

Hybrid Air Vehicles (HAV) / Northrop Grumman HAV-3 and HAV-304 (LEMV)

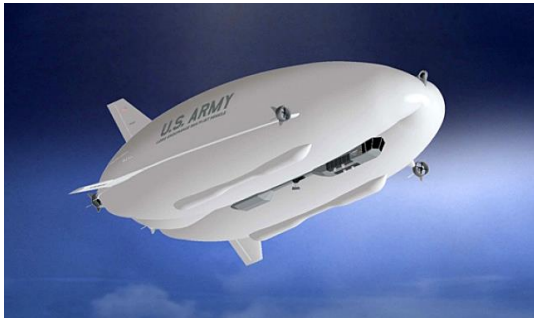
Peter Lobner, Updated 24 August 2021

1. Introduction

In 2007, Roger Munk founded the UK firm Hybrid Air Vehicles (HAV, <https://www.hybridairvehicles.com/about-us>) after successive business failures of its predecessor firms, Advanced Technologies Group (ATG) in 2006 and then SkyCat Group Ltd. in 2007. In the process, HAV acquired the rights to ATG's hybrid airship technologies dating back to about 1999, including the designs for the SkyCat heavy lift hybrid airships and the Condor hybrid ultra-long endurance, high-altitude, optionally-manned, surveillance airship.

In June 2010, the team of HAV and Northrop Grumman competed against Lockheed Martin and won a \$517 million US Army contract to develop and operationally demonstrate a Long Endurance Multi-Intelligence Vehicle (LEMV), which was a medium altitude hybrid airship designed to provide persistent intelligence, surveillance and reconnaissance (ISR) services for 21 day while operating at 20,000 ft. (6,096 m). The winning airship platform was the HAV Condor 304, or simply the HAV-304. Roger Munk died in February 2010.

Lockheed Martin's losing bid offered a hybrid airship based on their P-791 prototype that flew in 2006 as part of the Defense Advanced Projects Research Agency (DARPA) Project WALRUS Phase 1



Northrop Grumman / HAV LEMV (Left) & Lockheed Martin LEMV (Right). Source: HAV & NAA Noon Balloon (Winter 2009)

2. The HAV-3 technology demonstrator

In 2007, the former ATG technology demonstrator, *SkyKitten*, which had been acquired by HAV, was renamed the HAV-3 and continued its role as a hybrid airship demonstrator. A distinguishing feature in its HAV-3 guise is the lateral thruster installed on top of the nose to aid in controlling airship heading during slow speed flight.

The 50 foot (15 meter) long HAV-3 flew from 2007 to 2010 and served to validate the hybrid airship design features, including thrust vectoring and slow speed pointing accuracy with the bow thruster, that would be used on the much larger HAV-304. HAV-3 also demonstrated short- and vertical takeoff and landing (STOL / VTOL) capabilities.



*HAV-3 at Cardington.
Source, both photos: The Airships at Cardington, UK*

3. The HAV-304 (LEMV) prototype airship

In June 2010, the Northrop Grumman / HAV team was awarded the LEMV contract to deploy a large, optionally manned airship capable of flying surveillance missions of up to three weeks duration, carrying a one metric ton (1,000 kg, 2,204 lb) payload at 20,000 feet (6,096 m) in uncontested airspace in conflict zones; initially in Afghanistan.

The winning HAV-304 hybrid airship configured for the LEMV mission is shown in the following diagram.



LEMV airship mission concept, serving as an intelligence, surveillance and communications (ISR) hub.

Source: US Army / Northrop Grumman

Basic characteristics of the HAV-304 airship are listed below:

