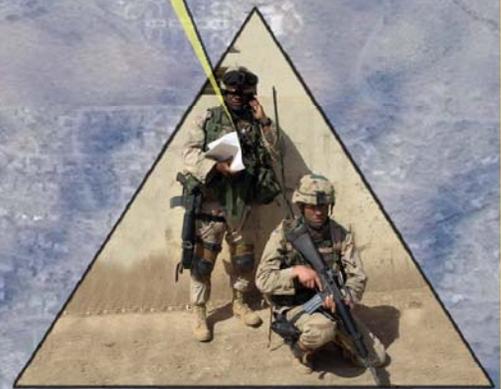
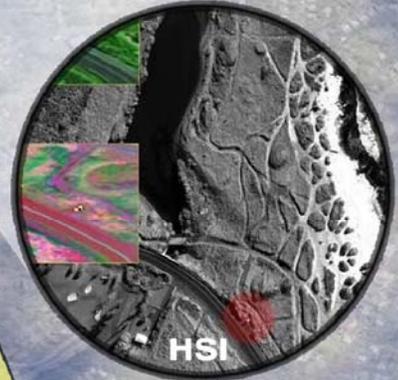


# Lighter Than Air

April 2006



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OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY  
(RESEARCH, DEVELOPMENT AND ACQUISITION)

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The Panel concluded that several Lighter Than Air (LTA) vehicles now available could provide the endurance and station-keeping needed for persistent ISR, communications relay, and electronic warfare. These vehicles can provide a desired long range communication relay for the Marine Corps and can perform port and harbor security missions at low costs. LTA vehicles offer the potential to provide an enhanced capability for high-altitude (greater than 60,000 feet) communications and surveillance at significantly lower cost than current heavier-than-air vehicles. LTA vehicles also could provide the capability to lift and deliver more than 500 tons of material or personnel to an operational area. While this capability does not exist today, with significant technology development, LTA vehicles could carry out these missions.

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# Lighter Than Air

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## **Executive Summary**

The Panel concluded that several Lighter-Than-Air (LTA) vehicles currently available could provide the endurance and station-keeping needed for persistent Intelligence, Surveillance, and Reconnaissance (ISR), communications relay, and electronic warfare (EW). These vehicles can provide a desired longer range communication relay for the Marine Corps and can perform port and harbor security missions at low costs.

The Panel believes that LTA vehicles offer the potential to provide an enhanced capability for high-altitude (greater than 60,000 feet) communications and surveillance at significantly lower cost than current heavier-than-air vehicles. LTA vehicles also could provide the capability to lift and deliver more than 500 tons of material or personnel to an operational area. This capability does not exist today. However, the Panel believes that significant technology development is required before LTA vehicles can perform these missions.

To demonstrate the feasibility of LTA vehicles for current and future naval missions, the Panel developed a number of specific recommendations, including field testing of aerostats for port and harbor security, and development of an aerostat that could be employed aboard a Navy ship. The Panel also recommended the demonstration of low-altitude unmanned airships as ISR, communications, and EW platforms; leveraging the Defense Advanced Research Projects Agency (DARPA) Integrated System is Structure (ISIS) program for development of a large-aperture radar that could be employed from a low-altitude LTA vehicle; and further studies to explore the use of a hybrid cargo-lift LTA vehicle to support future sea-basing concepts.

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# Introduction

Midway through the first decade of the 21<sup>st</sup> century, the Navy and Marine Corps confront a complex mix of missions ranging from traditional forward-presence operations to a frontline role in the Global War On Terror (GWOT). These missions demand persistent ISR capabilities, secure wide-area communications, EW, and heavy-cargo lift from ship to shore. Anti-terror operations may also require various approaches to psychological operations. At the same time, the sea services face severe constraints on funding for both acquisition of new platforms and Research, Development, Test & Evaluation (RDT&E) for new technologies. LTA vehicles such as; free-floating balloons, aerostats, and airships (a field where the Navy has had a wealth of experience); may offer cost-effective solutions for these complex mix of missions.

The Assistant Secretary of the Navy (Research, Development, and Acquisition) (ASN(RD&A)) asked the Naval Research Advisory Committee (NRAC) to examine the potential for LTA aircraft to provide answers for emerging Navy and Marine Corps missions.

The Lighter Than Air Systems for Future Naval Missions Panel was composed of former flag and general officers with extensive fleet command experience, as well as senior engineers and scientists from industry and academic institutions. The LTA Technologies study is the result of numerous hours of discussions and deliberations with experts in the field from DOD, the Services, and industry. The Panel proposes a number of proactive steps aimed at exploiting the advantages of LTA vehicles, while minimizing risks and costs, to provide the Navy-Marine Corps team with the new operational capabilities they require.

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## Panel Membership

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Texas Christian University

**Mr. Richard L. “Dick” Rumpf — Vice-Chair**  
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Northrop Grumman Electronic Systems Sector

**Dr. Patrick H. Winston**  
Massachusetts Institute of Technology

**Mr. David B. Bailey—Executive Secretary**  
Naval Air Systems Command

## Panel Membership

The LTA Study Panel was composed of highly accomplished experts with extensive experience in the fields of naval aviation operations, acquisition management, and engineering. The membership included former Navy flag and Marine Corps general officers with several years of experience in operations and acquisition, former Senior Executive Service members involved in the management of Navy technology development and acquisition programs, experts from defense and commercial companies, and senior scientists from university-affiliated research centers and academia.

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## Terms of Reference Objectives

- **Assess applications of LTA technology for the full spectrum of Sea Power 21 missions and for providing capabilities to meet new GWOT**
  
- **Emphasize:**
  - **Security of naval port/harbor resources**
  - **Force protection from cruise missiles, fast boats, shallow-water submarines and mines**
  - **Global transoceanic and sea-based delivery of cargo**
  
- **Sponsors:**
  - *Mr. William Balderson, Deputy Assistant Secretary of the Navy (RDA) for Air Programs*
  - *RDML Jeff Wieringa, Assistant Commander for Research & Engineering, Naval Air Systems Command*

## Terms of Reference Objectives

The Study Terms of Reference (TOR) defines the assignment to the Panel by the ASN(RD&A) and asks the Panel to evaluate the potential of LTA vehicles to contribute to emerging and traditional Navy and Marine Corps missions in an environment of constrained funding. The TOR requested the Panel to examine the designs, capabilities, and projected costs for several LTA types: Free-floating balloons, aerostats, and manned and unmanned airships in the context of the Navy and Marine Corps demanding new roles in GWOT and in the traditional missions of providing a forward-deployed naval presence. Within the study of missions and vehicle types, the Panel also evaluated potential payloads, including ISR sensors and communications systems that could provide cost-effective options for LTA vehicles. The Panel was asked specifically to assess the use of LTA vehicles for port and harbor security force protection against several threats and the use of LTA systems in a heavy-lift role. Mr. William Balderson, Deputy Assistant Secretary of the Navy for Air Programs for Air Programs and RDML Jeff Wieringa, Assistant Commander for Research & Engineering, Naval Air Systems Command (NAVAIR), were the sponsors for this study.

A copy of the TOR is provided in Appendix B.

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## Specific Tasks

- **Accomplishments:**
  - Reviewed current LTA development/acquisition, including U. S. and foreign military and commercial
  - Reviewed state of LTA industrial base
  - Identified strengths and weaknesses of current LTA technologies
  - Identified and prioritized missions for current and proposed LTA vehicles
  - Assessed costs of current LTA platforms
  - Proposed specific near, mid and far term actionable recommendations
- **Due to lack of future naval LTA concepts, did not assess:**
  - Systems and infrastructure
  - Life cycle costs
  - Acquisition strategy

## Specific Tasks

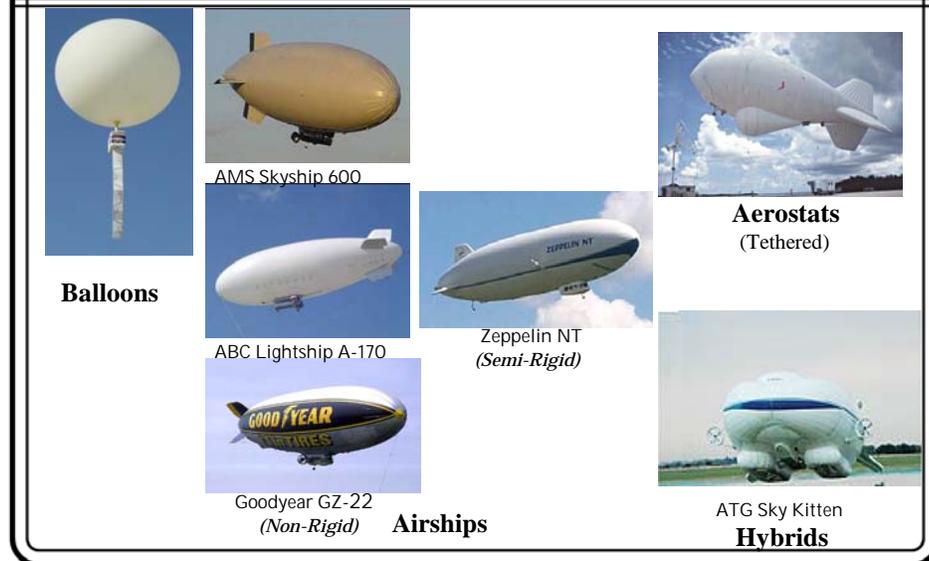
The Panel reviewed the current status of existing LTA vehicles, identified strengths and weaknesses of these LTA vehicles, and prioritized the use of LTA against potential high-value missions. The study also assessed the feasibility of two new proposed LTA concepts for high altitude (60,000-80,000 feet) and heavy-lift operations and developed recommendations for both classes of vehicles. Finally, the Panel assessed both unit and operating costs of existing systems and developed recommendations for LTA vehicles relative to high-value missions.

The Panel did not attempt to develop concepts for operations of LTA vehicles and therefore did not address life-cycle costs or acquisition strategies.

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## Categories of LTA Vehicles



## Categories of LTA Vehicles

For the purposes of this study, the term LTA will be applied to four buoyant types of vehicles. Some of these buoyant vehicles may not be neutrally buoyant, but by common usage are classified as LTA.

Balloons are near-spherical fully-buoyant LTA vehicles. Untethered balloons are released into the atmosphere and travel wherever the winds take them. They generally carry a range of payload weights and reach high altitudes. Balloons can be built either with closed envelopes that must expand as they rise in altitude, or as “zero-pressure” devices that have vents to prevent rupture of the envelope as the balloon rises. Most high-altitude balloons are “zero-pressure” balloons. There are numerous variations from these norms.

Some balloons are tethered vehicles that carry up to 30 passengers aloft at amusement parks or serve as aerial advertising billboards above sponsoring businesses. Other balloons (zero-pressure) have carried payloads of up to 5,000 pounds to altitudes as high as 134,000 feet.

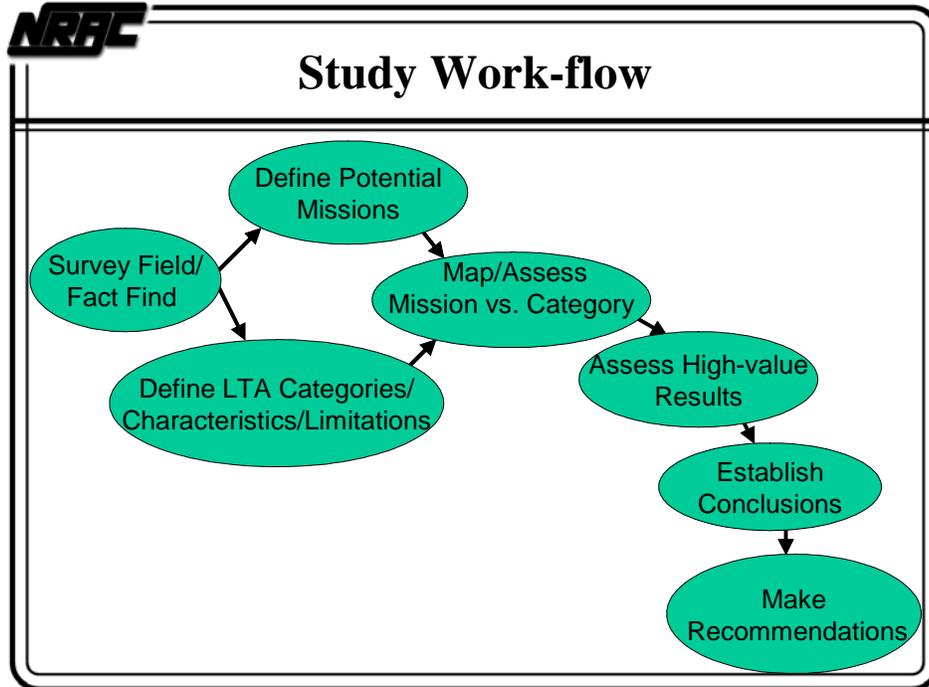
Aerostats are tethered, roughly cigar-shaped, unmanned, fully-buoyant vehicles.

