Lockheed Martin HALE-D

Peter Lobner, 21 December 2020

1. Introduction

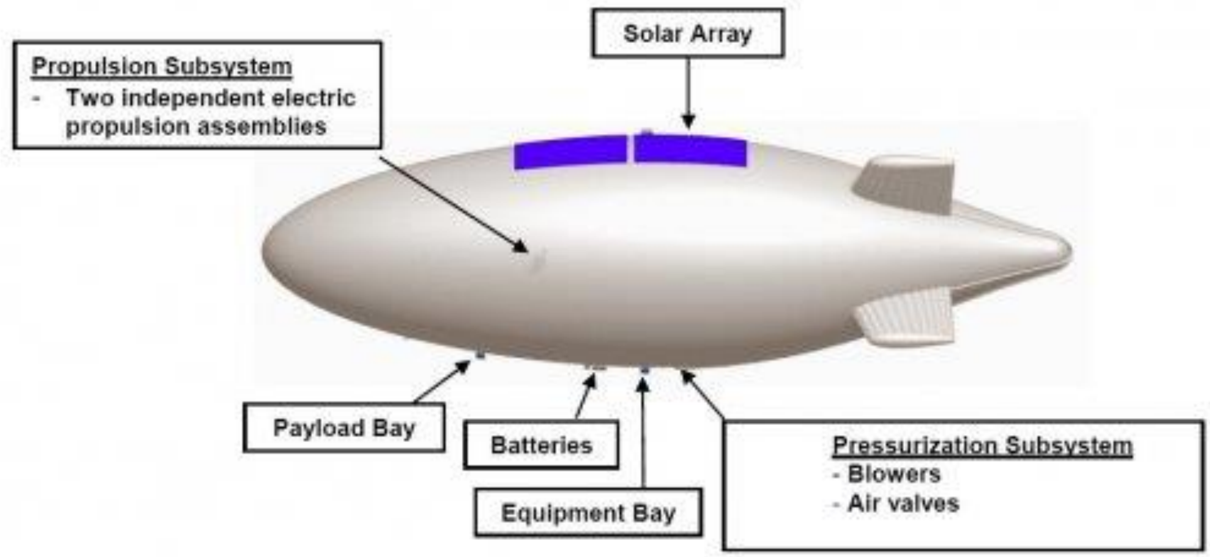
The High-Altitude Long-Endurance Demonstrator (HALE-D) was a science and technology development effort that was part of the Army’s High Altitude Airship (HAA) Advanced Concept Technology Demonstration (ACTD) program, which also included the HiSentinel family of airships. The long-term goal of the HAA program was to develop the full-scale HAA.

The ACTD program was focused on the developing the following key technologies for a high-altitude airship:

- Material suitability, primarily high-strength, light-weight fabrics for hull construction
- Fabrication methods
- Power systems, including thin-film solar arrays and a regenerative power supply (batteries)
- Aerodynamics
- Propulsion, focusing on lightweight units for station-keeping at high altitude
- Flight controls, including a remote piloting data link
- Thermal management over widely varying day / night environmental conditions at high altitude
- Gas pressure management
- Systems integration

HALE-D was initiated in FY 2003 by the Missile Defense Agency (MDA) with plans to build a prototype and a subsequent full-scale airship. In FY 2005, the program scope was reduced to develop just a single prototype. The Army’s Space and Missile Defense Command (SMDC) took over funding in FY 2008. Lockheed Martin was the prime contractor.

