability of employing hybrid airships as a future mode of U.S. military airlift, personnel must understand the value of assessing hybrid airships as a different transportation mode.

This can be done by briefly examining general airship history and the basic concepts of using hybrid airships for military transport while considering the strategy and doctrine shaping lift requirements for the future joint operating environment.

Airship History: An Exemplary Record

Hybrid airships should be examined as a distinctive mode of transportation for the global logistics system instead of trying to model them strategically and operationally as simply another airlifter.

Although airships are different for a number of reasons, the first barrier to a reasonable assessment arises from a selective deliberation on general airship history. In military airlift discourse, airships invoke a false idea of obsolete technology; most personnel immediately envision the *Hindenburg* crash of 1937. Despite more than 70 years of technological and engineering advances, the *Hindenburg* connection quickly reduces the debate to presupposed inadequacies in airship safety, which makes the military lift platform seemingly easy to dismiss. The first step in detaching the airship analysis from the standard airlift paradigm is to examine the often-forgotten history of its extraordinary performance in a challenging military environment that ended more than 50 years ago.

Although a number of historic airship tragedies easily affect current airship analysis, it is equally important to recall the impressive operational record of airships during the first half of the 20th century. Twenty years before the *Hindenburg* was destroyed, a German airship transported more than 30,000 pounds of cargo 3,600 miles from Bulgaria to Africa in 95 hours—landing with 64 hours of fuel remaining.[3] In 1929, the *Hindenburg's* sister ship, the *Graf Zeppelin*, circumnavigated the

This Lockheed Martin concept of the hybrid air vehicle has a very different look from the Goodyear blimp typically envisioned when thinking of an airship. (Photo courtesy of Lockheed Martin)

[2] Robert R. Boyd, "Performance of Hybrid Air Vehicles, American Institute of Aeronautics and Astronautics Report 2002−0388, 40th Aerospace Sciences Meeting and Exhibit, 12−15 January 2002, Reno, Nevada, p. 1.

[3] Colonel Walter O. Gordon, USAFR, and Colonel Chuck Holland, USAF (Ret.), "Back to the Future: Airships and the Revolution in Strategic Airlift," *Logistics Dimensions 2006*, July 2006, p. 19.

globe with only four stops, completing a 7,000-mile leg between Germany and Japan in 100 hours.[4] Both feats were unimaginable by aircraft at the time and proved that airships offered incredible potential for numerous military applications despite primitive technology and engineering in the contemporary aerospace field.

The U.S. Navy operated only four rigid airships from 1923 to 1941. They did suffer a 75-percent loss rate because of weather-related accidents—a significant, but understandable, number given the problematic weather prediction and monitoring capabilities of the time.[5] However, few recall that three of these four Navy airships logged over 1,500 flight hours before loss or retirement, a record far more remarkable than that of the first four U.S. military aircraft.[6] All things considered, in a period of limited weather forecasting and primitive technological development, rigid airships performed at an exemplary level in a demanding global aviation environment.

The transition to nonrigid airships resulted in even more robust vehicles executing a number of complex military missions. During World War II, the Navy used nonrigid airships for antisubmarine warfare, convoy escort, and airborne early warning. It operated 134 blimps with an 87-percent availability rate and suffered only 1 combat loss.[7] Before retiring the last nonrigid vehicle in 1961, the Navy flew 36,000 missions and accumulated a remarkable 412,000 flight-hours.[8] Equally impressive was the 1957 flight of the Navy's nonrigid ZPG−2 *Snow Bird*, which took its crew on a 264.2-hour, 9,448-nautical-mile voyage and broke world records for total continuous unrefueled distance and time aloft. [9]

Thus, for a 50-year period ending more than half-a-century ago, airships posted noteworthy safety and mission completion records in a number of dynamic environments despite the limited technology of the time. If it were not for tremendous advances in fixed-wing aircraft technology, airship development might have accelerated in parallel and hybrid airship cargo platforms would be employed today.

Although this is only a small sampling of the historical capabilities of airships, it is the first step in demonstrating that airships should not be assessed using a traditional airlift paradigm. While historical airship difficulties are important to consider, their tremendous accomplishments are also critical to assess when contemplating the use of such vehicles in the future.