Airships are characterized as untethered and are equipped with propulsion systems that allow them to travel from site to site, as required for the mission. Airships generally are cigar-shaped and may have rigid frames. Those without rigid frames are termed blimps (etymology is type B-limp).

To date, airships all have been manned, but unmanned versions will be introduced eventually. Most commercial blimps are roughly 200 feet long and 50 feet in diameter. The famous Hindenberg, a rigid airship, measured 813 feet in length and 135 feet in diameter, held 7.2 million ft<sup>3</sup> of hydrogen, and generated 112 tons of net lift. Currently existing airships operate below 10,000 feet mean sea level (MSL).

Hybrids incorporate significant aerodynamic shaping to decrease shape drag and gain efficient lift while underway. These vehicles are expected to generate up to 40 percent of their underway lift from their aerodynamics, unlike airships, which achieve no more than 10 to 20 percent aerodynamic lift. Because hybrids are expected to generate so much lift aerodynamically, they are always projected to operate in a heavier-than-air mode.

Most existing hybrid vehicles are small-scale prototypes, such as the Sky Kitten, but are being promoted as being scalable for heavy-lift applications, due to their improved speed and lifting efficiency when compared to airships. For example, the proposed DARPA project named Walrus, has a design payload of more than 500 tons and a range of 12,000 nautical miles.



## Study Work Flow

The Panel’s work flow was organized around the following key tasks.

**Survey Field/Fact Finding:** The Panel first conducted an extensive review and assessment of current LTA programs and research activities from a broad range of government, industry, and academic sources through both briefings and site visits. During this phase, the Panel received more than a dozen industry briefings and 16 government briefings (both U.S. and foreign).

### Site Visits:

**ILC (Dover):** The company manufactures many of the aerostats and airships currently in use. The visit focused on envelope-fabric technology and assembly techniques.

**Zeppelin (France):** Zeppelin briefed the Panel members and provided a demonstration ride in a semi-rigid airship. Of particular interest was the airship’s zero-speed maneuverability and the small ground-support team required for landing and takeoff operations.

**Selenia/Nautilus (Genoa, Italy):** The company is developing plans for a hybrid demonstrator in conjunction with the University of Turin. This effort is focused primarily on control concepts for an unusual hybrid airship configuration. The Panel believes that the design is immature, however the projected flight test (delayed about a year), will be a significant learning milestone.

**ATG (Bedford, England):** ATG showed credibility in technical and pragmatic understanding of airship design and operation. Panel members examined several variations of ATG-built airships, including the scaled remotely controlled “Skykitten” hybrid. The Panel watched video of flights and landings, both on land and water. ATG also demonstrated a mockup of the gondola for an airship to be built for the United Arab Emirates. This airship would

accommodate both troops and small boats for coastal monitoring, control, and launch of boarding parties for maritime inspections.

Definition of Potential Missions: The Panel reviewed the study TOR, heard briefings, and compiled a list of the maritime missions that could be supported by LTA systems.

Definition of LTA Categories: The Panel categorized LTA types, including high-altitude (65,000 feet and above) and low-altitude categories. The team then identified key type characteristics and limitations for each LTA category.

Map/Assessment of Missions vs. Categories: The Panel mapped out potential missions for LTA categories to provide a framework to assess the value of the “intersection” of missions with the categories to identify high-value applications.

Assessment of “High-value” Results: These “high-value applications” then became the focus of the study and served as the basis for conclusions and recommendations.



## Briefings Received

### Programs

- JLENS
- TARS
- SASS
- REAP
- RAID
- Combat SkySat
- HATB
- Talon Topper
- HABIT
- ISIS
- WALRUS
- PTDS
- MARTS
- HAA

### University

- NMSU
- UCLA

### Congress

- HPSCI

### Non-Profit

- AIAA

### Government Organizations

- OFFICE OF NAVAL RESEARCH
- NAVAIR
- DARPA
- HQMC (I & L)
- MCSC
- NASA Dryden
- US Army G2 & ASA
- CAA (Army)
- USAF (Near Space & Battle Lab)
- DASN-AIR, DASN- RDT&E
- NAVSEA (DEW Office)
- OPNAV/N71
- AF Science Advisory Board (SAB)

### Consultants

- Chuck Myers (Hybrid Airships)
- Prof Don Layton (USN/NPGS, Ret)
- CAPT Lyn Whitmer (USN Ret)
- CAPT Bob Ashford (USN Ret)
- MAJ Greg Gotlieb (UK Army Ret)
- LCOL Mike Woodgerd (USA Ret)

### Industry

- Lucent
- Northrop Grumman
- L3 Communications
- Lockheed Martin
- American Blimp Corp
- Raytheon
- Airship Mgt Services
- ILC Dover
- PSL (NMSU)
- TCOM

### International

- Zeppelin (GER)
- ATG (UK)
- Selenia/Nautilus (IT)
- Israel MOD
- Japan/JAXA/Sojitz

## Briefings Received

The Panel received in-depth program and technology briefings from a diverse field of experts in industry, the Services, and the Science and Technology (S&T) community. Panel members examined several current LTA initiatives, including the Army's Joint Land Attack Elevated Netted Sensor (JLENS), DARPA's Walrus and ISIS programs, and the Missile Defense Agency's High-Altitude Airship (HAA) effort. Panel members also met with technology managers from Service acquisition commands and laboratories, and U.S. companies including; Lockheed Martin, Raytheon, Northrop Grumman, and L3 Communications. Several builders of LTA vehicles also briefed the Panel on their programs and Research and Development (R&D) efforts. Finally, Panel members met with officials of Zeppelin, ATG, Selenia, Israeli Ministry of Defense (MOD), and Japan's JAXA/Sojitz.

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## Navy LTA Background

- **Navy in LTA business from 1917 to 1962**
- **Observation balloons (WWI era)**
- **Non-rigid (“blimps”)--241 acquired**
- **Rigid airships--4 acquired, including the aircraft-carrying *Akron* and *Macon***
- **World War II: 168 blimps operational for coastal patrol and convoy escort**
- **Cold War: 56 blimps procured for ASW and homeland defense AEW**
- **Program ended in 1962 for threat and fiscal reasons**
- **Limited R&D effort 1975-1990**

*No currently active LTA programs*

## Navy LTA Background

The U.S. Navy was in the LTA “business” from 1917 to 1962. In April 1917, the year the United States entered World War I, the Navy accepted its first LTA aircraft, the non-rigid airship (“blimp”) D-1. This was the progenitor of 245 manned LTA craft acquired by the Navy. These were in addition to several tethered observation balloons (operated by the Navy mostly from ships) during World War I.

Navy LTA development between the world wars included non-rigid blimps and rigid airships. Two of the rigid airships, the Akron and Macon, were “flying aircraft carriers,” each capable of storing, launching, and retrieving four fighter aircraft.

The Navy stressed the development and procurement of non-rigid airships. During World War II, the Navy’s LTA strength reached 168 blimps, which were engaged in coastal patrol and convoy escort, mainly in the Atlantic and North African theaters. Although the blimps scored no U-boat sinkings—and one blimp was shot down by a U-boat—the airships did make a major contribution as a deterrent to submarine attacks and carried out other reconnaissance missions.

Navy interest in LTA continued into the Cold War era with the procurement of 56 blimps of advanced design, initially for anti-submarine warfare, and subsequently for the airborne early warning mission. The latter were for use on the seaward extension of the early warning network built to warn of a Soviet air attack against the United States. In this role, the radar-configured airships were to supplement EC-121 Constellation-type aircraft, surface radar picket ships, and fixed offshore radar stations.

In 1962 the Navy’s airship program was terminated because of fiscal constraints as other Navy aviation and missile programs (including the Polaris deterrent system) were accorded higher priorities.

The U.S. Navy carried out a limited LTA research and development effort from 1975 to 1990, oriented primarily to maritime patrol and cruise missile defense for surface combatants. A prototype airship, the Sentinel 1000, was procured for tests. A 1985 agreement between the Navy and Coast Guard transferred responsibility for tethered aerostats to the latter service. (The Coast Guard operated several aerostats and support ships until 1992, after which the program was transferred to the Army and promptly disbanded by the Army.)



## Renewed Interest in LTA?

- **Threat has changed (from high tech aircraft, missiles to terrorists)**
  - Need to extend the horizon
  - Need persistence
- **With station keeping, LTA provides persistent presence with increased line of sight**
  - Low altitude (< 10,000 ft) relatively easy
  - High altitude (60,000 – 80,000 ft) desired, but difficult
- **Potential payloads are lighter and more capable**
- **Better meteorological prediction capability**
- **Potential to lift and transport very heavy payloads directly to the war fighter**

## Renewed Interest in LTA?

Current U.S. naval operations, ashore and afloat, and especially for the GWOT, have demonstrated the need for persistent ISR for specific areas. LTA vehicles, whether tethered (aerostats) or free floating (airships) are capable of remaining in the same location for prolonged periods and providing a persistent presence.

Similarly, commanders, whether afloat or ashore, have always sought to extend their horizons—to see farther or “over the next hill.” Tethered or free-floating LTA vehicles can provide the ability to carry ISR, EW, and communications-relay systems to greater altitudes than can presently be reached for ships or tactical units, and can be directly responsive to the needs of ship or unit commanders.

At the same time, potential ISR, EW, and communications-relay payloads for LTA vehicles are lighter and require less power than their predecessors. Airships can also help to mitigate “urban canyon” effects on ISR, communications, and navigation aides

Persistence can be achieved relatively easily with current LTA technology to altitudes up to about 10,000 feet. Although higher altitudes for ISR/EW/communications relay systems are highly desirable, reaching them is relatively difficult and presents technological challenges.

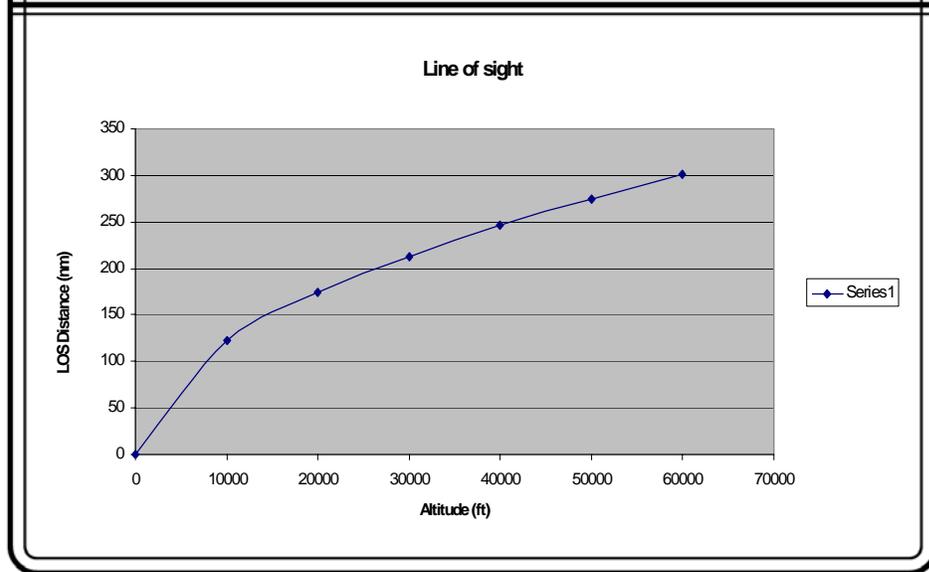
In many respects, LTA vehicles represent a potentially cheaper option for providing certain capabilities than satellites or Unmanned Aerial Vehicles (UAVs).

LTA vehicles also offer the potential to lift and transport heavy payloads over long distances directly to the vicinity of the warfighter – “from fort to foxhole.” This mode of transport can eliminate transfer points (e.g. ship to pier to road convoy), the vulnerability of road convoys, and need for intermediate depots.

