Lighter-Than-Air Systems for Future Naval Missions

Flag Officers
And
Senior Executive Service

4 October 2005
The Pentagon Auditorium
Outline

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- Study Findings
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  - High Altitude Airship
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- Conclusions
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# Panel Membership

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<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
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</thead>
<tbody>
<tr>
<td>Dr. Walton E. Williamson, Jr. — Chair</td>
<td>Chair</td>
<td>Texas Christian University</td>
</tr>
<tr>
<td>Mr. Richard L. “Dick” Rumpf — Vice-Chair</td>
<td></td>
<td>Rumpf Associates International</td>
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<tr>
<td>VADM William C. Bowes, USN (Ret.)</td>
<td></td>
<td>Private Consultant</td>
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<tr>
<td>Dr. Jim Engelland</td>
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<td>Private Consultant</td>
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<tr>
<td>Dr. Fernando “Frank” L. Fernandez</td>
<td></td>
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<tr>
<td>MajGen Paul Fratarangelo, USMC (Ret.)</td>
<td></td>
<td>Contrail Group, Inc.</td>
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<tr>
<td>VADM E. R. “Rudy” Kohn Jr. USN (Ret.)</td>
<td></td>
<td>Private Consultant</td>
</tr>
<tr>
<td>Mr. Mark J. Lister</td>
<td></td>
<td>SARNOFF Corporation</td>
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<tr>
<td>Dr. William A. Neal, M.D.</td>
<td></td>
<td>Robert C. Byrd Health Sciences Center</td>
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<tr>
<td>Mr. Norman Polmar</td>
<td></td>
<td>U.S. Naval Institute</td>
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<tr>
<td>Ms. Teresa B. Smith</td>
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<td>Northrop Grumman Electronic Systems Sector</td>
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<tr>
<td>Dr. Patrick H. Winston</td>
<td></td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>Mr. David B. Bailey—Executive Secretary</td>
<td></td>
<td>Naval Air Systems Command</td>
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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
Categories of LTA Vehicles

Balloons
- AMS Skyship 600
- ABC Lightship A-170
- Goodyear GZ-22 (Non-Rigid)

Airships
- Zeppelin NT (Semi-Rigid)

Aerostats (Tethered)
- ATG Sky Kitten

Hybrids
## Executive Summary

### Conclusions

- LTA vehicles exist that offer enhanced, lower cost capability for persistent ISR, communications relay or electronic warfare capabilities
  - Marine Corps communication relay
  - Port/harbor security
- Both persistent high-altitude airships and heavy-lift airships offer desired solutions for future maritime missions, but require significant technology development

### Recommendations

- Acquire and evaluate capability of aerostats for naval port/harbor security and for Marine Corps communications relay
- Develop an aerostat for shipboard operations underway, e.g. LCS
- Demonstrate low-altitude, unmanned airship to provide rapid reaction for ISR, communications relay, electronic warfare and other capabilities
- Leverage the DARPA ISIS S&T program for the development of a low-power-density, large aperture radar system for application in low-altitude LTA vehicles
- Conduct studies to understand how a hybrid/cargo lift prototype vehicle interfaces with future sea-basing concepts, including MPF(F)
LTA Committee Study Work-flow

1. Define Potential Missions
2. Define LTA Categories/Characteristics/Limitations
3. Map/Assess Mission vs. Category
4. Assess High-value Results
5. Establish Conclusions
6. Make Recommendations

Steps:
- Survey Field/Fact Find
- Define Potential Missions
- Define LTA Categories/Characteristics/Limitations
- Map/Assess Mission vs. Category
- Assess High-value Results
- Establish Conclusions
- Make Recommendations
# LTA Briefings Received