The Hybrid Airship: An Augmenting Capability

A second aspect that is essential to accurately framing an analysis of the hybrid airship is a basic understanding of the vehicle itself. A working knowledge of its capabilities and operational concepts is critical in recognizing that it does not fit into a standard airlift paradigm.

When developing airship platforms for heavy lift, modern aircraft manufacturers are developing concepts based on the hybrid airship. Unlike traditional airships that rely on a contained gas within the envelope to provide all required lift for flight, hybrid airships use a combination of buoyant lift (provided by a gas such as helium), aerodynamic lift (generated by airflow across the surfaces of the vehicle) and, in some cases, direct vertical lift provided by propulsion systems (similar to current rotary-wing aircraft). In essence, this lift combination allows the vehicle to climb and descend in a heavier-than-air fashion—a critical attribute that allows for a greater useful payload range and overcomes the historical challenges of buoyancy control that have plagued engineers when designing airships for lift.

With envelope buoyancy providing 70 to 80 percent of the required lift and aerodynamic lift providing the remainder, engineers can maximize payload ranges and optimize fuel and speed efficiencies.[10] This gives the hybrid airship significant advantages and potential operational capabilities when augmenting traditional lift modes. Tremendous fuel efficiency, a cruise capability of 100 or more knots, a payload-driven short takeoff and vertical landing capability, and self-contained ground-handling systems place hybrid airships in an entirely different category of lift options.

Many aspects of this platform are drastically different from current land and sea mobility platforms, so it is beneficial to use perspectives from both modes to best assess hybrid airship operational capability. Instead of a flight deck, a hybrid airship would be controlled like a traditional ship's bridge, with a mission commander overseeing critical phases of the mission (similar to naval operations). This introduces significant implications for mission planning, crew management, and a number of other operational issues that require a different perspective from legacy lift platforms. For example, traditional runway and terminal operations do not apply to the hybrid airship; in-

[4] Ibid., p. 20.

[5] Military Potential of Hybrid Airships, RAND Project Air Force Report FA7014–06–C–001 (Proprietary), RAND, Santa Monica, California, May 2008. [Information cited by author is non-proprietary, used with permission from Blaise Durante, SES, SAF/AQX, 23 August 2011.]

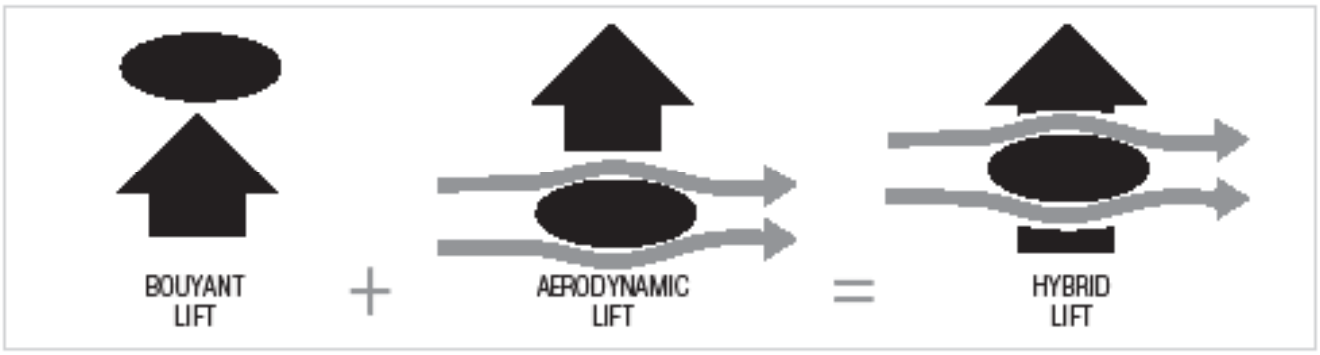
[6] Gordon and Holland, "Back to the Future," p. 20.

[7] RAND, Military Potential of Hybrid Airships, p. 27.

[8] Ibid, p. 27.