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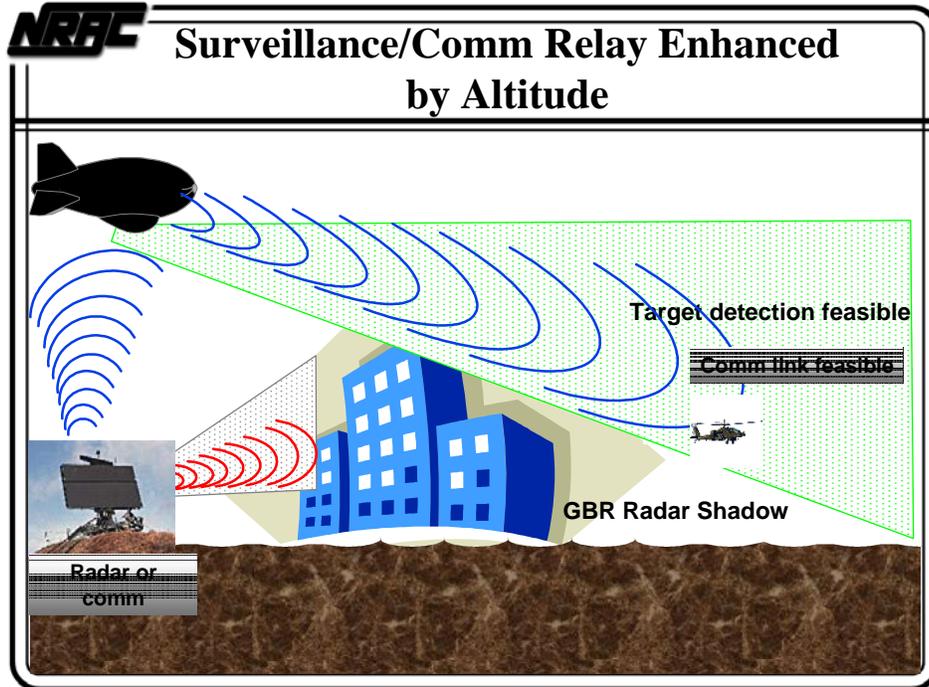
## Line of Sight Distance to Horizon vs Altitude



## Line of Sight Distance to Horizon vs Altitude

LTA vehicles are capable of ascending to altitude and increasing the line of sight to the horizon. This figure shows how the line of sight is increased as altitude increases. In a typical environment, line of sight (for communication or surveillance) is limited to less than 20-25 nautical miles. Line of sight can be increased to over 100 nautical miles by ascending to less than 10,000 feet, an altitude easily attainable by the aerostats available today. It also demonstrates the value of moving to higher altitudes since line of sight can be increased to over 300 nautical miles by ascending to or above 60,000 feet.

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## Surveillance/Comm Relay Enhanced by Altitude

Altitude also provides the ability to see and achieve line of sight over both urban and geographic terrain features. At altitude, an aerostat can provide communication connectivity to a low flying helicopter hidden by terrain or urban structures and provide surveillance of threats, which might otherwise be hidden by the environment. (Note: GBR-Ground Based Radar)

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## Attributes of LTA Vehicles

- **LTA vehicle volumes are relatively large, potential for very large, internal antennas**
- **Platform nonrecurring costs low relative to aircraft**
- **Operating infrastructure costs potentially low relative to other forms of aviation**
- **Low signatures—acoustic, IR, RF**
- **LTA envelopes are highly survivable**

## Attributes of LTA Vehicles

LTA vehicles have relatively large volumes when compared to aircraft, an attribute that offers the potential for very large, internal antenna apertures. Furthermore, platform non-recurring costs of LTA vehicles are relatively low when compared to aircraft procurement. Similarly, LTA infrastructure costs are potentially low relative to the costs of other forms of aviation, both manned and unmanned. LTA vehicles also permit quiet operation, an attribute that enhances survivability and may create advantages for psychological warfare.

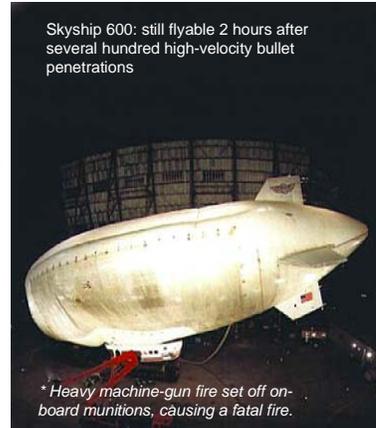
The LTA envelope is relatively survivable against most conventional weapons. When punctured by bullets, the envelope deflates slowly, undergoing a controlled degradation.

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## Airship Envelope Survivability

- **Airship envelopes are highly survivable against conventional threats:**
  - Gas leaks slowly, even from multiple holes in envelope
  - Live-fire testing in U.S. & U.K. confirms survivability
  - Recovery likely even after severe damage, as experienced in Iraq
  - Missiles unlikely to fuze



*Numerous Examples Show Airships  
Are Not Easy To Bring Down...*

## Airship Envelope Survivability

Airship envelopes are highly survivable against small arms.

Airships and aerostats operate at a low internal pressure – generally less than 0.1 psi over the surrounding atmospheric pressure. Consequently, helium will not escape from the envelope even when small holes develop in it. Tests done both in the United States and the United Kingdom showed that an airship (shown above) remained flyable after being punctured with several hundred bullet holes.

Missiles designed to fuse on a hard surface will pass directly through the envelope without fusing.

Due to their slow speed and large size, airships can be targeted easily by fast moving enemy platforms or threats armed with anti-LTA weapons. While the Panel did not have access to data on specific anti-LTA weapons testing, it assumed that LTA platforms are highly vulnerable to specialized high-tech threats.

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## LTA Limitations

- **Airship cruise speed < 80 knots**
  - **Easily visually targeted (Aerostats and low flying airships)**
  - **Airspace deconfliction**
- **Airship and helium infrastructure (hangars and bottles)**
- **LTA vehicles are affected by weather and winds**
  - **Take-offs and landings could be difficult**
  - **Winds affect altitude flight options**

## LTA Limitations

Airship size and cruise speeds of less than 80 knots, make them more easily visible and targeted than comparable-payload aircraft.

Airspace deconfliction, already a major concern for military commanders, will be exacerbated by the presence of LTA vehicles. The relatively low speed of airships and the fixed (tethered) operating mode of aerostats must be addressed for both combat and behind-the-lines areas.

Similarly, while helium is readily available in the United States, the establishment of a naval LTA program will require the development of an infrastructure to acquire, inspect, store, and transport the gas to LTA facilities.

At this time, there is no naval airship infrastructure. A large number of aerostats have been built and are in operation, making it relatively easy for the Navy to procure and evaluate them further. Presently, the airship community is limited to relatively few commercial vehicles. Thus, Navy airship operations would require the development of a procurement and evaluation process, establishment of a training program and personnel career-planning programs, building of a logistics structure, and other steps.

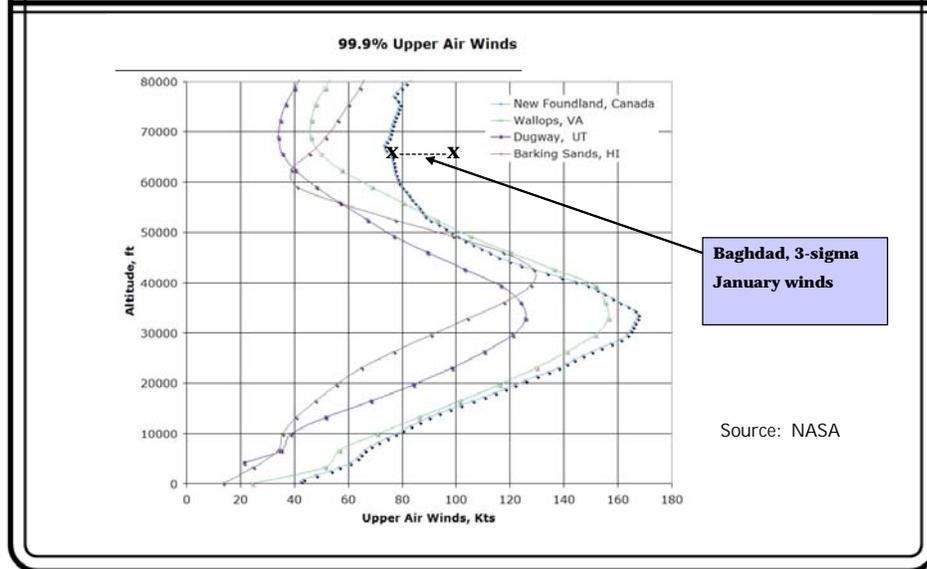
Because of their large surface areas and lack of aerodynamic control surfaces, LTA vehicles are affected greatly by weather and winds—less a concern for the airship, which can maneuver out of weather, but still a major consideration for all forms of LTA vehicles.

Takeoffs and landings of LTA vehicles, both manned and unmanned, can be difficult because of wind and weather conditions. Airships can, under certain circumstances, avoid unfavorable weather and, if necessary, land at alternative locations. Aerostat landings are more problematic because they must be winched down in the event of unfavorable weather or winds; bringing down an aerostat from 10,000 feet could take up to two hours.

Historically, rigid airships have been susceptible to severe atmospheric turbulence. The primary options for avoiding high winds and atmospheric turbulence are flying the airships to a safe location or securing them in hangars designed to withstand hurricane-force winds. This will likely continue to be the dominant threat to LTA vehicles.



## Winds Affect Flight Altitudes



## Winds Affect Flight Altitudes

The chart above shows maximum wind velocities from the earth's surface to an altitude of 80,000 feet. The chart does not depict wind direction, which varies considerably within the bands shown. The higher wind velocities shown between 10,000 and 60,000 feet are not prevalent at all latitudes. For example, the jet stream produces winds well in excess of 100 knots between 24,000 and 48,000 feet over the northern United States, while winds may be less than 50 knots over southern Texas at the same altitudes.

The chart shows the altitudes best-suited for station-keeping. LTA platforms must navigate changing winds and changing wind velocities, temperatures, and external pressures while ascending to operating altitude and during descent.

When not station-keeping, airships will float with the winds. Station-keeping requires an expenditure of energy (thrust) proportional to the drag (wind velocity squared). Hence the most energy-efficient altitudes for station-keeping are either low or 60,000 to 70,000 feet. While altitudes change with latitude and season, generally there is a low-altitude and high-altitude solution near 70,000 feet that allows the airship to station-keep with minimum energy consumption.

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## Sea-Based Aerostat Systems



Maritime Interdiction and Surveillance Team (MIST) – Coast Guard – 1980's  
Small Aerostat Surveillance System (SASS) – Army – 1980's

## Sea-Based Aerostat Systems

During the 1980s, ships with aerostats operated in the Gulf of Mexico to carry out drug-interdiction missions through the Maritime Interdiction and Surveillance Team (MIST) conducted by the Coast Guard, and the Small Aerostat Surveillance System (SASS) conducted by the Army. Both programs used ship-based aerostats to look for fast drug boats. Both were successful at detecting and tracking small boats suspected of drug-trafficking. The ships hosting the aerostats traveled at less than 10 knots. The bad weather in the Gulf of Mexico and limited availability of ships contributed to the demise of both the MIST and the SASS programs.

However, these programs demonstrate the feasibility of operating aerostats on slow speed ships and the feasibility of carrying sensors capable of detecting small high speed boats from aerostat operating altitudes.

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## LTA Today

	Balloons	Aerostats	Airships
<b>Commercial - International &amp; U.S.</b>			
– Tourism			•
– Advertising		•	•
– Communications	•	•	•
<b>U.S. Department of Defense</b>			
– Marine Corps COMM in Iraq		•	
– Army Surveillance/force protection in Iraq/Afghanistan		•	
– Air Force Border Surveillance		•	
<b>U.S. Department of Homeland Security</b>			
– Border Patrol		•	
– Detection of low-flying aircraft		•	
– Detection of drug trafficking (aircraft, boats, people)		•	
<b>Israel MOD</b>			
– ISR		•	
– Border surveillance		•	
– Naval surveillance		•	
– Counter terrorism		•	
<b>Other Security Roles</b>			
– NYPD Fleet Week			•
– Olympic Games (Atlanta, Athens)			•

**All applications 15,000 ft. or below**

## LTA Today

There are three main categories of LTA vehicles in use today: Balloons, aerostats, and airships. In terms of number of units and hours flown, the largest use is for commercial applications.

**Commercial LTA Use:** The primary utility of LTA vehicles in the commercial arena is for advertising, followed by tourism and communications. Blimps with advertising slogans boldly displayed on their skins are a common sight at sporting events and large public gatherings.