- Type: Semi-rigid, hybrid
- Length: 299 feet (91 m)
- Width: 143 feet (43.5 m) at its wingtips
- Gas envelope volume: 1,340,000 cubic feet (38,000 cubic meters).
- Speed: 30 knots (56 kph) cruise; 80 knots (148 kph) maximum
- Maximum altitude: 20,000 feet (6,096 m)
- Propulsion:
 - 2 x flank-mounted ducted propulsors that can pivot 20° up or down to vector thrust
 - 2 x fixed stern-mounted ducted propulsors with four triangular-shaped variable vanes for re-directing thrust
 - Each propulsor was driven by a 325 hp (242 kW) V8 diesel engine
 - Fuel consumption is about 3,500 gallons on a 21 day mission
- Electric power:
 - Each diesel engine also drove a 67 hp (50 kW) generator to supply airship systems and the mission payload
 - Up to 16kW of electrical power was available for the mission payload.
- Payload:
 - About 2,500 lb (1,134 kg) configured for an ISR mission
 - Up to 30,000 lb (13,608 kg) configured for a heavy lift cargo mission
- Range: 2,400 miles (3,900 km) at 27 knots (50 kph) with ½ of max. payload
- Mission duration:
 - 21 days unmanned ISR mission at 20,000 ft (6,096 m)
 - 5 days manned at 16,000 ft (4,877 m)

The envelope was slightly pressurized to about 0.15 psid to maintain its aerodynamic shape. Even with this low pressure differential, the inflated envelope was stiff enough for a person to walk on the top. The gas volume within the envelope was segregated into six main compartments, each of which could be individually isolated in the event of a leak.

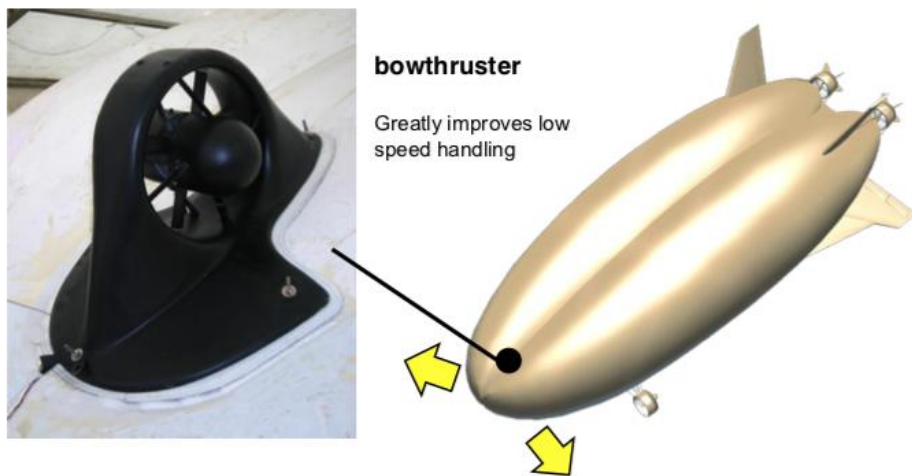
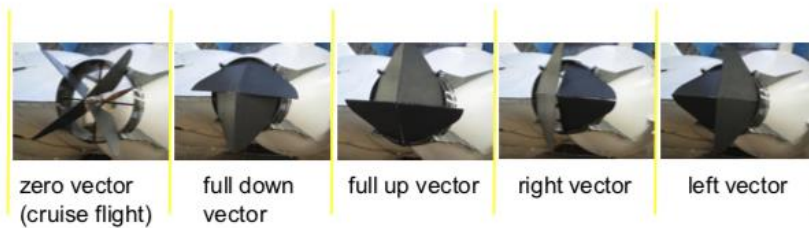
HAV describes the airship's construction as follows:

“There is no internal structure it maintains its shape due to the pressure stabilization of the helium inside the hull, and the smart and strong Vectran material it is made of. Carbon composites are used throughout the aircraft for strength and weight savings.”

As a hybrid airship, the semi-buoyant HAV-304 is heavier-than-air and generates only part of its lift from helium aerostatic lift, nominally 60 – 80%. The balance of the lift is generated by vectored-thrust propulsors and by aerodynamic lift from the shaped gas envelope, which acts as a lifting body when the airship has forward speed.

The control system coordinates the thrust vectors generated by the bow thruster (left/right), pivoting flank propulsors (up/down), and four triangular-shaped variable vanes in the slipstream of each stern propulsor (up/down/left/right).

VECTORED THRUST control systems



Source: HAV (2009)

A 149 foot (45.4 meter) long rigid mission module installed on the centerline under the gas envelope supports the optionally-manned cockpit, flight control and mission systems, cargo and fuel. Weight from this rigid structure is carried by catenary cables into a central diaphragm inside the gas envelope, between the two main lobes of the hull. From the diaphragm, the loads are distributed out along the entire top surface of the airship.