[9] Roy A. Grossnick, ed., *Kite Balloons to Airships . . . the Navy's Lighter-than-Air Experience*, U.S. Government Printing Office, Washington, DC, 1987, pp. 73−75, <www.history.navy.mil/branches/lta-m.html>, accessed 7 September 2011.

[10] Robert R. Boyd, Interview with author, 31 August 2011.



Modern aircraft manufacturers are using the hybrid lift concept in developing airship platforms. (Chart courtesy of Lockheed Martin)

stead of a runway, operators would be concerned about a clearway. And crosswind arrival and departure operations are not an issue; the vehicles always operate into the wind.

In light of these and many other nontraditional factors, operational assessments of hybrid airships diverge significantly from traditional fixed- and rotary-wing platforms. Hybrid airships would not replace mobility modes but would enhance future distribution systems. Instead of supplanting the other air, sea, and land modes of transport, hybrid airships would augment the intermodal system and operate in the critically uncontested cost and speed gap between surface (sea and land) and traditional air modes of transportation.

Based on quantitative and qualitative analyses, the U.S. Transportation Command (TRANSCOM) recently released its 2011 Future Deployment and Distribution Assessment, which provides a cogent summary of hybrid airship capabilities:

> *The capabilities of hybrid airships could be applied to a multitude of missions throughout the range of military operations. They offer the payload and range to deliver operationally significant forces and sustainment over strategic distances. They could access any open location in the Joint Operations Area (JOA), have the ability to bypass enemy defenses and overcome area denial efforts, and have the precision to deliver to or near the desired point of need that may not have adequate infrastructure.*[11]

Faster than a ship but significantly cheaper than strategic and tactical aircraft, hybrid airships can deliver cargo directly to the land and sea points of need with minimal fixed infrastructure requirements. This minimizes the cost and transload-time requirements inherent in contemporary multimodal operations.

In fact, recent TRANSCOM analyses suggest that, while costlier than surface shipping, hybrid airship operating and sustainment costs range from one-half to one-tenth of current air modes (CH−47 Chinook helicopter to Boeing 747−400) and cost 10 times less to develop than commercial and military aircraft.[12] This is a critical consideration for a potential joint vehicle supporting all DOD branches since aircraft development costs can now reach tens of billions of dollars and aging equipment and fuel costs push operating and sustainment costs prohibitively higher.

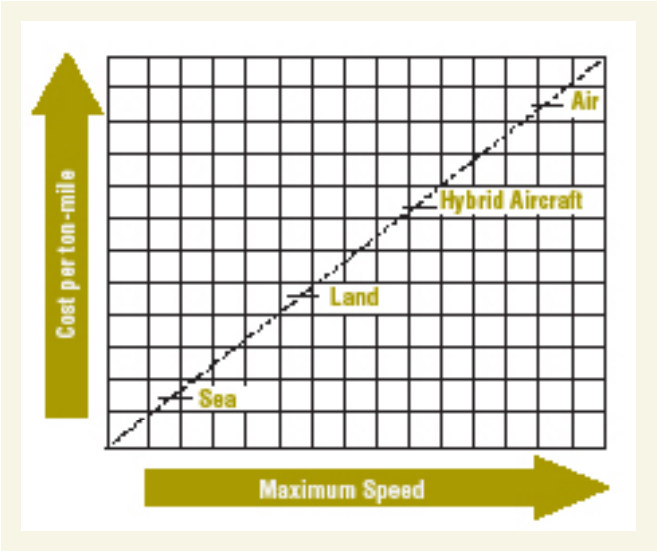
Advances in materials, propulsion, and ground-handling technology have resulted in the potential for a wide range of payload options, ranging from 20 to 500 tons, with self-contained on-and-off-load capability and mooring systems that reduce the intensive manpower requirements that plagued early airships. Industry experts believe 500-ton payload variants will be technologically viable within 20 years.[13]

These are simply a few of the many advantages of employing hybrid airships for lift, and they demonstrate that the platform does not neatly fit the traditional airlift model. In a pragmatic assessment of future military use, hybrid airship size, employment, and capability are remarkably different from conventional airlift and should be viewed as such. Linking this idea with logistics doctrine and strategy reinforces the idea that the hybrid airship should be appraised through its own framework.

