

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

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1. Introduction

Hybrid Air Vehicles (HAV) was formed in the UK in 2007 after successive business failures by its predecessor firms, SkyCat Group Ltd. and Advanced Technologies Group (ATG). In the process, HAV acquired the rights to ATG's SkyCat hybrid airship technologies dating back to about 1999.

The team of Northrop Grumman and HAV proposed their HAV-304 hybrid airship design (based on SkyCat) for the US Army's Long Endurance Multi-Intelligence Vehicle (LEMV) program and won the contract. Their competition for the LEMV award was Lockheed Martin, which proposed a hybrid airship based on their P-791 prototype that flew in 2006 as part of Project WALRUS Phase 1.

The HAV website is here:

<https://www.hybridairvehicles.com/about-us>

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, all three 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 (6,100 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 a surveillance and communications 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.”

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.

As a hybrid airship, the HAV-304 generated only part of its lift from helium, 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.

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's first and only flight for the Army occurred on 7 August 2012, about two years after the Army signed the LEMV contract with the Northrop Grumman team. However, because of various delays, the projected LEMV deployment date had slipped to about 16 months behind the Army's original schedule.

The HAV-304 made its 90 minute first and only flight at Joint Base McGuire-Dix-Lakehurst in New Jersey. You'll find a short (1:54 minute) video of that flight here:
<https://www.youtube.com/watch?NR=1&feature=endscreen&v=z72GPZ3MI2M>



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





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

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 removing 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/>
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- 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/>
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- 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/>
- Grahame Wilson, “The Airships at Cardington, UK,” <http://members.ozemail.com.au/~p0gwil/AIRSHIPS-CARDINGTON/AIRSHIPS-Introduction.htm>
- 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>