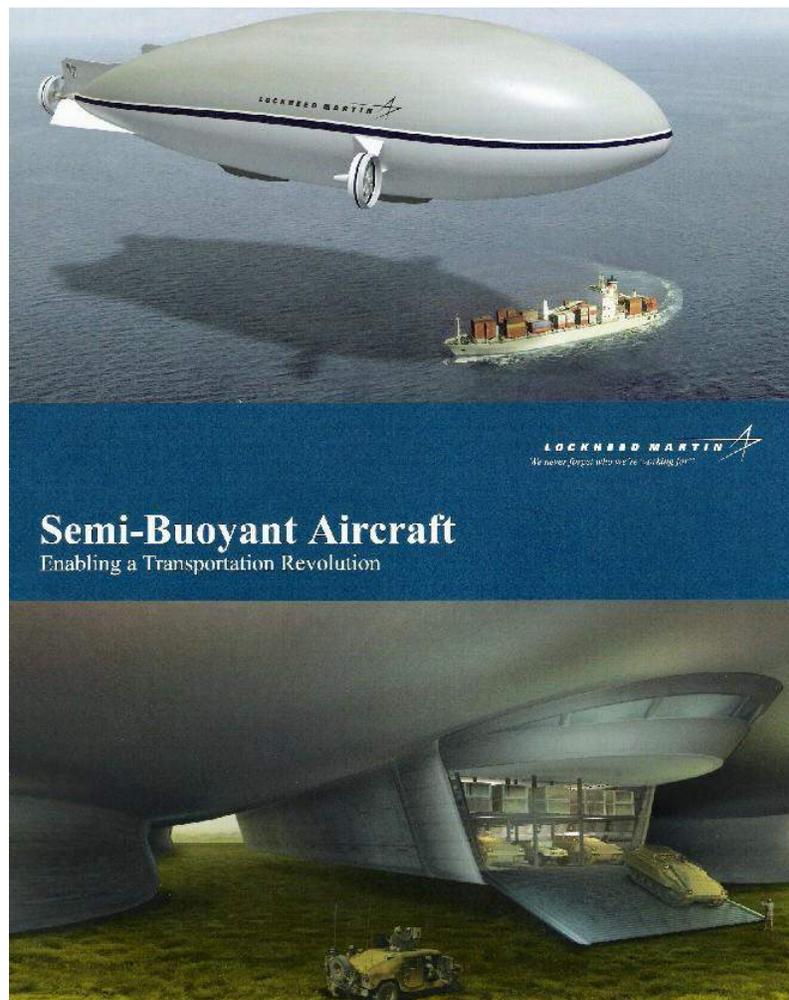


Lockheed Martin - SkyTug and LMH-1 hybrid airships

Peter Lobner, updated 8 March 2022

1. Introduction

In the early 2000s, Lockheed Martin began developing hybrid airship technology. Their P-791 technology demonstrator flew in January 2006 under Phase 1 of the Defense Advanced Research Projects Agency's (DARPA's) Project WALRUS. Examples of Lockheed Martin's early large civilian hybrid airship concepts are shown on the following graphics. These concepts evolved into the later, more refined SkyTug and LMH-1 hybrid airships addressed in this articles.



Source: Lockheed Martin



Source: Lockheed Martin



Source: Lockheed Martin via Army Sustainment (Nov-Dec 2012)

During the early 2000s, Lockheed Martin developed an impressive patent portfolio addressing key technologies associated with their hybrid airship designs, including:

- Semi-buoyant airship with pressure stabilized hull generating aerodynamic lift
- Thrust vectoring propulsion system
- Means to mount propulsion units directly on non-rigid airship hulls
- Means to support propulsion units with a rigid framework inside a non-rigid hull
- Air cushion landing system (ACLS)

For details on these Lockheed Martin patents, please refer to my separate article on their P-791 hybrid airship technology demonstrator.

In 2020, Lockheed Martin's hybrid airship program is based in Palmdale, CA. Their website is here:

<https://www.lockheedmartin.com/en-us/products/hybrid-airship.html>

2. First there was the SkyTug airship (2011 – 2013)

In March 2011, Lockheed Martin announced that it planned to develop a larger commercial version of the P-791, to be called SkyTug, which would be a scaled up hybrid airship designed to carry at least 20 tons of cargo. A trademark application for the term “SkyTug” was filed on 25 August 2011.