Doctrine and Strategy: Future Requirements

U.S. national security strategy and military doctrine provide the basis for future military logistics require-

[11] "Future Deployment and Distribution Assessment: Mobility Lift Platforms (Volume I)," TRANSCOM Joint Distribution Process Analysis Center, Scott Air Force Base, Illinois, June 2011, pp. 2–3.
[12] Boyd, interview, 31 August 2011.
[13] Ibid.



Using hybrid airships to transport cargo could provide an alternative to land transportation that would provide significant cost savings over traditional air transport. (Chart courtesy of Lockheed Martin)

ments and how they assist DOD in meeting national security commitments. The key strategy and doctrine quoted below provide the basis for leveraging potential hybrid airship capabilities in conjunction with current and future lift modes and reinforce the requirement to analyze the hybrid airship as a distinctive, but complementary, transportation mode.

2011 National Military Strategy: Joint forces will "become more expeditionary in nature and will require a smaller logistical footprint." They will "perform full spectrum operations to assure . . . rapid global mobility . . . and retain the ability to project power into distant, anti-access environments."[14]

2010 Joint Operating Environment: "In planning for future conflicts, Joint Force commanders and their planners must factor two important constraints into their calculations: logistics and access."[15]

2009 Capstone Concept for Joint Operations: "We will need to develop new capabilities . . . . We will need to develop new technologies and adapt existing ones to new missions."[16] Joint forces "will require a mix of air and sea strategic and operational lift capable of delivering forces and materiel to their destinations, often in the absence of capable airfield and port facilities."[17]

2006 Joint Logistics (Distribution) Joint Integrating Concept: The capabilities of the "theater distribution segment(s) fall short of what is required to integrate into a comprehensive end-to-end distribution pipeline . . . . Intra-theater lift (will be) challenged to accommodate demands of increasingly more simultaneous, distributed, and non-contiguous operations."[18]

An essential task of the JDDE [Joint Deployment and Distribution Enterprise] will be to "accomplish the closure of early-deploying, expeditionary joint forces across strategic and theater movement segments in a single movement from their point of origin to a point designated by the JFC [joint force commander] and bypassing, if necessary, traditional ports of debarkation, enabling units to move to points of need for prompt operational employment in support of 'seizing the initiative'."[19]

Without assessing the hybrid airship within the framework of future mobility requirements set forth by U.S. civilian and military leaders in these guidelines, an accurate appraisal is not possible. Most importantly, these guidelines dictate that future logistics operations must be able to be executed in anti-access, area-denied environments despite any damaged or insufficient infrastructure.

DOD will be required to develop robust capabilities that enable theater access to austere land and sea ports while reducing reliance on intermodal cargo transfers. Current airlift platforms and the intermodal nature of the existing distribution network are not optimized for this direct-delivery environment. Hybrid airships can fill the void.

In essence, as a distinct mobility airlift platform, the hybrid airship cannot replace current transportation modes. But it can augment their capabilities by being employed in the critical cost-speed gap. Hybrid airships provide capabilities that are not necessarily better or worse than those of fixed- and rotary-wing lift assets—they are just different and should be viewed as such.

A true understanding of the hybrid airship's capabilities cannot be acquired without developing a new paradigm, different than that of current mobility aircraft, for hybrid airship analysis. Contemplating airship history (both good and bad) and basic hybrid airship operational concepts while understanding the future joint logistics environment provide the appropriate perspective for assessing their viability for future lift.