Airships are also used for tourist rides, although somewhat less frequently in the U.S. than in Europe. For example, rides are a principal venue for the Zeppelin airships in Europe.

An interesting and important commercial application of LTA technology is the use of high-altitude balloons for low-cost, sustained, area communications coverage. Oil companies in Texas rely on the prevailing west winds across Texas to float a continuing series of balloons across the state to provide a constant and direct network between isolated well-heads and company control centers. The balloons, fitted with communications packages, are released in New Mexico, float across Texas, and are deflated and collected in Louisiana for return and re-use. The recovery/reuse rates are above 90 percent.

**Government/Military LTA Use:** The only LTA vehicles being used for military applications are aerostats, which are employed by the U.S. Departments of Defense (DOD) and Homeland Security, as well as Israel's MOD.

In these applications, the primary functions of the aerostats are communications enhancement, range expansion, or surveillance/detection. The key reason for using aerostats in these roles is their ability to dwell persistently, for days or weeks, over a designated area.

For example, the U.S. Marine Corps is using them for communications in Iraq, and the Army is using them in both Iraq and Afghanistan for surveillance and force protection.

In addition, the U.S. Air Force and the Department of Homeland Security are using aerostats in a major role for border surveillance and detection of drug trafficking by boat, aircraft, or persons on foot. Aerostats also provide coverage along the entire length of the U.S.–Mexican border.

Like the U.S. armed services, Israel’s defense forces employ aerostats for border and naval surveillance. Israel has also used aerostats for counterterrorism and traffic monitoring in cities and along key rural roads.

Other Security Roles: The Panel also found several unique non-commercial uses of LTA airships by U.S. police and security authorities, including surveillance by the New York Police Department for the Navy’s Fleet Week, and by security forces at the 2000 Olympic Games held in Atlanta and the 2004 Games in Athens. Based on the success of these events, the Panel expects this area of utilization to continue to expand.

Despite optimistic projections, the Panel found that except for high-altitude balloons, all LTAs currently in use are limited to altitudes below 15,000 ft MSL.



# JLENS RAID Deployments



RAID 1 - OEF

RAID 2 -OEF/OIF

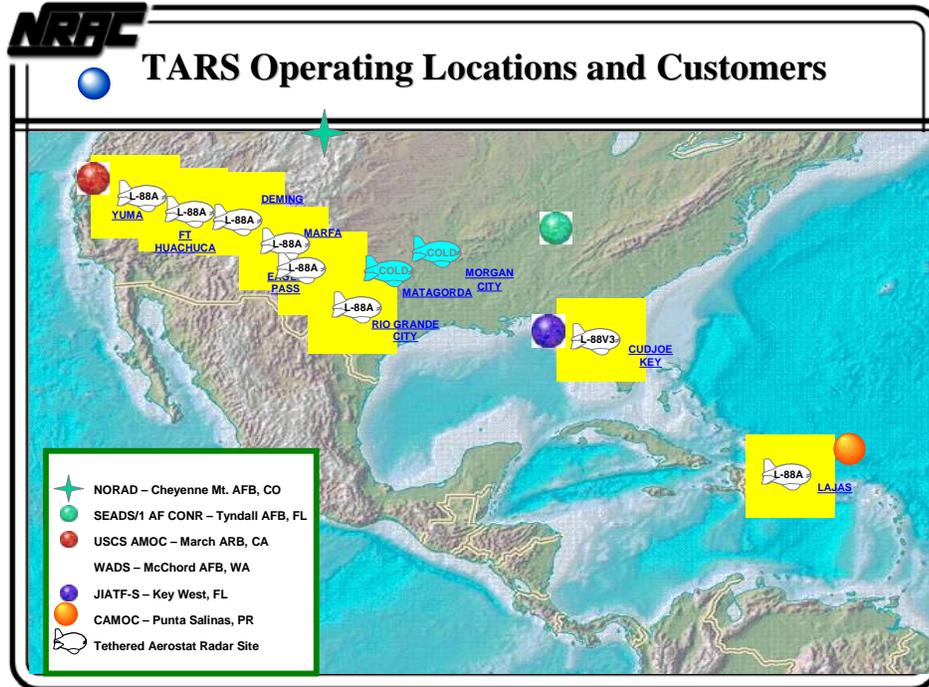


**Mission:** Provide Base Security Cells With Hi-resolution, Day/night Surveillance Capability That Provides Enhanced Target Recognition and Situational Understanding.

## JLENS RAID Deployments

This chart demonstrates the existing use of LTA to provide surveillance of individuals who might be involved in planting Improvised Explosive Devices (IEDs). The Rapid Aerostat Initial Deployment (RAID) program is an example of an LTA application for a current Army mission. It is a short-term initiative of the JLENS program. For the RAID effort, aerostats fitted with high-resolution day and night cameras providing surveillance capability are being deployed in both Afghanistan and Iraq. The photograph in the lower left corner of the graphic illustrates use of the RAID system to detect and observe the activities of adversaries on the ground at night.

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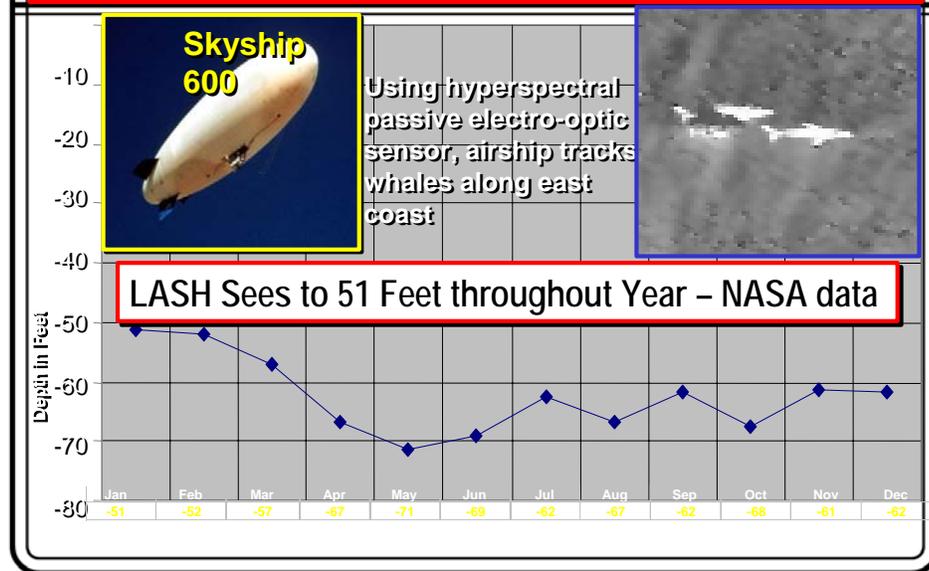


## TARS Operating Locations and Customers

The graphic above shows the location of aerostats deployed along the southern U.S. border to support drug-interdiction operations. The program, managed by the Air Force Air Combat Command and designated the Tethered Aerostat Radar System (TARS), demonstrates the ability of aerostats fitted with currently fielded radar to detect low-flying aircraft. The TARS, manufactured by Lockheed Martin, has been effective in reducing the number of aircraft flying drugs directly into the United States. Only six such systems are required to cover the entire U.S.-Mexico border. The actual system availability of the TARS system along the Mexican border is almost 70-75%.

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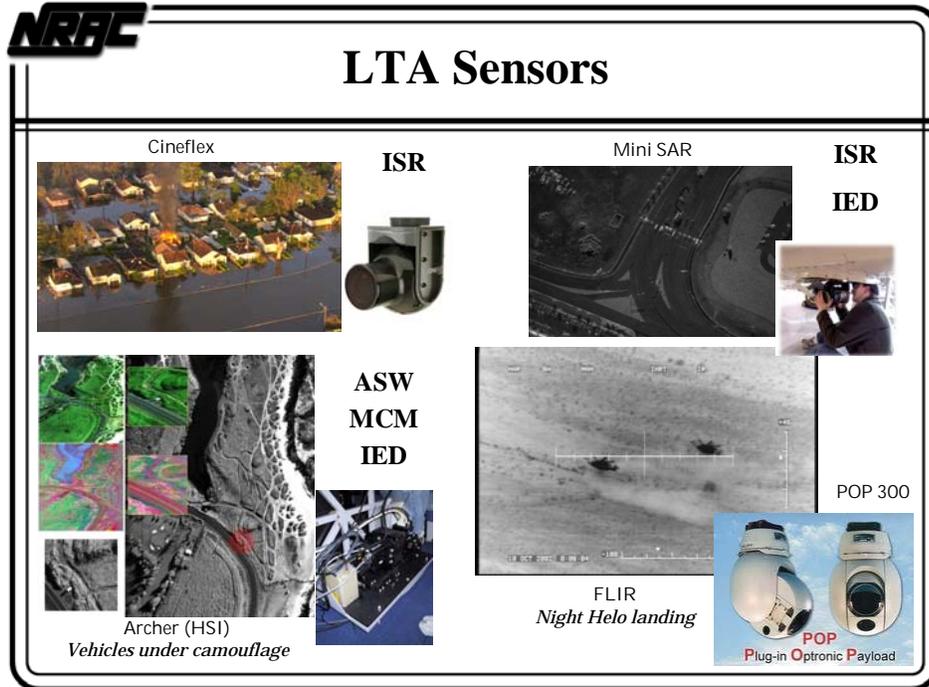
## **NRAC** NAVAIR Littoral Airborne Sensor Hyperspectral (Lash)



## **NAVAIR Littoral Airborne Sensor Hyperspectral (Lash)**

The Navy recently used a leased airship to track whales in eastern coastal waters, demonstrating the use of hyperspectral sensors to both detect and track moving objects below the surface. The capability may have significant implications for port and harbor security.

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## LTA Sensors

A key factor in the renewal of interest in LTA systems is the fact that a variety of sensors for potential LTA system missions are available commercially and in some cases already in use, by the military. Examples include high-definition low-light TVs, hyperspectral cameras, Synthetic Aperture Radars (SAR) and Electro-Optical (EO) Infrared (IR) day-night systems with laser range-finders and laser designators.

Most of the pictures of the damage from hurricanes Katrina and Rita were taken from the Cineflex High-Definition Television (HDTV) system which is a 150-pound fully-stabilized sensor with zoom capability.

The California Civil Air Patrol is flying the Archer hyper spectral camera which has multi channel real time spectral capabilities from 400-3000 nanometers with capability to detect vehicles under camouflage, water and soil contamination, and the location of mines and tunnels.

The continued development and refinement of high resolution SAR systems by Sandia National Laboratory (which provided the design of the LYNX (TAR) SAR system built by General Atomics) in use today on Predator UAVs in Operation Iraqi Freedom (OIF), Operation Enduring Freedom (OEF), and other hot spots, has evolved from a 125-pound SAR with 4-inch resolution to a 26-pound SAR system ready to be manufactured and used.

The day-night EO-IR system, POP-300, with laser ranger and laser designation capability is currently installed in the Army's Tactical Unmanned Aerial Vehicle (TUAV) (Shadow 200) and the USMC's Pioneer TUAVs in OIF today.

All of these sensor systems are examples of mature, demonstrated systems which could be installed and utilized on manned or unmanned LTA systems.

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## Existing LTA Vehicle Comparison

	Payload	Endurance	Station Keeping	Line of Sight	Issues
Balloons	8000 lb @ 134 kft	Few days	Multiple launches	450 nm	Environment
Aerostats	2200 lbs < 15 kft	15-30 days	Tether	150 nm	Tether vulnerable
Airships (Low altitude)	3000 lbs < 10 kft	Few days	Maneuverability allows precise location and look angles	150 nm	Unmanned not demonstrated

## Existing LTA Vehicle Comparison

There are three types of LTA vehicles in operation today. Each type has characteristics that limit its utilization.

The balloon is a free floater that is capable of carrying heavy loads to high altitudes. The weather balloon is a common example. Balloons are used by the National Aeronautics and Space Administration (NASA) and other research activities to venture above the stratosphere and higher. Payloads of 8,000 pounds borne aloft to an altitude of 134,000 feet and higher are not uncommon. The military application for balloons is limited, however. Subject to the atmosphere's prevailing winds, free-floaters are unable to maintain position over an area, a capability necessary for persistence. Multiple launches at intervals could allow this vehicle to attain some mission efficacy. The oil industry launches balloons daily from New Mexico, which float over Texas, to allow continuous communication between isolated oil fields and operations in cities such as Houston.