<table>
<thead>
<tr>
<th>Programs</th>
<th>Government Organizations</th>
<th>Industry</th>
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<tbody>
<tr>
<td>• JLENS</td>
<td>• OFFICE OF NAVAL RESEARCH</td>
<td>• Lucent</td>
</tr>
<tr>
<td>• TARS</td>
<td>• NAVAIR</td>
<td>• Northrop Grumman</td>
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<td>• SASS</td>
<td>• DARPA</td>
<td>• L3 Communications</td>
</tr>
<tr>
<td>• REAP</td>
<td>• HQMC (I &amp; L)</td>
<td>• Lockheed Martin</td>
</tr>
<tr>
<td>• RAID</td>
<td>• MCSC</td>
<td>• American Blimp Corp</td>
</tr>
<tr>
<td>• Combat SkySat</td>
<td>• NASA Dryden</td>
<td>• Raytheon</td>
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<td>• HATB</td>
<td>• US Army G2 &amp; ASA</td>
<td>• Airship Mgt Services</td>
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<tr>
<td>• Talon Topper</td>
<td>• CAA (Army)</td>
<td>• ILC Dover</td>
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<tr>
<td>• HABIT</td>
<td>• USAF (Near Space &amp; Battle Lab)</td>
<td>• PSL (NMSU)</td>
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<td>• ISIS</td>
<td>• DASN-AIR, DASN- RDT&amp;E</td>
<td>• TCOM</td>
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<td>• WALRUS</td>
<td>• NAVSEA (DEW Office)</td>
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<td>• PTDS</td>
<td>• OPNAV/N71</td>
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<td>• MARTS</td>
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<td>• HAA</td>
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<tr>
<td>• NMSU</td>
<td>• Chuck Myers (Hybrid Airships)</td>
<td>• Zeppelin (GER)</td>
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<tr>
<td>• UCLA</td>
<td>• Prof Don Layton (USN/NPGS, Ret)</td>
<td>• ATG (UK)</td>
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<td>• CAPT Lyn Whitmer (USN Ret)</td>
<td>• Selenia/Nautilus (IT)</td>
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<td>• CAPT Bob Ashford (USN Ret)</td>
<td>• Israel MOD</td>
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<td></td>
<td>• MAJ Greg Gotlieb (UK MOD Ret)</td>
<td>• Japan/JAXA/Sojitz</td>
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<tr>
<th>Non-Profit</th>
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<td>• AIAA</td>
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</table>
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
Why 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
Line of Sight Distance to Horizon vs Altitude

![Graph showing the relationship between Line of Sight Distance and Altitude](image-url)
Surveillance/Comm Relay Enhanced by Altitude

Target detection feasible
Comm link feasible

GBR Radar Shadow

Radar or comm
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
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…

Skyship 600: still flyable 2 hours after several hundred high-velocity bullet penetrations

*Heavy machine-gun fire set off on-board munitions, causing a fatal fire.
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
Winds Affect Flight Altitudes

Source: NASA

Baghdad, 3-sigma January winds
Sea-Based Aerostat Systems

Maritime Interdiction and Surveillance Team (MIST) – Coast Guard – 1980’s
Small Aerostat Surveillance System (SASS) – Army – 1980’s
## LTA Today

<table>
<thead>
<tr>
<th></th>
<th>Balloons</th>
<th>Aerostats</th>
<th>Airships</th>
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<tr>
<td>Commercial - International &amp; U.S.</td>
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<tr>
<td>- Tourism</td>
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<td>- Advertising</td>
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<tr>
<td>- Communications</td>
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<tr>
<td>U.S. Department of Defense</td>
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<tr>
<td>- Marine Corps COMM in Iraq</td>
<td>●</td>
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<tr>
<td>- Army Surveillance/force protection in Iraq/Afghanistan</td>
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<tr>
<td>- Air Force Border Surveillance</td>
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<td>U.S. Department of Homeland Security</td>
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<tr>
<td>- Border Patrol</td>
<td>●</td>
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<tr>
<td>- Detection of low-flying aircraft</td>
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<tr>
<td>- Detection of drug trafficking (aircraft, boats, people)</td>
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<td>Israel MOD</td>
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<td>- ISR</td>
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<tr>
<td>- Border surveillance</td>
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<td>- Naval surveillance</td>
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<td></td>
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<tr>
<td>- Counter terrorism</td>
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<td>Other Security Roles</td>
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<td>- NYPD Fleet Week</td>
<td>●</td>
<td></td>
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<tr>
<td>- Olympic Games (Atlanta, Athens)</td>
<td>●</td>
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All applications 15,000 ft. or below
Mission: Provide Base Security Cells With Hi-resolution, Day/night Surveillance Capability That Provides Enhanced Target Recognition and Situational Understanding.
Tethered Aerostat Radar System (TARS)

Operating Locations and Customers – AF ACC

- ORAD – Cheyenne Mt. AFB, CO
- SEADS/1 AF CONR – Tyndall AFB, FL
- USCS AMOC – March ARB, CA
- WADS – McChord AFB, WA
- JIATF-S – Key West, FL
- CAMOC – Punta Salinas, PR
- Tethered Aerostat Radar Site
Using hyperspectral passive electro-optic sensor, airship tracks whales along east coast.