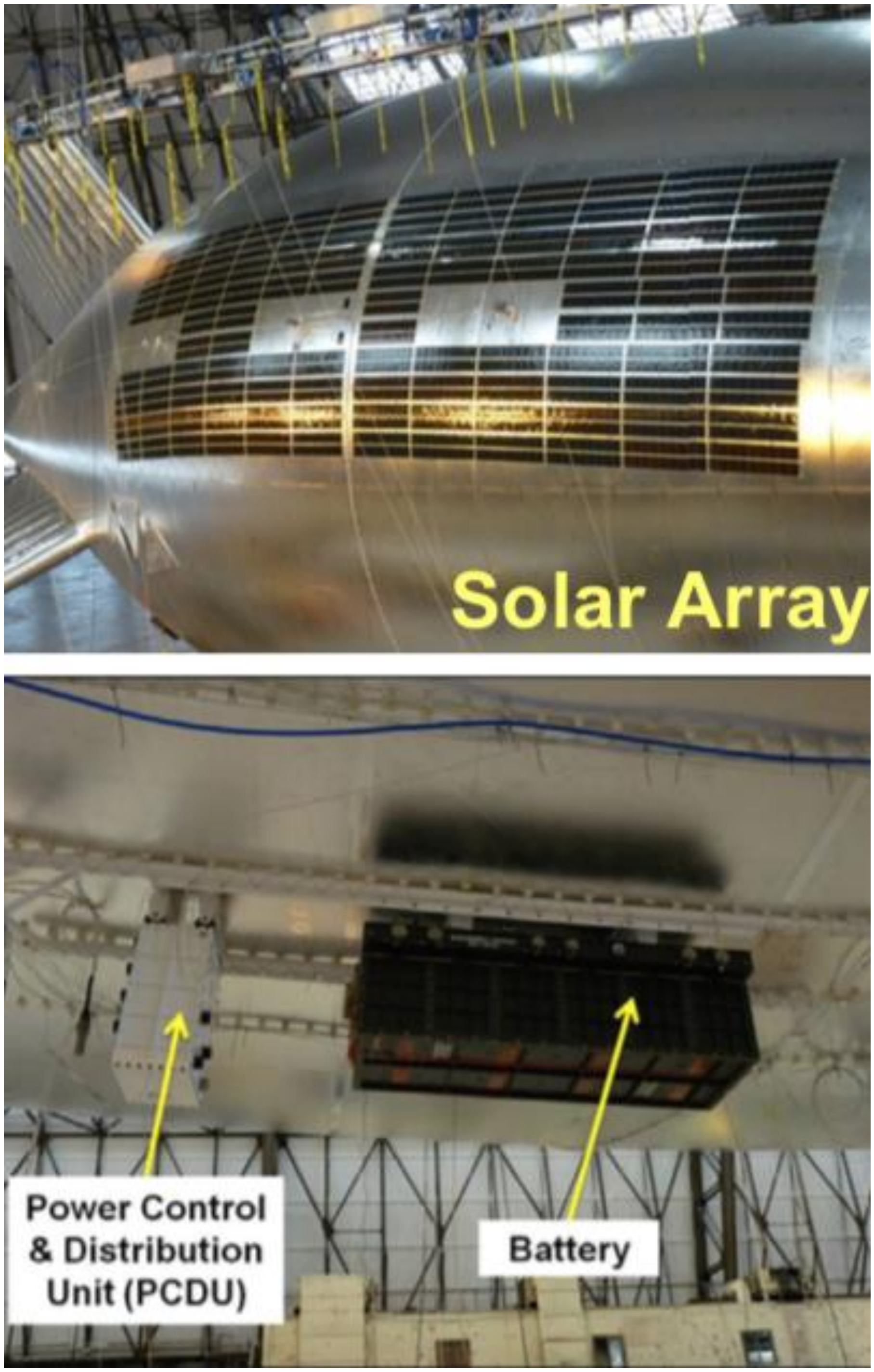
2. The HALE-D airship



HALE-D airship general arrangement. Source: Lockheed Martin

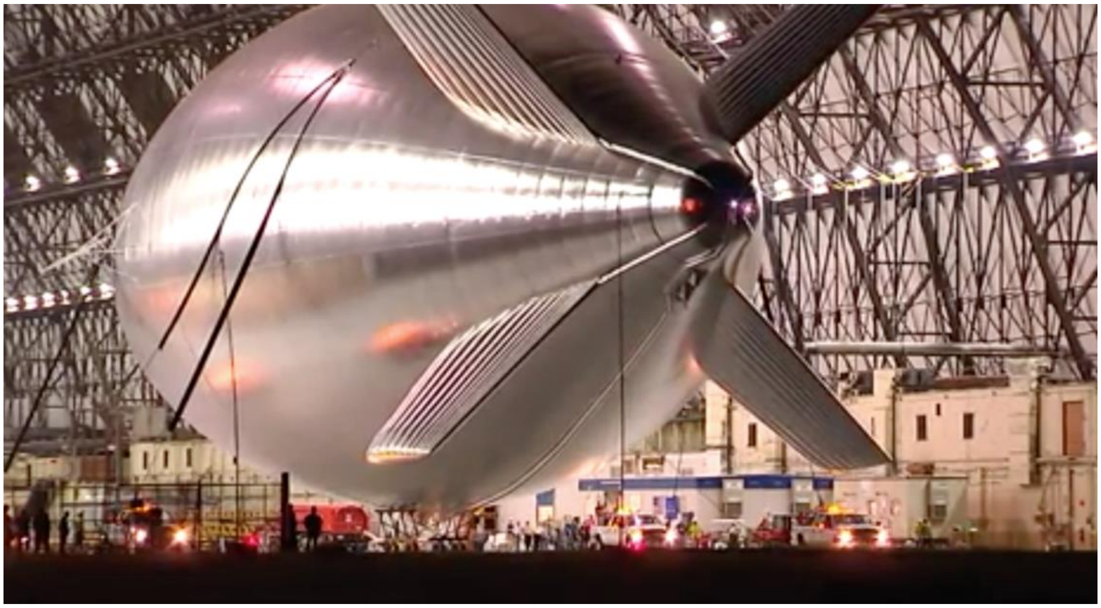
Basic characteristics of the HALE-D airship are outlined below:

- Type: Non-rigid gas envelope (blimp) with ballonets
- Length: 240 feet (73.1 m)
- Diameter: 70 feet (21.3 m)
- Gas volume: 500,000 ft^3 (14,158 m^3)
- Airship mass: 3,800 lb (1,724 kg)
- Payload: About 80 lbs (36 kg)
- Mission payload: High-resolution camera system and communications equipment, 150 watts payload power
- Mission duration: 2 to 3 weeks
- Maximum altitude: 60,0000 feet (18,288 m)
- Power source: 40 kW-hr, 270 volt lithium ion batteries supplemented by a 15 kW lightweight, thin-film, amorphous silicon photovoltaic array on the top of the gas envelope
  - First airborne use of flexible substrate cells
- Propulsion: Two flank-mounted electric motor-driven propellers, 2 kW propulsion power
- Speed: 18 knots cruise; 26 knots maximum



HALE-D solar , battery & PCDU installations.
Note the equipment rail installed along the bottom centerline of the airship.
Source: Lockheed martin

HALE-D in the Lockheed Martin Airdock hanger at Akron, OH. Source: Lockheed Martin



HALE-D in Airdock hanger. Source: Lockheed Martin

HALE-D was equipped with the same payload package as used on SMDC's other HAA program, HiSentinel 80. This payload package included an ITT high-resolution electro-optical camera system, a Thales Multichannel, Multiband Airborne Radio (MMAR) prototype, and an L3 Communications Mini-Common Data Link (MCDL).

HALE-D launched before dawn on its first, and only, flight on 27 July 2011 from the Lockheed Martin airship facility in Akron, Ohio.

HALE-D first flight, 27 July 2011. Source: Lockheed Martin

HALE-D first flight, 27 July 2011. Source: Lockheed Martin

This test flight originally was targeted to reach an altitude of 60,000 feet, but was terminated after reaching 32,600 feet due to technical issues and subsequently crash landed at a heavily wooded site in Ohio, south of Pittsburgh.

HALE-D after crash landing, 27 July 2011.
Source: Channel 4 WTAE Pittsburgh

The sequence of events leading up to the crash have been described in the 2016 document, “High-Altitude Platforms — Present Situation and Technology Trends” (see link below):

> “It was noticed a decrease in the rate of climb, which could take the airship to leave the restricted area defined by the American air traffic control agency (Federal Aviation Administration - FAA). It was decided to command an emergency recovery, with release of the helium gas. The aircraft descended on trees, after 2 hours and 40 minutes of flight. During the recovery operation, after removal of most of the equipment, a short circuit in solar panels caused a fire, destroying the aircraft. No person was injured due to the accident. After the accident analysis, it was verified that the rate of climb decrease was caused by freezing in the air valve.”