*Lockheed Martin SkyTug hybrid airship concept drawing.
Source: Lockheed Martin*

SkyTug was being developed for the Canadian firm Aviation Capital Enterprises of Calgary. The SkyTug was intended for use as a long-range transport for heavy machinery and equipment for oil and gas rigs drilling in remote locations. Instead of building expensive roads or railways to Arctic drilling sites, the SkyTug would enable equipment and personnel to be delivered by air directly to the site. The first commercial airship was expected to be delivered in 2012, and future versions were expected to have larger cargo carrying capacity.

According to Aviation Capital, “the fully vertical-takeoff-and-landing (VTOL) capable SkyTug will provide ‘greater payload and range at a

fraction of the cost of a helicopter'. The larger ships that will follow apparently won't be fully VTOL - they'll require something of a run-up on the ground to generate dynamic lift and get airborne, rather as an airplane does."

Evidently, the VTOL version was to have proportionally more powerful vectored thrust engines to provide the needed propulsive lift for VTOL operations, while the larger versions would have had short takeoff and landing (STOL) performance typically associated with hybrid airships.

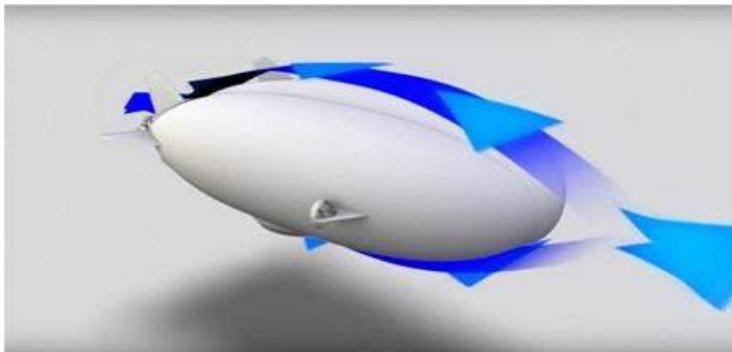
The basic performance characteristics of the SkyTug are summarized below (from 2011 CBO report):

- Length: 300 ft (91.4 m)
- Flight altitude: 10,000 ft (3,048 m)
- Average cruise speed: 80 – 100 knots
- Maximum payload: 20 – 30 tons (18.1 – 27.2 metric tons)
- Range: 1,500 miles (2,414 km)

The SkyTug trademark was abandoned in 2013.

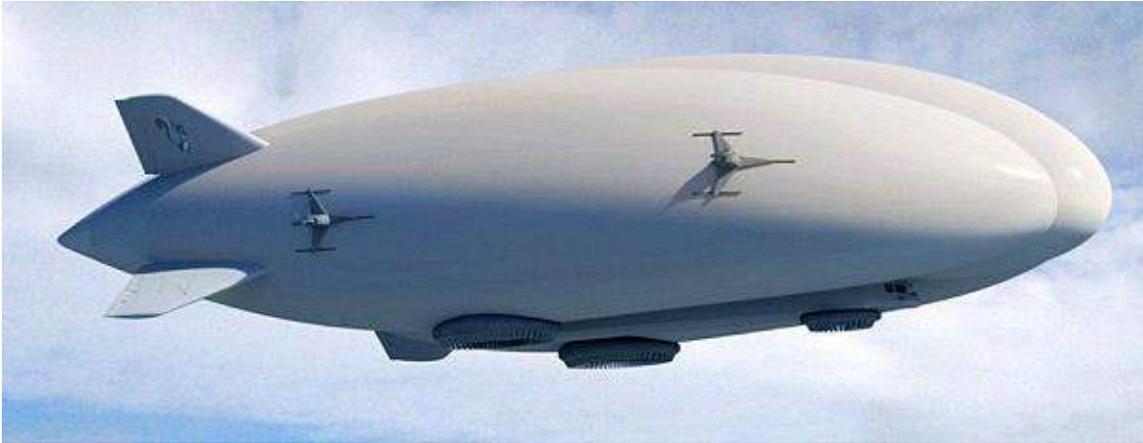
3. The LMH-1 airship

By 2013, reference to SkyTug had disappeared and Lockheed Martin was promoting the LMH-1 as their next large commercial hybrid airship based on the P-791 design. Like the P-791, the LMH-1 will generate about 80% of its total lift from helium buoyancy and the balance from direct lift from vectored thrust engines and, in forward flight, from aerodynamic lift generated by the lifting-body fuselage.