LASH Sees to 51 Feet throughout Year – NASA data

- Depth in Feet
- January (Jan) -81
- February (Feb) -52
- March (Mar) -57
- April (Apr) -67
- May (May) -71
- June (Jun) -69
- July (Jul) -62
- August (Aug) -67
- September (Sep) -62
- October (Oct) -68
- November (Nov) -61
- December (Dec) -62

Skyship 600
LTA Sensors

Cineflex

ISR

Mini SAR

ISR

IED

ASW

MCM

IED

POP 300

Archer (HSI)

Vehicles under camouflage

FLIR

Night Helo landing
# Existing LTA Vehicle Comparison

<table>
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<tr>
<th></th>
<th>Payload</th>
<th>Endurance</th>
<th>Station Keeping</th>
<th>Line of Sight</th>
<th>Issues</th>
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<tbody>
<tr>
<td>Balloons</td>
<td>8000 lb @ 134 kft</td>
<td>Few days</td>
<td>Multiple launches</td>
<td>450 nm</td>
<td>Environment</td>
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<tr>
<td>Aerostats</td>
<td>2200 lbs &lt; 15 kft</td>
<td>15-30 days</td>
<td>Tether</td>
<td>150 nm</td>
<td>Tether vulnerable</td>
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<tr>
<td>Airships (Low altitude)</td>
<td>3000 lbs &lt; 10 kft</td>
<td>Few days</td>
<td>Maneuverability allows precise location and look angles</td>
<td>150 nm</td>
<td>Unmanned not demonstrated</td>
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</table>
Comparison of Past, Current, and Proposed Airships

Altitude (thousand ft.)

Gas Volume (cubic feet)

- Notional ISIS Concept
- High Platform II
- HAA
- SA-60
- YEZ-2K
- ZR-3
- ZRS-4/5
- Hindenburg
- YeZ-2K
- ZR-3
- ZRS-4/5
- Hindenburg

Proposed
Current
Past
Past
Aerostat

Walrus
30,000,000
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 (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)
Findings
# LTA Mission/Vehicle Potential

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<th></th>
<th>ISR</th>
<th>Comm Connectivity</th>
<th>Electronic Warfare</th>
<th>Quick Reaction Weapons</th>
<th>PSYOPS</th>
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<td>Aerostats</td>
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<td>Medium</td>
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<td>Low Alt</td>
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<td>Low Alt</td>
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<td>Medium</td>
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<td>Unmanned Airships</td>
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<td>High Alt</td>
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</table>
Aerostats and Low Altitude Airships
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
## Summary of Aerostat and Airship Costs

<table>
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<tr>
<th>LTA Types</th>
<th>Unit Cost System Estimate</th>
<th>Development or Deployment</th>
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</thead>
<tbody>
<tr>
<td><strong>Aerostats</strong></td>
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<tr>
<td>&lt; 15,000 ft</td>
<td>$5M - $6 M</td>
<td>Deployment: $0.5M - $1.0M (year)</td>
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<tr>
<td><strong>Manned Airships</strong></td>
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<tr>
<td>low &lt; 10,000 ft</td>
<td>$3M - $10M</td>
<td>Deployment: $1M - $3M (year)</td>
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<td><strong>Unmanned Airships</strong></td>
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<tr>
<td>low &lt; 10,000 ft</td>
<td>$3M - $10M</td>
<td>$10M - $20M RDT&amp;E</td>
</tr>
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</table>

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

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

• 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
### 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
Low-Altitude Airships Conclusions

- 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
Recommendations: Low-Altitude Airship

- 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)
High Altitude Airship
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 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 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 (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
Heavy Lift
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

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<th>Demo Phase</th>
<th>Final Goal</th>
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<tr>
<td>IOC</td>
<td>2009</td>
<td>??</td>
</tr>
<tr>
<td>Range</td>
<td>2000 nm</td>
<td>12000 nm</td>
</tr>
<tr>
<td>Payload</td>
<td>40 Tons</td>
<td>&gt; 500 Tons</td>
</tr>
<tr>
<td>Volume</td>
<td>2,500,000 ft³</td>
<td>30,000,000 ft³</td>
</tr>
<tr>
<td>Speed</td>
<td>&gt;70 Kts</td>
<td>&gt; 70 Kts</td>
</tr>
<tr>
<td>T.O./Lndg/Cargo Ops</td>
<td>??</td>
<td>??</td>
</tr>
</tbody>
</table>
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
Size Perspective for Walrus
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
Summary
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
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 countermine, 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)
Questions ?