Lockheed Martin claimed the following success from this flight:

> “We demonstrated a variety of advanced technologies, including launch and control of the airship, communications links, unique propulsion system, solar array electricity generation, remote piloting communications and control capability, in-flight operations, and controlled vehicle recovery to a remote un-populated area."

The last claim of a “controlled vehicle recovery”, seems to be a bit of an overstatement. The HALE-D airship was not rebuilt.

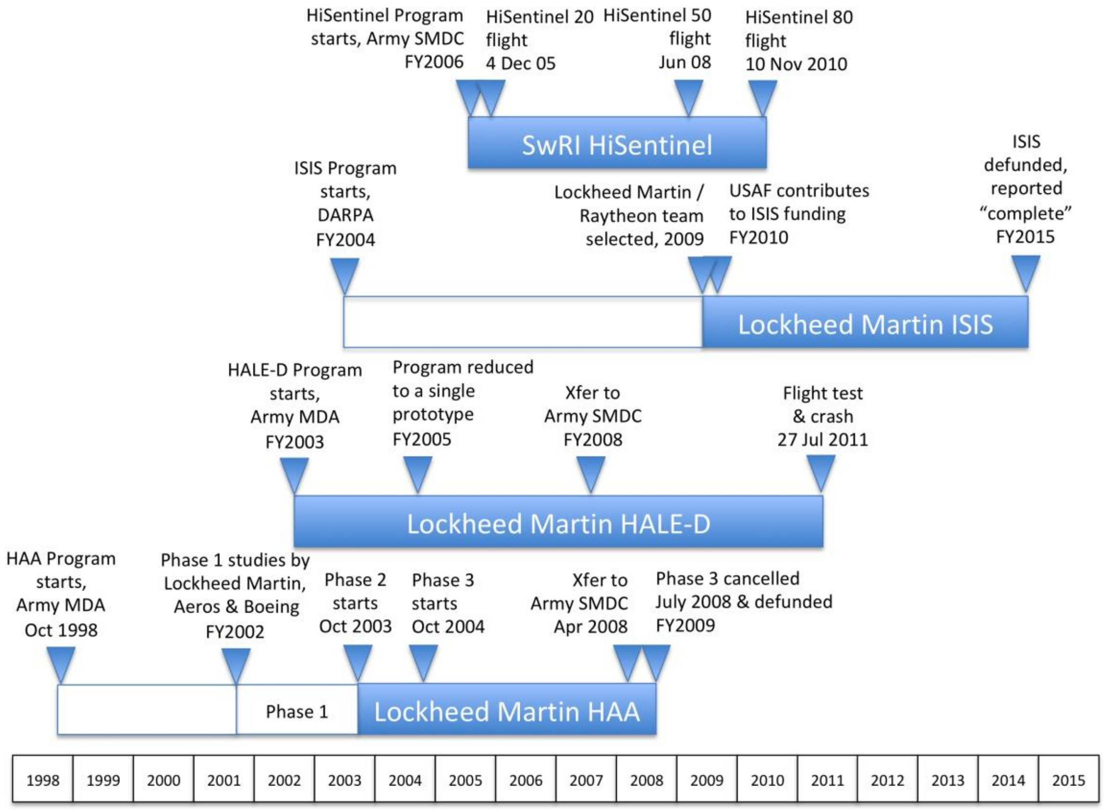
The GAO also reported that $36.3 million had been spent on the HALE-D program between FY 2008 and FY 2011.

3. HALE-D Postmortem

Several key technologies incorporated into the HALE-D airship and briefly tested during its one and only flight also were intended for use on larger, operational stratospheric airship systems. Lockheed Martin noted that airship hull materials and the power system account for about 80% of the weight of an airship. They identified the following technologies as being key enablers for smaller, more capable stratospheric airships:

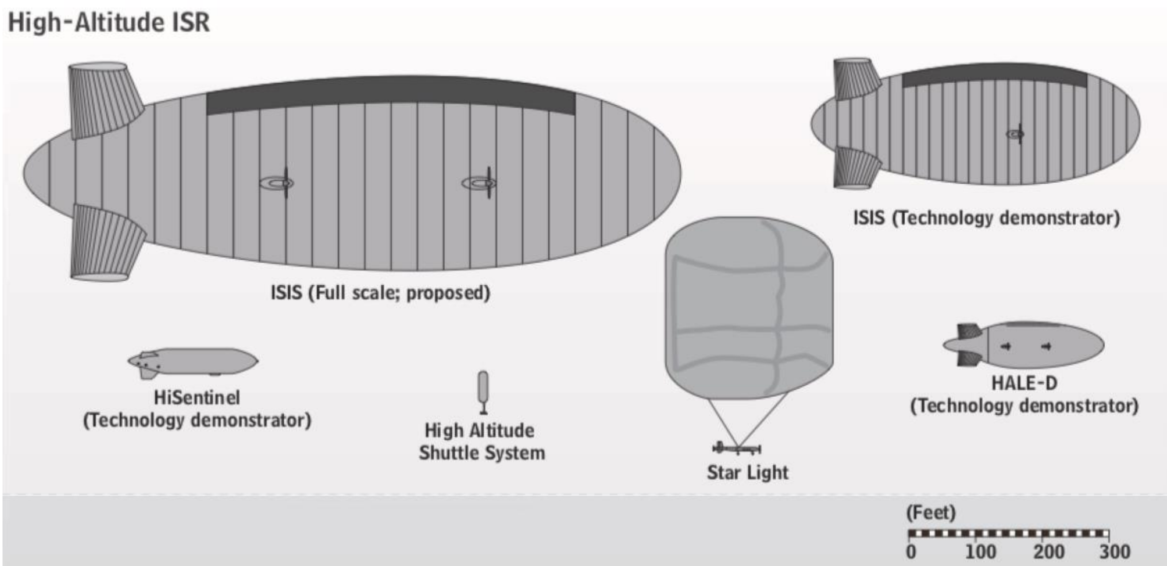
- Higher strength-to-weight hull materials (fabrics) with improved thermal properties, tolerant of long-term operation in the stratosphere.
- Advanced power system technologies:
  - High-efficiency, low-weight, flexible solar photovoltaic (PV) arrays.
    - The HALE-D flexible PV array was rated at 15 kW.
    - L-M was developing a 200 kW array for the ISIS Demonstration System (DS) airship.
  - 2X higher specific energy (watt-hours/kg) rechargeable batteries.
    - HALE-D used a 40 kW-hr lithium ion battery
  - High-efficiency, high-power regenerative fuel cells (not used on HALE-D).
  - Advanced power electronics.

4. Timelines for US military high altitude airship programs



Timelines for the US Military High Altitude Airship Programs

As shown in the following chart, HALE-D was quite small in comparison to the planned ISIS airships and one of the two DoD two-component maneuverable balloon systems (StarLight)



Source: Congressional Budget Office, Nov. 2011

5. For more information:

- Tamir Eshel, “HALE-D High Altitude Airship Crashed in Ohio,” Defense Update, 29 July 2011: https://defense-update.com/20110729_hale-d-high-altitude-airship-crashed-in-ohio.html
- GAO-13-81, “Defense Acquisitions - Future Aerostat and Airship Investment Decisions Drive Oversight and Coordination Needs,” Government Accountability Office, October 2012: https://www.gao.gov/assets/650/649661.pdf
- Report to Congress, “Summary Report of DoD Funded Lighter-Than-Air-Vehicles,” DoD Office of the Assistant Secretary of Defense for Research and Engineering, 1 November 2012: https://www.hsdl.org/?view&did=728733
- “Lockheed Martin Lighter-Than-Air Programs,” JPL / Caltech Airship Workshop, 30 April – 3 May 2013: https://kiss.caltech.edu/workshops/airships/presentations/horvarter.pdf
- YouTube video, “US-Army unmanned untethered 60,000ft Altitude Helium Airship, Hale-D takes off at sunrise in Akron” (1:48 minutes), 17 May 2013: https://www.youtube.com/watch?v=Qu7HOTYurqM
- Flavio Araripe d’Oliveira, et al., “High-Altitude Platforms — Present Situation and Technology Trends,” J. Aerospace Technology and Management, Vol. 8 No. 3, São José dos Campos, Brazil, July/Sept. 2016: https://www.scielo.br/scielo.php?pid=S2175-91462016000300249&script=sci_arttext&tlng=en#B23