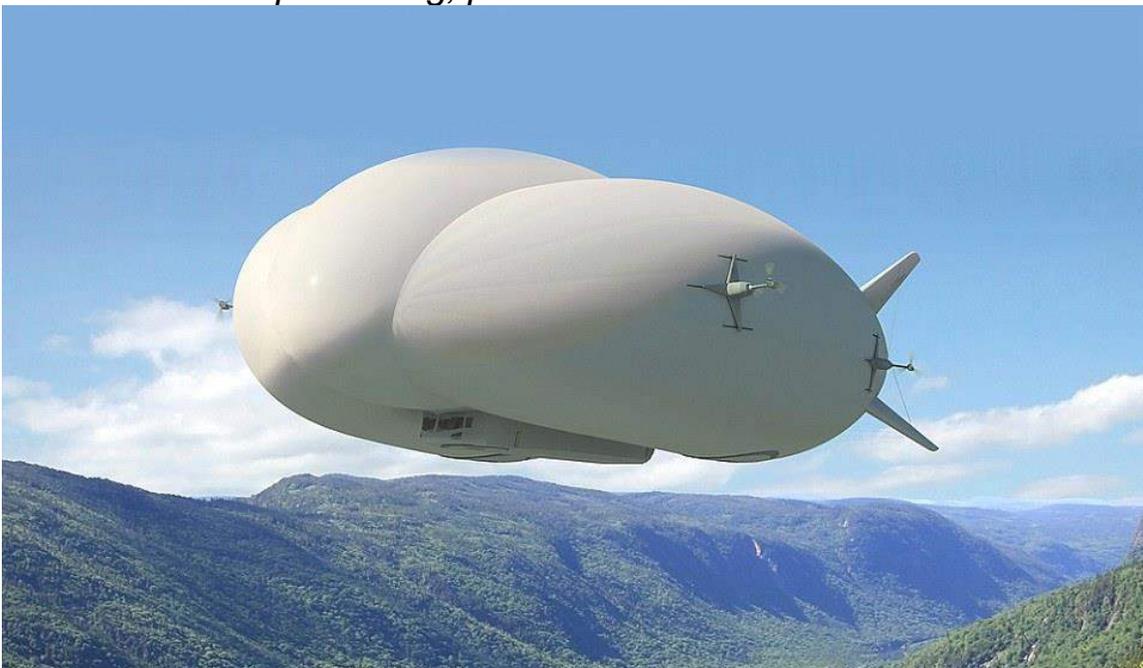


The hull of the LMH-1 generates aerodynamic lift in forward flight.

Source: Lockheed Martin via LTA Society



LMH-1 concept drawing, profile view. Source: Lockheed Martin



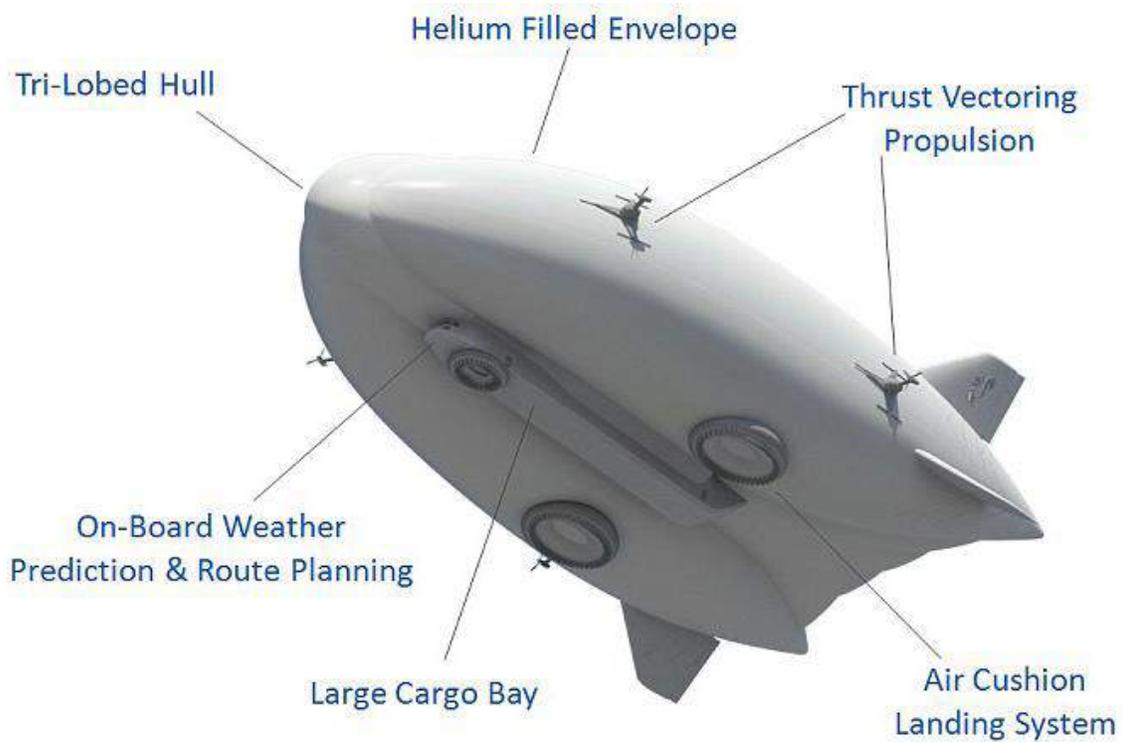
LMH-1 concept drawing, bow quarter. Source: Lockheed Martin