Recommendations

Clearly understanding the hybrid airship's unique operational characteristics and visualizing its use as a

[14] National Military Strategy of the United States of America 2011: Refining America's Military Leadership, 8 February 2011, Joint Chiefs of Staff, Washington, DC, pp. 18–19.4 Ibid., p. 20.
[15] The Joint Operating Environment (JOE) 2010, U.S. Joint Forces Command, 18 February 2010, p. 63.6 Gordon and Holland, "Back to the Future," p. 20
[16] Capstone Concept for Joint Operations (CCJO), Version 3.0, 15 January 2009, U.S. Department of Defense, p. iv.
[17] Ibid, p. 31.
[18] "Joint Logistics (Distribution) Joint Integrating Concept (JLDJIC), Version 1.0, 7 February 2006, Joint Chiefs of Staff, Washington, DC, p. 10.
[19] Ibid, p. 14.

distinct transportation mode reveal that it has the potential to fill the critical transportation cost-speed gap and increase lift options across the range of military operations, from humanitarian assistance to combat employment. Once the concept is judiciously examined, DOD should consider means to procure the platforms. This can be done organically or by incentivizing industry partners to acquire the assets for commercial use and military employment under a Civil Reserve Air Fleet (CRAF)-type construct. Under such an arrangement, commercial users would own and operate the vehicles and augment the DOD organic lift fleet when needed during both peacetime and contingency operations.

A significant difference between hybrid airship and traditional military lift vehicles is commercial practicability. While military variants might include defensive systems and other features needed to meet military specifications, the principle platform, from small to large variants, is being considered for a range of commercial lift requirements. This vehicle has the potential to meet the critical needs of energy and mining logistics operations in the austere locations of northern Canada, the Arctic, and Africa.

Unfortunately, the commercial demands of this niche market will not attract the funding aerospace companies need to develop a cargo hybrid airship; a clear demand signal and investment from potential military or other Government users is needed. [20] For this reason, it is critical for DOD to engage with industry to complete risk-reduction analysis and insist on cost-sharing arrangements for future hybrid airship development and production.

Approval of a joint capabilities technology demonstration administered by DOD in partnership with Air Force and industry would provide the basis for proving the baseline capabilities that these vehicles might offer for the future distribution system. As former Chief of Staff of the Air Force, General Norton A. Schwartz, commented, the success of the military and industry "are now mutually related, perhaps more than they have ever been, and especially with the ongoing convergence of fiscal pressures and strategic uncertainty."[21]

In light of pending budget constraints, if the platform is developed and produced for commercial use, DOD must consider hybrid airship employment under a CRAF-type construct. This gives the Nation access to these critical assets when necessary while sharing the costs of initial design and development efforts with commercial partners.

In order to meet global mobility requirements in the future joint operating environment under constrained budgets, senior military leaders must pragmatically assess the capabilities and liabilities of hybrid airships for lift. Realistically assessing the vehicle's operational capabilities and challenges in the future joint operating environment requires personnel to examine the hybrid airship through the appropriate framework—a distinct mode of transportation that can significantly enhance the distribution network.

This framework must be properly constructed through an honest examination of airship successes throughout history in dynamic military environments and through a working knowledge of the capabilities and operational concepts that set it apart from legacy lift platforms. When assessing the vehicle in this light, along with significant technological leaps in all aspects of the hybrid airship, the platforms might be seen as viable lift options to fill the current cost-speed gap in the distribution system.

Hybrid airship concepts present DOD with incredible capabilities for future joint logistics at a critical time in U.S. history. Hybrid airship technology continues to mature, giving the military and its commercial partners a solution for tactical and strategic delivery to point-of-need locations without regard to intermodal infrastructure or destination austerity. Hybrid airship engineering and operational technologies are mature. The hybrid airship is now a viable lift option, and the military must partner with industry to fund and develop the hybrid airship to meet future requirements.

While procurement for an organic fleet may not be fiscally or operationally realistic, vehicle development for a CRAF-type arrangement allows DOD to leverage this tremendous capability when needed while avoiding the associated costs of operating and maintaining an organic fleet when traditional lift platforms can meet steady-state requirements. While commonly dismissed as a feasible lift option for a number of flawed or misinformed reasons, hybrid airships should be strongly and rationally considered for use in the future joint transportation distribution system.

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[20] "Future Deployment and Distribution Assessment: Mobility Lift Platforms (Volume I)," pp. 2–6.

[21] General Norton A. Schwartz, Chief of Staff of the Air Force, Address to the Air Force Association Convention, Washington, DC, 20 September 2011.