Aerostats achieve persistence over an area of interest. The aerostat offers the advantage of retaining a position and the ability to extend the horizon. Today, aerostats are used for advertising, communications relay, surveillance, and other ISR missions. They range from those used at a tethered altitude of several hundred feet with a light payload, to those that can ascend to 15,000 feet and accommodate a 2200-pound payload.

Today's manned airships can operate in benign areas. Present payload ranges are about 3,000 pounds and maximum altitudes are less than 10,000 feet. The altitude extends the horizon for ISR. Current airborne endurance is limited by both crew endurance and fuel capacity. While airship envelopes can survive numerous penetrations from small-arms and higher-caliber fire, aircrews remain vulnerable. If airships are to be considered for extended-duration surveillance or operations in less-than-benign areas, further development and maturation will be required.



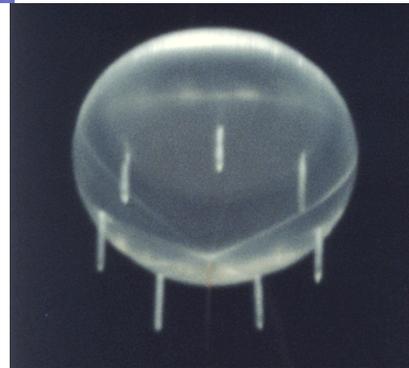
## How Big is Big?



Goodyear Blimp  
202,700 ft<sup>3</sup>  
(Altitude = 10,000 Ft)

NASA's Largest Zero-Pressure  
Balloon

39,570,000 ft<sup>3</sup>  
(Altitude = 134,000 Ft)

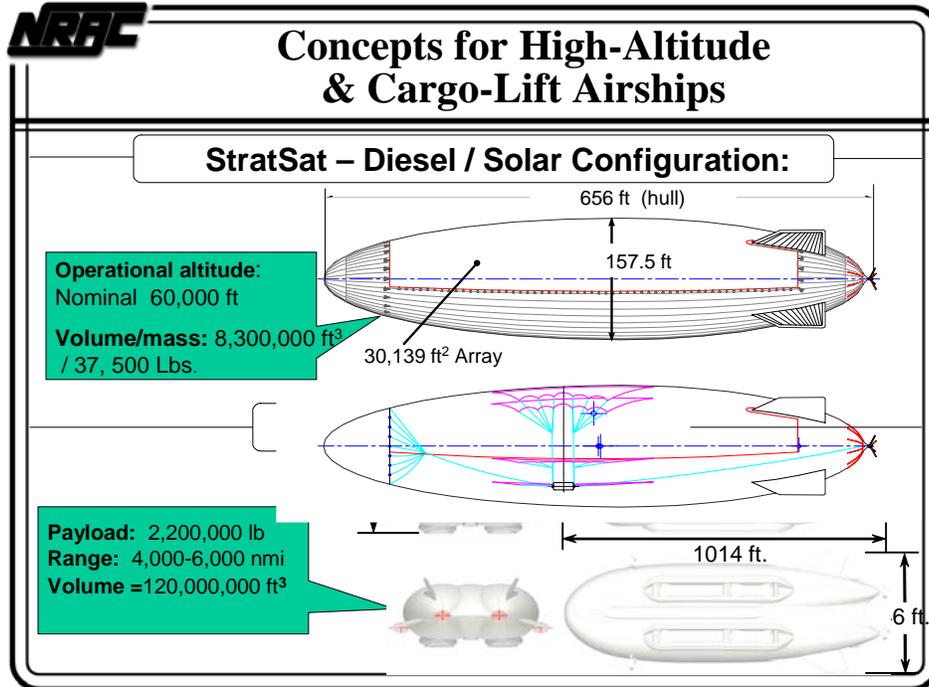


## How Big is Big?

Most of the airships currently flying are similar in size to the Goodyear airship, which is approximately 100 feet long, contains 200,000-300,000 ft<sup>3</sup> of helium, and operates at altitudes below 10,000 feet. Existing aerostats fall into a similar size range. High-altitude airships will require a significant increase in size to reach the altitudes desired. For example, NASA's high-altitude balloon requires 40 million cubic feet of helium to fly to an altitude of 130,000 feet.

The high-altitude balloons flown by NASA are zero-pressure balloons. Zero-pressure balloons have small openings (the teardrop-like objects hanging below the balloon) and the pressure inside of the balloon reaches equilibrium with the surrounding atmosphere. An airship capable of carrying 2,000 pounds to high altitude will have a volume in the range of 1,000,000 cubic feet and require significant technology development to operate as a pressurized vehicle.

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## Concepts for High-Altitude & Cargo-Lift Airships

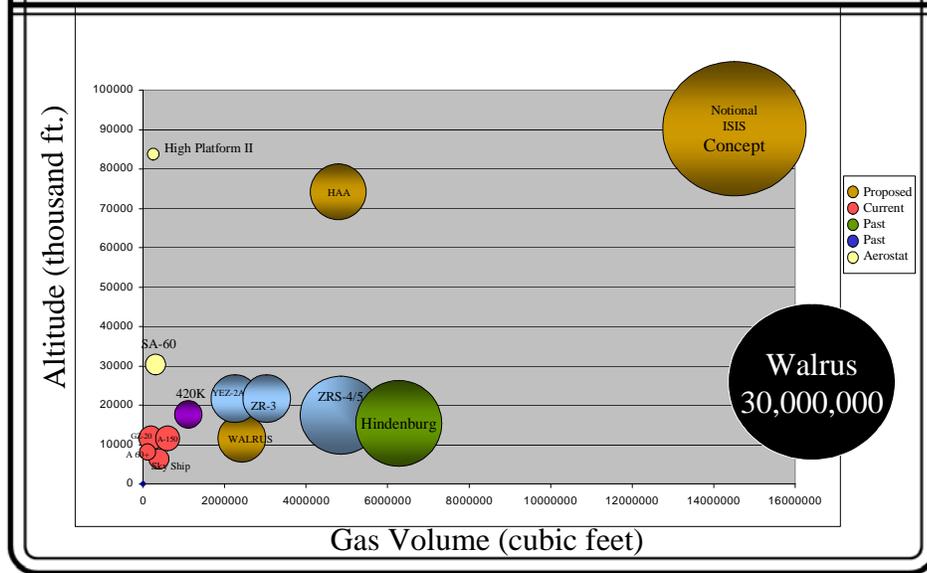
This graphic shows a concept for a high-altitude LTA vehicle, called StratSat, that would be much larger than currently flying airships. It would require more than 8 million cubic feet of helium and measure more than 600 feet in length.

The SkyCat 1000 concept shows that a vehicle designed to lift 1,000 tons would be more than 1,000 feet long and have a capacity of more than 120 million cubic feet. An enormous vehicle like this poses significant technical challenges for the designer.

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## Comparison of Past, Current, and Proposed Airships



## Comparison of Past, Current, and Proposed Airships

This chart shows operating altitude against size of currently operating and proposed LTA vehicles. The vehicles in red are operational today and operate below 10,000 feet. The vehicles in blue are rigid airships used by the Navy almost 50 years ago. The vehicles in brown are notional/concept vehicles.

The concept for ISIS, funded by DARPA, shows how large a vehicle must be to perform the high-altitude ISR mission. The proposed ISIS vehicle has a capacity in excess of 14 million cubic feet. The proposed, currently funded HAA program could demonstrate the capability to station-keep at high altitudes. The HAA concept is considerably smaller than the full-sized ISIS vehicle and will have less electronic capability than ISIS. Similarly, a LTA vehicle designed to carry 500 tons will be the size of the black Walrus vehicle shown above. DARPA is currently funding a prototype development which is substantially smaller, but has the potential to carry 40 tons.

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## Missions for LTA

- **Global war on terrorism:**
  - Concern about small groups of terrorists acting independently
  - Terrorists organizing and executing activities – planting IED's
  - Potential for multiple threats, geographically dispersed
  - Need for
    - Persistent ISR
    - Secure communications
    - Electronic warfare
    - Rapid response and precision kill
  
- **ISR for force protection:**
  - Force protection ashore and afloat
  - Unmanned, multisensor electronic surveillance

## Missions for LTA

Two factors add complexity to the missions likely to be assigned to naval forces: (1) the asymmetric threats that characterize the GWOT; and (2) the increasing availability of high-capability weapons manufactured in and sold by technologically-sophisticated countries. Both threats require an improvement in the ability of naval forces to conduct persistent surveillance, communicate continuously, and neutralize precisely. LTA platforms have the potential to offer an improvement in these capabilities.

GWOT: Suicide bombing and the use of remotely-activated IEDs have become part of the modus operandi of terrorists in Iraq and elsewhere. To counter this, the military requires sophisticated sensors operating round-the-clock, often in urban areas. Countering such threats is less difficult if areas of vital infrastructure are placed under a shield of persistent surveillance, jammed radio signals, and an array of lethal and non-lethal weapons delivered with the precision of Global Positioning System (GPS) guidance.

So far, terrorists have not shown any inclination to use high-tech weapons, suggesting little ability at present to attack LTAs with anything other than ground small-arms fire, which would be ineffective.

Force Protection: At sea, protecting military assets requires defense against low-flying fast cruise missiles, which requires persistent wide-area surveillance. On land, protection of bases and ports requires defense against terrorist attacks, increasing the persistent surveillance requirement.

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## Missions for LTA (cont)

- **Communications connectivity**
  - Longer range comm relay, including in urban environments
  - High-bandwidth required for precision situation assessment, targeting, and BDA
- **Electronic Warfare**
  - IED countermeasures
  - Targeted communications disruption in urban environments
  - Defense against cruise missiles
  - GPS enhancement for anti-jamming
- **Cargo Lift/Delivery**
- **Emergency Response for communications and surveillance (DHS)**

## Missions for LTA (cont)

Communications Connectivity: Operations in urban and mountainous environments pose significant problems for communications, especially for small units that increase with the bandwidth requirements for network-centric situation assessment, precision-targeting, and battle-damage assessment. The Navy and Marine Corps face an urgent need to solve these communications-relay problems.

Operational units must also employ large arrays of untended sensors positioned to monitor enemy activity over long periods. Generally, to limit detection, these broadcast on low power.

Electronic Warfare: The GWOT adds requirements to traditional military requirements for monitoring communications (such as civilian communications via cell phones). The IEDs used by terrorists are often triggered by cell phones, and the capability to jam cell-phone signals intermittently (for example, in areas transited by convoys) is a desirable tactic. Against more traditional threats, EW neutralization of cruise missiles and persistent standoff jamming are commonplace needs.

As U.S. weapon systems become more completely dependent on GPS guidance, the denial of the use of low-power GPS signals becomes a warfighter's nightmare. If an enemy is able to jam GPS transmissions, then localized augmentation of GPS signals can offer increased precision for U.S. weaponry and GPS deception to an enemy.

Heavy-Lift Cargo: Confederate Cavalry General Bedford Forrest popularized the slogan, "get there firstest with the mostest." Today, much is still invested in forward bases and pre-positioned ships. OIF has demonstrated that it remains difficult and expensive to quickly move heavy equipment where it is needed. Moreover, if the sea-basing concept becomes a

reality, some heavy lift capability will be needed to supply the sea bases so that they can supply units ashore.

Emergency Response: The recent hurricane which hit New Orleans created an environment where communication capability was severely limited. This could have been corrected with an aerostat performing a communications-relay mission.



### LTA Mission/Vehicle Potential

	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

### LTA Mission/Vehicle Potential

The Panel examined a series of potential naval missions for LTA vehicles and analyzed the value that different types of LTA assets would provide for those missions. The matrix above is a summary of the Panel's analysis.

The Panel first identified the potential naval mission applications. The mission areas were then organized into six major categories: ISR, communications/navigation, quick reaction weapons (low latency), EW, psychological operations and heavy-lift cargo delivery. These categories (horizontal axis) are those the Panel determined to have the most potential for naval LTA applications.

The Panel then looked at the six types of LTA platforms relative to these mission categories: Balloons, aerostats, low-altitude manned airships, low-altitude unmanned airships, high-altitude airships, and hybrids. It evaluated the potential of each LTA class against the six mission areas, and rated them as low, medium, and high. When no potential mission match was found, no rating was assigned. The ratings were based on the vehicle attributes and mission applicability. Attributes considered included characteristics such as: payload capacity, station-keeping ability, altitude, persistence, and deployment requirements.

Low: A low rating was given to a platform, relative to existing assets. If the vehicle could not accomplish the same mission as effectively as other assets, the mission potential was rated low.

Medium: A medium rating was assigned when the LTA platform was considered to be as effective as other assets in performing the mission.