As currently described by Lockheed Martin, the LMH-1 has the following general design characteristics:

- Accommodations: crew of 2, up to 19 passengers
- Payload / Range: 21 metric tons (21,000 kg / 46,300 lb) of cargo at a maximum speed: 60 kts (111 kph) over a range: 2,593 km (1,400 nautical miles).
- Cargo compartment: 18 x 3.2 x 3 meter (59 x 10.5 x 9.8 feet), a little bigger than the cargo box of the widely used Lockheed Martin C-130 Hercules fixed-wing cargo aircraft.



Overhead view of an LMH-1. Source: Lockheed Martin



LMH-1 general arrangement. Source: Lockheed Martin

As a hybrid airship, the LMH-1 typically will make a STOL takeoff and landing, using its air cushion landing system (ACLS) as demonstrated on the P-791. For an STOL takeoff at full load, the LMH-1 will require about 2,400 feet (732 meters) of clear space, which needs to be free of large obstacles but does not need to be paved. When lightly loaded, an LMH-1 may be able to takeoff and land vertically.

Since 2014, Hybrid Enterprises (<http://www.hybridhe.com>) has been marketing LMH-1 and is accepting orders at a price of about \$40 million USD plus an additional \$350,000 for a full charge of helium. This price is more than for a fixed-wing Hercules transport (\$12 – \$30 million). However, the airship is expected to have lower operating and maintenance costs, can takeoff and land on unimproved surfaces, requires minimal ground support equipment and can stay aloft for days if needed. You can review a 2017 Hybrid Enterprises / Lockheed Martin presentation on the LMH-1 hybrid airship here: <http://annualghac.com/images/presentations/original/2017/10/59e09fbb8990877500977.pdf>

Maintenance of the airship's large gas envelope is aided by an automated, self-propelled instrument called the SPIDER, which was developed in 2016 at the Lockheed Martin Skunk Works to find and repair pinhole leaks. SPIDER is shown in operation in the following short video (1:47 minutes):

<https://www.youtube.com/watch?v=86EAzvXrESg>

In September 2017, Lockheed Martin claimed it had Letters of Intent (LOIs) for 24 LMH-1 airships. It appears that their largest customer to date is Straightline Aviation (<https://www.straightlineaviation.com>), which has signed an LOI for 12 LMH-1s. You can watch a short (4:48 minute) 2018 video, "Straightline Aviation Hybrid Airship," that describes their plans to use the LMH-1 to serve remote areas in Alaska and other areas of the world, at the following link:

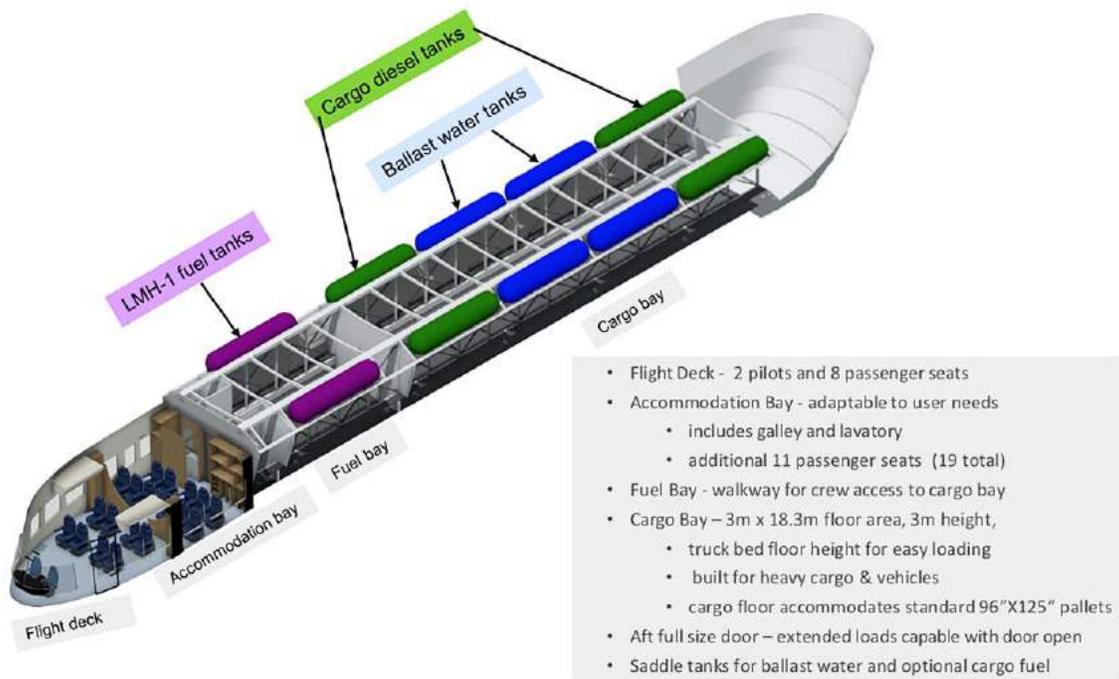
<https://www.youtube.com/watch?v=lx8KP3IU3Sw>



*LMH-1 exterior general arrangement.
Source: Lockheed Martin via BBC (November 2019)*



*LMH-1 gondola. Note the forward ACLS unit under the cabin.
Source: Lockheed Martin*



*LMH-1 interior layout.
Source: Hybrid Enterprises & Lockheed Martin (2017)*



LMH-1 flight deck for a crew of two. Source: Lockheed Martin



LMH-1 accommodation bay. Source: Lockheed Martin



Walkway in the LMH-1 fuel bay (aka equipment bay) between the accommodation bay and the cargo bay, contains the diesel engines and associated fuel tanks. Source: Lockheed Martin



LMH-1 cargo bay contains cargo tie-downs and a strengthened deck capable of taking heavy construction vehicles and bulldozers. Source: Lockheed Martin

Lockheed Martin has produced several videos on their LMH-1 airship. The following two provide a good overview of airship operations.

- 2016 video, “Hybrid Airship: No Roads, No Problem,” (1:42 minutes):
<https://www.youtube.com/watch?v=JO76dkzV28k&t=1s>
- 2019 video, “Hybrid Airship Ground Handling,” (4:42 minute)::
<https://www.youtube.com/watch?v=7i-pKuJThHA>

4. FAA certification of the LMZ1M (LMH-1) airship

In *Modern Airships – Part 1* (<https://lynceans.org/all-posts/modern-airships-part-1/>), I made the following comment on the current state of aviation regulations pertaining to advanced airships:

“Current US, Canadian and European airship regulations were developed for non-rigid blimps and they fail to address how to certify most of the advanced airships currently under development. This means that the first airship manufacturers seeking type certificates for advanced airships will face uphill battles as they have to deal with aviation regulatory authorities struggling to fill in the big gaps in their regulatory framework and set precedents for later applicants.”

On March 12, 2012 the U.S. Federal Aviation Administration (FAA) announced that Lockheed Martin Aeronautics submitted an application for type certification for the model LMZ1M, which is “a manned cargo lifting hybrid airship incorporating a number of advanced features.” The FAA assigned docket number FAA-2013-0550 to that application.