This hybrid airship is negatively buoyant and cannot hover or make a vertical takeoff or landing. The HAV-304 takes off and lands on inflatable skids and requires a short takeoff and landing (STOL) run of less than 1,000 feet (305 m). For the LEMV mission, the airship would transit at a maximum speed of 80 knots, and loiter in its designated operating area at 30 knots. Airship trim is controlled much like in a conventional blimp, using multiple ballonets located fore and aft in each side of the hull.

The HAV-304 made a 90-minute first flight on 7 August 2012 at Joint Base McGuire-Dix-Lakehurst in New Jersey. While this milestone was achieved about two years after the LEMV contract was signed, the projected LEMV deployment date to Afghanistan slipped to about 16 months behind the Army's original schedule.



HAV-304 first flight at Lakehurst, NJ. Source: Northrop Grumman



HAV-304 first and only flight at Lakehurst, NJ. Source: (above) Northrop Grumman, (below) Screenshot from video



The HAV-304 did not make another flight. The Army cancelled the LEMV contract in February 2013 after spending \$517 million on the project. The Army stated: “This project was initially designed to support operational needs in Afghanistan in Spring 2012; it will not provide a capability in the timeframe required. Due to technical and performance challenges, and the limitations imposed by constrained

resources, the Army has determined to discontinue the LEMV development effort."

Hybrid Air Vehicles was the only bidder for the Army's surplus LEMV airship and bought it back from the Army in October 2013 for \$301,000 along with an agreement to give the Army access to data from future civilian flights. After the Army removed LEMV mission-related hardware, HAV returned the HAV-304 airship to the UK where it served until 2019 as the prototype for the Airlander 10 civilian hybrid airship.

4. For more information:

- "Long Endurance Multi-Intelligence Vehicle (LEMV)," Army Technology: <https://www.army-technology.com/projects/long-endurance-multi-intelligence-vehicle/>
- "U.S. Army Orders Huge Airship to Aid Combat Missions," Space.com, 16 June 2010: <https://www.space.com/8615-army-orders-huge-airship-aid-combat-missions.html>
- John Cummings, "Long Endurance Multi-Intelligence Vehicle (LEMV) Agreement Signed," US Army, 17 June 2010: https://www.army.mil/article/41024/long_endurance_multi_intelligence_vehicle_lemv_agreement_signed
- Jason Ford, "US Army's LEMV successfully completes maiden flight," The Engineer, 1 August 2012: <https://www.theengineer.co.uk/us-armys-lemv-successfully-completes-maiden-flight/>
- Grahame Wilson, "The Airships at Cardington, UK," <http://members.ozemail.com.au/~p0gwil/AIRSHIPS-CARDINGTON/AIRSHIPS-Introduction.htm>
- 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>
- David Szondy, "US Army cancels LEMV airship project<" New Atlas, 15 February 2013: <https://newatlas.com/lemv-airship-canceled/26274/>
- "LEMV Airship Sold Back to Manufacturer for a Song, and Future Data," Defense Industry Daily, 24 October 2013:

<https://www.defenseindustrydaily.com/rise-of-the-blimps-the-us-armys-lemv-06438/>

- David Axe, “The U.S. Army Almost Had All-Seeing Spy Airships,” The National Interest, 2 April 2020:
<https://nationalinterest.org/blog/buzz/us-army-almost-had-all-seeing-spy-airships-140552>

Videos

- “Hybrid Air Vehicles Prototype Airship in Flight” (2:10 minutes), t43562, 4 March 2010:
<https://www.youtube.com/watch?v=mu2glpmRXIs&t=130s>
- “Northrop Grumman - Long Endurance Multi-Intelligence Vehicle (LEMV) First Flight” (1:54 minutes), arronlee, 10 August 2012:
<https://www.youtube.com/watch?NR=1&feature=endscreen&v=z72GPZ3MI2M>

Related *Modern Airship* articles

- Advanced Technologies Group (ATG) - SkyCat & SkyKitten
- ATG / HAV - Condor high-altitude surveillance hybrid airship
- Hybrid Air Vehicles (HAV) - Airlander 10 & 50 airships