High: A high rating indicated that the LTA vehicle could be more effective (including from a cost perspective) in achieving the mission compared to assets currently performing the mission.

The yellow cross-hash marks are indicative of types of vehicles that are either in prototype stage, partially demonstrated, or exist only as conceptual designs.

The Panel concluded from this analysis that aerostats offer high potential benefits for use in naval ISR, communication/navigation, and EW missions. Limitations of aerostats include fixed deployment, manned ground stations, weather vulnerability, and limited altitude. Despite this, naval missions not being addressed adequately by current assets would benefit from the use of relatively inexpensive aerostats. Examples include Beyond-Line-Of-Sight (BLOS) communication relays for the Marines, coastal surveillance for force protection, and defeat of IEDs via jamming.

The Panel also found that low-altitude unmanned airships offer benefits similar to those of aerostats in the same three mission areas. Aerostats are capable of longer endurance and station-keeping than low-altitude airships, but airships offer greater flexibility for deployment and positioning. Low-altitude manned airships were not considered as promising as either aerostats or their unmanned counterparts because of manning requirements and gondola vulnerability. The Panel believes that with minimal effort, autonomous flight controls developed for UAVs could be adapted for low-altitude airships, giving them far greater capability in expanded mission areas.

The Panel determined that high-altitude airships offer tremendous potential benefit for ISR and communications and navigation missions because of their endurance, large payload capacity, and wide-area coverage. The Panel believes that high-altitude airships can achieve capabilities similar to those provided by satellites at much lower cost. Several obstacles to development of such capability exist – they include skin materials (fabric) and power sources needed for long-term endurance.

Hybrids were also found to offer significant potential for satisfying the naval heavy-lift/cargo mission, especially relative to sea basing. Two key characteristics of the hybrid enable this. (1) The hybrid vehicle can generate up to 40 percent of its lift from aerodynamics which could reduce the difficulties with maintaining ballast during loading and unloading operations. This ability requires increased takeoff and landing speeds and distances, however, which in turn require larger, more “benign” landing fields – an important trade-off as hybrid designs emerge. (2) Hybrids are expected to achieve better equivalent lift/drag efficiencies than traditional airships; projections for hybrid ships capable of both long range and high cargo-lift capability appear technically feasible.

The key enabling technology for achieving successful hybrids is the vehicle envelope material. Currently available fabrics are suitable for units with cargo capabilities of 30 to 50 tons, but stronger and lighter fabrics will be required for cargo lifters with 400-500 ton payloads.

The Panel concluded that like high-altitude airships, significant technology development is needed before hybrid LTA vehicles could be deployed.

Aerostats and Low-Altitude Manned Airships: Both aerostats and low-altitude airships are being used today primarily for non-military missions. Both offer capabilities to the military to augment current capabilities. Currently the DOD only is using aerostats, but airships are available for conversion for military missions.



## **Virtues of Low-Altitude Aerostats/Airships**

- **Both aerostats and airships provide**
  - Persistence**
  - Altitude – line of sight**
  - Reasonably large payload size (antenna)**
  - Lower costs than UAV's or satellites**
- **Aerostat tether brings power, longer persistence**
- **Airships can relocate for better positioning**

## **Virtues of Low-Altitude Aerostats/Airships**

An aerostat is a tethered balloon; an airship is a buoyant air vehicle with steering and powering capability. Airships can relocate and remain on station for long periods. Despite these differences, aerostats and airships share some similarities.

Persistence: Both aerostats and airships provide the ability to stay on station with a sensor for longer periods than is possible with today's airplanes. Their capability is similar to a helicopter's ability to hover, but with far less noise. Aerostats that obtain power via the tether generate no noise. Airships using propellers to move and to station keep have very low noise signatures from the low-rpm propellers.

Payload/Coverage: The relatively large size of aerostats and airships enables them to carry very large antennas. Although only few aerostats and airships of varying sizes have been built, the risks associated with developing larger vehicles is considered to be low. Sizing flexibility allows building aerostats and airships with antenna spacing sufficiently large to enable the vehicles to be equipped with passive, self-contained direction-finding sensors.

Costs: Satellites and UAVs can provide persistent sensor coverage of areas of interest. However, the cost of acquiring and operating satellites and UAVs for that mission is greater than the costs projected for aerostats and low-altitude airships.

An aerostat's tether is both an advantage and a disadvantage. Because the tether counters the force of prevalent winds, fuel is not required for station-keeping. A tether also transmits power to the aerostat, thereby eliminating the need to size the aerostat to carry fuel and power generators.

Finally, if a mission requires relocation of the vehicle for increased or better persistence, this would be possible with a low-altitude airship, but not an aerostat.

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## **Aerostat/Airship Technical Challenges**

- **Station keeping in high winds**
- **Launch, recovery, and operation in foul weather (high winds, icing)**
- **Payload integration**
- **Underway shipboard aerostat operation**
- **Airship power consumption compromises persistence**
- **Survivability of payloads**

## **Aerostat/Airship Technical Challenges**

High winds are a challenge for both aerostats and airships. The larger the aerostat and the stronger the wind, the larger the force that the aerostat's fabric structure and tether must be able to withstand. For example, the TARS assets used for surveillance across the U.S.-Mexico border consist of two sizes of aerostats: A 420,000-cubic-foot aerostat that can operate in winds up to 45 knots, and a 275,000-cubic-foot vehicle that can operate in winds up to 65 knots.

Because of the large size of aerostats and airships, winds pose challenges for launch and recovery. Aerostats must often be lowered to earth when thunderstorms develop in areas in which they are operating. Airships are difficult to land because they are only slightly heavier than air when descending, and landing during windy conditions requires a large number of ground handlers to pull lines to stabilize the airship until it is docked. Some of today's airships use articulating engines, which make them easier to land in heavy weather.

The integration of payloads in aerostats and airships is also a challenge. Tradeoffs are required to balance the weight of payload, power and cooling requirements, power generation, propulsion system, fuel capacity, and on-station endurance.

As the Navy embarks on construction of the Littoral Combat Ship (LCS) and develops a Concept of Operations (CONOPS) for the LCS and other ships (independent of aircraft carrier battle groups), the need for improved communications links and self-protection capabilities will grow. The ability to launch, recover, and operate an aerostat with communications and/or sensor payloads from these independently operating ships could provide improved communications by increasing the ship's radar horizons, situational awareness, and self-protection.

Airships use their propulsion systems for both steering and propulsion. When the platforms encounter strong winds, airships will consume significant power to counter the force of the wind, adversely impacting endurance and persistence.

Although the envelopes of both aerostats and non-rigid airships have proved to be highly survivable when hit with small-arms fire, their large size makes them very visible and easily targeted. The payload and the crew placed in the airship gondola would require armor protection in a combat environment. Before large investments are made in airships, an investigation should be conducted to determine the feasibility and ease of developing low-cost weapons that could compromise airship survivability.



## Summary of Aerostat and Airship Costs

LTA Types	Unit Cost System Estimate	Development or Deployment
Aerostats < 15,000 ft	\$5M - \$6 M	Deployment: \$0.5M - \$1.0M (year)
Manned Airships low < 10,000 ft	\$3M - \$10M	Deployment: \$1M - \$3M (year)
Unmanned Airships low < 10,000 ft	\$3M - \$10M	\$10M - \$20M RDT&E

**Note:** System costs include: Helium, envelope material, structure (if semi-rigid), sensors (EO/IR, radar, others), tethers (aerostats), ground-handling equipment, ground-control systems (unmanned airships), and approximation of personnel costs. Development costs shown include actuals where programs are completed and ROMs where programs are in development.

## Summary of Aerostat and Airship Costs

The cost data for currently operational LTA systems is based on actual data obtained from the agencies that manage LTA projects: Balloon projects sponsored by NASA; aerostats procured by the Army, Air Force, and Marine Corps; manned airships used for commercial advertising (such as: the Goodyear GZ-22 blimps; the AMS and ABC low-altitude airships used for law enforcement; and the Zeppelin (semi-rigid) LZ N07 passenger-service airship).

System costs include: Helium, envelope material, structure (if semi-rigid), sensors (EO/IR, radar, others), tethers (aerostats), ground-handling equipment, ground-control systems (unmanned airships), and approximation of personnel costs. Development costs shown include actual costs for programs that are completed and rough order of magnitudes (ROM) where programs are in development.

The cost estimates for the unmanned airships at both low (less than 10,000 feet) and high (greater than 60,000 feet) altitudes were extrapolated from costs for manned low-altitude airships and actual data from in-service UAV programs that developed onboard controls, datalinks, and ground-control stations that could potentially be used in airships.

The cost data for additional sensors that could be installed on unmanned systems was gathered from Navy and Marine Corps aircraft and UAV programs purchasing various subsystems.

The envelope costs for LTA vehicles other than the large hybrid and the high-altitude airships, which will require R&D to develop higher-strength lightweight materials, are based on actual data from ILC Dover, TCOM, and Aerostar, which are the primary manufacturers of LTA envelopes in the United States.

The ground-service equipment, e.g., mooring masts, electric generators, fuel and helium-replenishment trailers, ground-crew workshop/sleeping quarters, and ground-control

center for data and power (aerostats only), distribution/dissemination, costs all are actual data from current LTA programs.

The development program costs were obtained from current programs, programs that were started in the last decade but never reached completion, and from the LTA database compiled by the American Institute of Aeronautics and Astronautics (AIAA).



### **Cost/Endurance Comparison for Persistent Surveillance Platforms**

<b>Platform</b>	<b>Cost/flight hour</b>	<b>Endurance (unrefueled)</b>
<b>AWACS</b>	<b>\$20,000</b>	<b>11 hours</b>
<b>JSTARS</b>	<b>\$20,000</b>	<b>11 hours</b>
<b>E-2C</b>	<b>\$18,700</b>	<b>4.7 hours</b>
<b>Global Hawk</b>	<b>\$26,500</b>	<b>35 hours</b>
<b>Predator</b>	<b>\$ 5,000</b>	<b>40 hours</b>
<b>420K TARS</b>	<b>\$ 300-500</b>	<b>15-30 days</b>
<b>Airship (Zeppelin)</b>	<b>\$ 1,800 (1 yr lease)</b>	<b>Few days</b>

### **Cost/Endurance Comparison for Persistent Surveillance Platforms**

For the persistent surveillance mission, one key metric is the comparison of cost per flight hour with endurance timeframes. The table above lists costs and endurance for platforms currently performing aerial surveillance missions.

This data was obtained from Navy and Air Force programs of record, and the German company Zeppelin. The data illustrate the longer endurance and significantly lower “cost per flight hour” for the LTA systems. The LTA, aircraft, and UAV data include the cost of manpower, fuel, support, and maintenance.

No reference information was available comparing platform vulnerability, area of coverage, operational altitude, etc., against cost or endurance. This is needed to consider a full evaluation of the alternatives.

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## Conclusions: Aerostats

- **Provide persistence for 15 –30 days**
  - Persistence reduced by weather
- **Carry sensors to**
  - monitor groups of people**
  - detect and track low flying aircraft**
  - detect and track small boats**
- **Lower cost option**
- **Provide low cost, persistence surveillance**
  - Port and harbor security
  - ISR for independently operating ships
- **Extend the horizon**
  - Communications relay for Marines on the ground
  - Communications link for ships operating independently

## Conclusions: Aerostats

Aerostats are available now. They have been used successfully since 1980 as part of Northern Command's surveillance network for the Mexican border and for counter-drug operations in the Florida Keys. Recently, the Army deployed (both in Iraq and Afghanistan) aerostats fitted with ISR sensors and communications-relay systems. The Marine Corps has also deployed one aerostat to Iraq for communications.

Israel has been a major user of aerostats providing surveillance of critical border areas. Israel has linked remotely controlled sniper rifles to the EO/IR sensor images generated by the aerostat. This capability could be easily exploited for port and harbor security, especially for ports overseas.

Independent steaming will most likely be part of the LCS operational concept. Without the airborne early warning provided by a carrier, the LCS will be dependent on their helicopter, Firescout UAVs, and the Global Information Grid (GIG) for the intelligence they require. Giving these ships the additional capability to deploy and operate an aerostat with EO/IR and communications payloads in all weather and at all ship speeds will extend their horizon for communications and ISR, provide improved situational awareness, and a more effective capability to detect and defeat incoming threats.

The Marine Corps has developed a Universal Need Statement (UNS) to evaluate and field a radio-relay system that can provide commanders and their units with the capability to communicate via very high frequency (VHF) and ultra high frequency (UHF). Such a relay system would address line-of-sight deficiencies of the current system. The Panel supports the UNS and believes that the use of aerostats to meet this requirement would be a low-risk solution.

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## **Conclusions: Low-Altitude Airships**

- **Provide enhanced capabilities for ISR**
  - Can maneuver and track movement
- **Army experience with aerostats and JLENS development**
  - Validated need for repositioning of sensors
  - Validated need (unfunded) for an unmanned airship
- **Unmanned airships desired for combat areas**
  - Aircrew vulnerability

## **Conclusions: Low-Altitude Airships**

Today, commercial airships operate regularly for a variety of missions. The value of a long-endurance vehicle that can relocate and provide persistent sensor coverage over an area is clear. However, the risks to crews of manned airships are too high in combat to recommend use of manned airships in that environment.

The JLENS program office has been responsive to the needs of the Army in Iraq and Afghanistan. JLENS has deployed aerostats to both regions for ISR and communications relay. However, based on experience with aerostats in combat and from the ongoing development of the JLENS, the program office has documented the need to remove the tether and provide ISR and communications-relay capabilities in an unmanned airship.

Manned low-altitude airships that operate below 10,000 feet are readily available for operational testing. While airship manufacturers believe that development of an unmanned airship is relatively simple, none have embarked on this effort with their own funds.

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## **Recommendations: Low-Altitude Aerostat**

- **Capture lessons learned from use of aerostats in Iraq and Afghanistan**
- **Support Marine Corps Universal Need Statement for aerostat comm relay (MCCDC)**
- **Acquire aerostats to conduct operational experimentation for port/harbor security (CFFC)**
- **Initiate program to develop aerostats for shipboard underway operations**
- **Conduct LTA GPS assurance experiments**

## **Recommendations: Low-Altitude Aerostat**

The NRAC LTA Panel urges the Navy to capture the lessons learned from the use of aerostats in Iraq and Afghanistan.

The Marine Corps UNS for a radio-relay system should be supported. The Marine Corps should either lease or procure aerostats to meet this need.

Commander Fleet Forces Command (CFFC) should acquire aerostats to conduct an operational evaluation of their utility for port and harbor security, both in the Continental United States (CONUS) and overseas. Many sources of operational experience are available to aid in developing operational concepts for the use of aerostats for port/harbor security.

Aerostats could provide significant capability enhancements for ships that steam independently. However, with the exception of Israel, no aerostats have been built that can withstand the environmental conditions of a ship underway at high speeds in bad weather. Israel is using aerostats on its SA'AR-4.5 and SA'AR-5 corvettes.

The Panel recommends that the Navy initiate an Advanced Concept Technology Demonstration (ACTD) to demonstrate and expand the operation of aerostats from underway ships. The ACTD should include methods to rapidly lower and stow the aerostat aboard ship without adversely impacting ship performance.

Finally, GPS jamming remains a significant concern because of the considerable dependence of U.S. forces and weapons on GPS for guidance and navigation. Aerostats or airships could potentially be used as "pseudo satellites" to transmit high-power GPS signals to defeat local jamming. The Panel recommends testing be conducted to prove the viability of this concept.

Note: Panel member Ms. Teresa B. Smith recused herself from participating in the discussion concerning the recommendation, “Initiate program to develop aerostats for shipboard underway operations”.



## **Recommendations: Low-Altitude Airships**

- **Support the NAVAIR Advanced Development Program Office (ADPO) dedicated to airship exploratory initiatives—near and far term**
- **Lease or procure an airship to develop and evaluate unmanned naval operation**
- **Pursue a joint ACTD for an unmanned airship with CENTCOM and/or SOCOM and DHS sponsorship**
- **Address survivability issues**
- **Conduct fleet operations to evaluate airships (CFFC)**

## **Recommendations: Low-Altitude Airships**

In June 2002, NAVAIR established an Advanced Development Program Office (ADPO) for exploratory airship initiatives to investigate the uses of LTA technology. The program office has been funded to set up an Advanced Airship Flying Laboratory (AAFL). Specific development tasks include: resizing an existing airship for a 20,000-foot operating envelope, adapting a heavy fuel engine for airship propulsion and operation at an altitude of 20000 feet, developing airship digital flight controls, and developing the capability to operate the airship in an unmanned configuration.

The Panel was in strong support of NAVAIR's LTA ADPO and its mission, but recommends that its exploratory responsibilities be expanded to include both near- and far-term projects. The Panel also supports the NAVAIR ADPO effort to demonstrate an unmanned airship with a 20,000-foot operating ceiling. This capability would have joint-service applications as well as applications for non-defense government agencies. It would also be a potential contributor to maritime domain awareness and represent a factor for consideration in the decision on meeting the Broad-Area Maritime Surveillance (BAMS) requirement.

The Panel recommends a joint ACTD to evaluate an unmanned airship to be sponsored by either Central Command (CENTCOM) or Special Operations Command (SOCOM) with the Department of Homeland Security sponsorship.

The Panel also supports an investigation to understand the kinds of enemy attacks that would compromise the envelope survivability of the airship. The Panel also calls for studies to determine the best ways to protect the airship sensor payload from enemy fire.

Finally, CFFC should participate in developing operational test parameters for the airship(s) acquired by NAVAIR and in conducting the operational testing.



## **High-Altitude Airship (Unmanned)**

- **Potential Missions**
  - **ISR (cruise missile defense)**
  - **Communications relay**
  - **GPS assurance and enhancement**
- **Potential Characteristics**
  - **Altitude: > 65,000 ft – increased line of sight**
  - **Endurance: >30 days**
  - **Large aperture antennas**
  - **Possible novel hybrid design**

### **High-Altitude Airships (Unmanned)**

The Panel also explored the feasibility of using LTA vehicles to provide enduring, persistent wide-area surveillance, communication relays, and organic GPS pseudo-satellites.

To perform these missions, operational altitude, endurance, sensors, and design issues must be considered. As described earlier, LTA platforms seem to operate most efficiently in the 60,000 to 70,000 feet altitude range. This altitude range derives from several factors. One is the need for station-keeping in prevailing atmospheric winds, which are much stronger above and below those altitudes. Another is the decreasing density of the earth's atmosphere, coupled with the need to maintain an internal envelope overpressure in order to maintain shape while station-keeping in the wind. Finally, the use of air-breathing engines is generally limited to this altitude regime.

The need for endurance of greater than 30 days probably requires regenerative power sources. Currently, solar power is being considered as such a source. In addition, the strong vertical wind shears in these regions might allow for the use of "sails" to augment the solar power source. Whatever the choice, this regenerative source must provide power for both station-keeping and active sensors, such as radars. For conventional approaches, the result of this is a very small payload fraction (a few percent), which can go to zero.

Finally, to perform the ISR mission, large aperture antennas need to be incorporated into the vehicle design and payload.

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## High-Altitude Airship Status

- **Required capabilities exceed current technology base**
- **DARPA sponsoring ISIS radar (1600 square meter antenna) development**
- **Missile Defense Agency/High Altitude Airship (HAA) is developing a scaled vehicle**
- **Others pursuing high altitude vehicle (Japan, South Korea, Sanswire ...)**

## High-Altitude Airship Status

The DARPA ISIS program is attempting to develop the technologies for a high-altitude airship. The ISIS consists of a very low-power density active radar in which the radar elements are integral to the structure. The program goal is to achieve acceptable wide-area performance by exploiting the ability to accommodate a very large aperture. This must be accomplished with an integrated structure/envelope/aperture weight per unit area of about one-half of that for a conventional airship envelope. This makes it a very high-risk development.

Another high-altitude technology program is the Missile Defense Agency's HAA program, which suffers from a small payload fraction problem.

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## **High-Altitude Airship S&T Issues**

- **Materials (corrosive ozone, ultraviolet radiation, high winds)**
- **Power sources (must be regenerative for mission and propulsion)**
- **Propulsion (station keeping/transit)**
- **Controls**
- **Data load handling**
- **Integration**

## **High-Altitude Airship S&T Issues**

The Panel reviewed several design studies and concluded that many technical capabilities required for high-altitude airships cannot be met with currently available technology.

For example, solar collectors, thermal-management systems, and lightweight envelope materials that can withstand the ultra-violet radiation and corrosive ozone at high altitudes are not mature enough to ensure effective operations. Vehicle control systems and data management also remain major challenges. Finally, the precise metrology required to combine antenna elements coherently with large flexible arrays has never been demonstrated.

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## **High-Altitude Airship (Unmanned) Recommendations**

- **Monitor high-altitude airship development but at this time do not allocate S&T funds or other resources to the program.**
- **Leverage the DARPA ISIS S&T program for the development of a low-power-density, large aperture antenna for application in LTA vehicles**

### **High-Altitude Airship (Unmanned) Recommendations**

Presently, the Panel does not recommend a Navy investment in high-altitude airships. Instead, the Panel urges the Navy to leverage some of the DARPA ISIS large-aperture, low-power-density integrated radar technology for lower-altitude airships

The Panel recommends that the Office of Naval Research (ONR) be asked to determine whether the technology being developed for the Advanced Multifunction RF Concept (AMRFC) can be used to support the High-Altitude RF sensor design.

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## Heavy-Lift LTA

### Heavy Strategic Lift to Sea Bases and Forces Ashore

- **Current Options:**
  - Multiple cargo transfers
  - Vehicles payload and range limited
- LTA Heavy Lift offers potential for direct heavy lift from CONUS to sea bases and forward-deployed ground forces
- Significant Technology Development Required
- DARPA Walrus to Demonstrate Several Heavy Lift Attributes

	Demo Phase	Final Goal
IOC	2009	??
Range	2000 nm	12000 nm
Payload	40 Tons	> 500 Tons
Volume	2,500,000 ft3	30,000,000 ft3
Speed	>70 Kts	> 70 Kts
T.O./Lndg/Cargo Ops	??	??

## Heavy-Lift LTA

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 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.

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## Heavy-Lift LTA Technical Challenges

- **Internal Buoyancy Control**
  - Fuel Burn/ Helium Degradation
  - Off-Loading Compensation
- **Fabric/Structure Development**
- **Ground/Ship Compatibility During Landing/Takeoff/Rest**
  - Wind/weather
  - Sea state
  - Loading/unloading

Heavy-Lift LTA Systems Are Promising  
But  
Not Ready for Acquisition

## Heavy-Lift LTA Technical Challenges

The heavy-lift LTA concept must surmount several technical challenges to be a viable operational platform.

To achieve desired payload fractions over the ranges required, the LTA vehicle (shape most likely a hybrid design) 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.

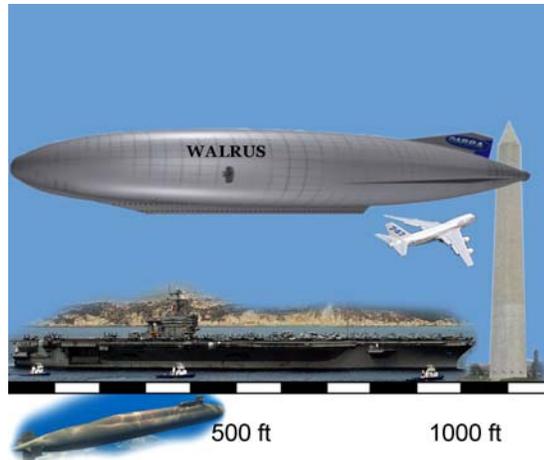
Heavy lift LTA vehicles must also be able to takeoff and land in a “heavy” or full load configuration without requiring the support of large ground crews.

The development and demonstration of concepts for the structure and fabric also remains a critical issue.

Finally, from the naval perspective, the 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.

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## Size Perspective for Walrus



## Size Perspective for Walrus

This graphic shows the dimensions of the DARPA proposed Walrus 500-ton vehicle. The Walrus is comparable in size to a Nimitz-class aircraft carrier, an Ohio-class ballistic missile submarine, a C-5A transport, and the Washington monument. The size scale of the Walrus concept is a dramatic step forward in large airship technology.

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## Heavy-Lift LTA Recommendations

- **Assign /establish responsibility for development of relevant CONOPS for heavy-lift LTA program**
- **Monitor and actively engage with Walrus prototype to investigate naval compatibility**
- **Conduct studies to ensure Maritime Prepositioning Force (Future)--MPF(F)--ships are compatible with proposed heavy-lift airship concepts**

## Heavy-Lift LTA Recommendations

The Panel believes that the Navy should initiate a series of studies to look at operational concepts for transit for heavy-lift LTA vehicles to and from ships.

The Panel recommends that the Navy adopt a “wait-and-see” strategy with respect to the DARPA Walrus program, until the prototype LTA platform is developed and demonstrated.

The Panel recommends a series of system-level studies to look at the requirements for ensuring that planned MPF(F) ships are compatible with proposed heavy-lift airship concepts.

Depending on the findings of the DARPA 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.

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## Conclusions

- **The Navy is behind the Marine Corps, Army, Air Force in the use of LTA for military missions.**
- **Aerostats provide affordable persistence for accomplishing Navy-Marine Corps missions:**
  - force protection ashore
  - communications relay
  - electronic warfare
- **Advanced LTA concepts—that require investment--offer promise for greatly enhancing performance**
  - unmanned airships
  - aerostats on underway ships
- **Advanced LTA concepts-that require significant S&T investment- offer promise for greatly enhancing performance**
  - high altitude airship
  - cargo lift
- **Current LTA capabilities for heavy lift and high altitude ISR are being oversold**

## Conclusions

At this time the Navy does not have an active LTA program or significant recent experience in this field. The Panel believes that a large segment of the military has a cultural bias against LTA vehicles. LTA is seen as old technology discarded by the Navy in 1960 with little utility for current missions.

The Panel has determined that aerostats currently are providing affordable, near-term solutions for military missions. These include: (1) the Marine Corps' use of aerostats in Iraq for communications relay; (2) the Army's use of aerostats in Iraq and Afghanistan for ISR and base security; (3) the employment of aerostats fitted with cameras and radars by the Air Force and Department of Homeland Security for border security; and (4) aerostats flown by the Israeli government for counter-terrorism, military (including naval operations), and border-security missions.

Commercial LTA activities worldwide are limited primarily to the advertising market. While low-altitude manned airships have some military application, they do not provide the basis for supporting a broad military LTA program. Therefore, advanced LTA concepts will require some investments in order to prove technology and mission viability.

The technologies required for persistent, high-altitude airships are being pursued by the Missile Defense Agency HAA program and the DARPA ISIS program. However, both need to overcome significant technical challenges before they are demonstrated. Nevertheless, an unmanned HAA could greatly benefit naval operations ashore and afloat.

The technologies required for heavy-lift airships now being pursued by the DARPA WALRUS program, also pose significant technical challenges. The Walrus program is in its early stages, with a technology demonstrator scheduled to be tested in 2009.

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## Summary Recommendations

- Expand and sustain the existing NAVAIR Advanced Development Program Office (ADPO) to include all naval LTA R&D systems activities—near to far term
- Evaluate capability of aerostats for naval port/harbor security and for Marine Corps communications relay
- Demonstrate an aerostat for underway shipboard operations—50 knots, sea state 3+
- Demonstrate low-altitude, unmanned airship to provide rapid reaction for ISR, communications relay, electronic warfare, mine countermeasure, and ASW
- Leverage the DARPA ISIS S&T program for the development of a low-power-density, large aperture antenna for application in low-altitude LTA vehicles
- Explore utility of ONR Advanced Multi-function RF Concept (AMRFC) technology for high-altitude, low-power-density, large aperture LTA radar systems
- Conduct studies to understand how the WALRUS prototype vehicle interfaces with future sea-basing concepts, including MPF(F)

## Summary Recommendations

The Panel's recommendations for Navy and Marine Corps use of LTAs are as follows:

The scope of the current NAVAIR Airship ADPO should be expanded to include consideration of unmanned LTA vehicles, aerostats and airships in particular, and the compatibility of these platforms with combat ships. The ADPO office should become the center for LTA R&D within the Department of Navy (DON) and should develop a plan for both near- and far-term research and development (R&D), including needed S&T investments and LTA-specific needs and infrastructure. After review, this activity should be adequately resourced, and both should be accomplished as soon as possible.

The Navy should undertake a serious effort to determine where LTA technologies and systems can help meet current and future needs of the Navy and Marine Corps. In the near-term, the ADPO should work with the Marine Corps Command Development Command (MCCDC), Navy Warfare Development Command (NWDC), and CFFC to set the specifications to allow the Marine Corps to lease or procure aerostats for naval port/harbor security and for Marine Corps communication relays.

The use of aerostats as a platform for ISR sensors and communication-relays during underway ship operations should be demonstrated as soon as practical. This should stress the aerostat operational envelope to about 50-knot ship speed and sea state 3-plus.

Rapid-reaction unmanned low-altitude airship operations should be demonstrated as multi-purpose platforms for ISR, communication-relays, and EW. Emphasis should be on determining and resolving relevant airspace-management issues, modular payload packages and easily transportable infrastructure.

For the longer term, the Navy should determine whether any of the technologies being developed and tested in the ONR AMRFC program have utility for low-power-density, large-aperture, and low altitude LTA radar systems. The Navy should also examine how it can leverage the DARPA ISIS program for near-term applications of the integrated radar aperture/structure concepts for low-altitude airships and aerostats.

Finally, the Panel recommends that the Navy initiate a series of detailed studies to understand how the DARPA WALRUS prototype vehicle interfaces with future sea-basing concepts, including MPF(F). Depending upon the results of these studies, consideration should be given to modifying a Navy amphibious ship to serve as a test platform to evaluate and demonstrate loading, unloading, landing, and takeoff concepts.

# Appendix A

## Glossary

AAFL	Advanced Airship Flying Laboratory
ACTD	Advanced Concept Technology Demonstration
ADPO	Advanced Development Program Office
AIAA	American Institute of Aeronautics and Astronautics
AMRFC	Advanced Multifunction RF Concept
ASN(RD&A)	Assistant Secretary of the Navy (Research and Development)
AWACS	Airborne Warning and Control System
BAMS	Broad Area Maritime Surveillance
BDA	Battle Damage Assessment
BLOS	Beyond Line of Sight
CENTCOM	Central Command
CFFC	Commander Fleet Forces Command
CONOPS	Concept of Operations
CONUS	Continental United States
DARPA	Defense Advanced Research Projects Agency
DASN	Deputy Assistant Secretary of the Navy
DHS	Department of Homeland Security
DOD	Department of Defense
DON	Department of the Navy
EO	Electro-Optical
EW	Electronic Warfare
GBR	Ground Based Radar
GIG	Global Information Grid
GPS	Global Positioning System
GWOT	Global War on Terror
HAA	High Altitude Airship
HDTV	High-Definition Television
IED	Improvised Explosive Device
IR	Infrared
ISIS	Integrated Sensor is Structure

ISR	Intelligence, Surveillance and Reconnaissance
JLENS	Joint Land-attack Elevated Netted Sensor
JSTAR	Joint Surveillance Target Attack Radar System
KFT	Thousand Feet
LASH	Littoral Airborne Sensor Hyperspectral
L/D	Lift To Drag
LCS	Littoral Combat Ship
LTA	Lighter-than-air
MCCDC	Marine Corps Command Development Command
MIST	Maritime Interdiction and Surveillance Team
MOD	Ministry of Defense
MPF(F)	Marine Pre-Positioning Force (Future)
MSL	Mean Sea Level
NASA	National Aeronautics & Space Administration
NAVAIR	Naval Air Systems Command
NRAC	Naval Research Advisory Committee
NWDC	Naval Warfare Development Command
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
POP	Plug-in Optronic Payload
R&D	Research and Development
RAID	Rapid Aerostat Initial Deployment
ROM	Rough Order of Magnitude
RD&A	Research Development and Acquisition
RF	Radio Frequency
RTD&E	Research, Development, Test and Evaluation
S&T	Science and Technology
SAR	Synthetic Aperture Radar
SASS	Small Aerostat Surveillance System
SOCOM	Special Operations Command
TARS	Tethered Aerostat Radar System
TOR	Terms of Reference

TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
UNS	Universal Needs Statement
VHF	Very High Frequency



# Appendix B

## Terms of Reference

### Objective

To consider each of the forms of Lighter-than-air (LTA) Technology that are or could be available to fleet units within a decade and perform an assessment of their potential value for the full spectrum of Sea Power 21 missions from an affordability and utility perspective identifying opportunities to reduce the reliance upon existing Heavier Than Air assets and provide capabilities to meet new Global War on Terror (GWOT) generated needs. Emphasize the applications for (1) global transoceanic and sea based delivery of heavy, oversized cargo into areas which lack reception infrastructure (ports, airports, or landing fields) at sea and on land, (2) security of naval port/harbor resources (3) force protection from cruise missiles, fast boats, shallow water submarines and mines at sea and in port. Include manned and unmanned systems and options for government procured and crewed versus leased equipment with full contractor support.

### Background

Twenty-first century Naval Forces must be prepared to cope with a wide variety of threats ranging from port and base protection from terrorists attacks to the possibility of littoral warfare against emerging peer forces. The range of threat and security tasks requires the need for persistent intelligence, surveillance, reconnaissance, and communication (ISR&C) needs. The current family of air systems can provide a presence for relatively short periods but are costly. The Navy must identify and evaluate through demonstrations a means to provide persistent ISR&C. Extended airborne flight utilizing lifting gas is an ancient method that has been employed periodically for important naval missions. The confluence of modern communications, sensors, propulsion systems and new materials presents and opportunity for a broader and more cost-effective exploitation of LTA technology. Airships and aerostats are being used in at least 13 different countries for commercial, military, and homeland security applications. Airship and aerostat programs are funded and exist today in U.S. Army, U.S. Air Force, Navy, DARPA, USCG and U.S. Northern Command in stages from operational (in OEF/OIF/Southern U.S., Gulf of Mexico) to ATD/ACTD.

The Naval Air Systems Command Airship Advanced Programs Development Office categorizes forms of manned and unmanned LTA vehicles and their possible applications as follows:

#### Category 1

COTS Commercial Airships: 150,000-300,000 cu ft non-rigid envelope airships which are primarily used for commercial advertising. Such crafts may be (and have been) leased and equipped with sensors/communications for use in domestic surveillance of high value assets or, when equipped with protective systems, may be employed in hostile environments as they were by the UK over N. Ireland to counter IRA terrorism.

Sea Power 21 Application: High Value Asset Protection.

#### Category 2 – Military Airships

1960s era USN airships which varied in size from 500,000 to 1.5M cu ft configured for long-range ocean patrol and with weapons for ASW or equipped with very large aperture radars (7'x 48') for air surveillance.

Sea Power 21 Application: Coastal patrol for USCG/DHS, ASW, Sea Shield

### Category 3 – Hybrid Airships

Ultra-large blimps shaped like a low speed airfoil to exploit the dual benefits of static and dynamic lift. The lift envelopes for such craft will vary from 1 million to 50 million cu ft and carry payloads up to 500 tons over trans-global ranges. The major advantage of this design is that it eliminates the operational burden of ground crews to assist in airship landing, arrestment and cargo loading/unloading. The hybrid utilizes a proven air cushion system for ground contact and therefore can land or takeoff from most surfaces to include lakes, rivers, the ocean or desert. The trans-global cruise speeds can vary from 50 to 100 kts with ranges in excess of 5000 nmi.

Sea Power 21 Applications:

- Rapid delivery of heavy equipment and troops over strategic distances to advanced sea base or directly into foreign territory, thus countering enemy anti-access measures or hauling supplies into areas which lack air/sea ports in support of disaster relief. Future Sea Base Connector. – TACAMO – extended loiter in support of submarine communications.
- Navy/Army Low Altitude Air Defense against CM (Sea Shield).
- Battle Force CISR (FORCE Net).

### Category 4 – High Altitude/Near Space Platforms (pseudolytes) and Aerostats

Platforms included tethered aerostats, HAA and freelight balloons equipped with sensor/comms payload. Sea Power 21 Application: Sea Shield

In general, the primary product of LTA is Affordable Persistence while the Hybrid Aircraft offers a “transformation” in the areas of trans-global lift.

## **Specific Tasking**

Specifically, this NRAC study will:

- Identify opportunities for and obstacles to exploitation of LTA technology for naval missions (e.g. budget, culture, technology maturity, COTS, International technologies, Congress, etc.)
- Based on potential utility/effectiveness, identify and prioritize the missions where LTA systems (manned or unmanned) offer the greatest promise in near, mid and long term to address future capability gaps (Sea Power 21, GWOT other)
- Identify technology development risks for the most promising applications
- Assess the potential of the industrial base to provide air vehicles, vehicle control systems, data links, sensor systems and affordable manufacturing for the various types of airship and aerostat systems

- If possible, assess manpower requirements for operations and support of these LTA systems (manned and unmanned)
- If possible, recommend an acquisition strategy for the highest payoff LTA systems (consider teaming/leveraging with other Services, other government agencies, etc.)

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