To address the gap in airship regulations head-on, Lockheed Martin submitted to the FAA their recommended criteria document, “Hybrid Certification Criteria (HCC) for Transport Category Hybrid Airships,” which is a 206 page document developed specifically for the LMZ1M (LMH-1). The HCC is also known as Lockheed Martin Aeronautics Company Document Number 1008D0122, Rev. C, dated 31 January 2013. You can download the HCC document and related public docketed items on the FAA website here:

<https://www.regulations.gov/docket/FAA-2013-0550/document>

In November 2015, the FAA's Seattle Aircraft Certification Office, approved Lockheed's project-specific certification plan for the LMZ1M (LMH-1). In their 17 November 2015 press release, Lockheed Martin announced:

"Given that Hybrid Airships did not fit within existing FAA regulations, the team worked to create a new set of criteria allowing non rigid hybrid airships to safely operate in a commercial capacity. Transport Canada was also involved in the development of this criteria to ensure it included safety concerns unique to Canada."

"Lockheed Martin and the FAA have been working together for more than a decade to define the criteria to certify Hybrid Airships for the Transport Category. This criteria was approved by the FAA in April 2013. Following that approval, the team has been developing the project specific certification plan over the past two years, which details how it will accomplish everything outlined in the Hybrid Certification Criteria."

"Earlier this year Lockheed Martin along with Hybrid Enterprises LLC kicked off sales for the 20 ton variety of the Hybrid Airship. They are on track to deliver operational airships as early as 2018."

There is nothing on the public webpage of docket FAA-2013-0550 that indicates the status of the certification effort. By 2017, the first "float out" of the LMZ1M (LMH-1) had slipped to 2019, and as of this update in early 2022, the airship had not yet been unveiled.

5. Beyond the LMH-1

Lockheed expects that the basic LMH-1 design can be scaled up to carry much heavier cargo. After LMH-1, Lockheed Martin has revealed plans to build a larger LMH-2 90 ton cargo hybrid airship that would be more competitive with trucking and rail transport in remote areas. Eventually, a 500 ton cargo airship may be possible.



- Regional cargo transport
- 3,000+ nm range
- Take-off & land from unimproved fields or water
- Lower operating costs (similar to fixed wing)



- Global cargo transport
- 6,000+ nm range
- Very large cargo hold
- Containerized freight mover
- Take-off & land from unimproved land or sea
- Lowest operating cost



Source: Hybrid Enterprises & Lockheed Martin (2017)

6. For more information

LMH-1

- FAA Notice, “Airworthiness Criteria: Proposed Airship Design Criteria for Lockheed Martin Aeronautics Model LMZ1M Airship,” 25 June 2013:
<https://www.federalregister.gov/documents/2013/06/25/2013-15056/airworthiness-criteria-proposed-airship-design-criteria-for-lockheed-martin-aeronautics-model-lmz1m>
- Trefis team, “A Comprehensive Look At Lockheed Martin's Hybrid Airships,” Forbes, 9 July 2015:
<https://www.forbes.com/sites/greatspeculations/2015/07/09/a-comprehensive-look-at-lockheed-martins-hybrid-airships/?sh=1bcc6974c9dc>
- “Lockheed Martin Hybrid Airship Certification Plan for Commercial Transport Approved by the FAA,” Lockheed Martin via CISION PR Newswire, 17 November 2015:
<https://www.prnewswire.com/news-releases/lockheed-martin-hybrid-airship-certification-plan-for-commercial-transport-approved-by-the-faa-300179764.html>
- James Drew, “Lockheed venture lifts off with LOI for 12 hybrid airships,” FlightGlobal, 30 March 2016:
<https://www.flightglobal.com/lockheed-venture-lifts-off-with-loi-for-12-hybrid-airships/120141.article>
- Andrew Toopf, “Canadian rare earths mine to transport ore using airships,” Mining dot com, 22 November 2016:
<http://www.mining.com/canadian-rare-earths-mine-transport-ore-using-airships/>
- Howard Slutsken, “LMH-1 airship “float out” pushed to 2019,” Skiesmag.com, 22 September 2017:
<https://www.skiesmag.com/news/lmh-1-airship-float-pushed-2019/>
- Hybrid Enterprises & Lockheed Martin presentation at the 9th Global Humanitarian Aviation Conference & Exhibition, 11 – 13 October 2017:
<http://annualghac.com/images/presentations/original/2017/10/59e09fbb8990877500977.pdf>

- Guy Norris, “Up Close: Lockheed Martin’s LMH-1 Hybrid Airship,” Aviation Week Network:
<https://aviationweek.com/aerospace/close-lockheed-martins-lmh-1-hybrid-airship>

SkyTug

- Stephen Trimble, “Skunk Works P-791 airship revived as civil cargo-lifter,” FlightGlobal, 23 March 2011:
<https://www.flightglobal.com/skunk-works-p-791-airship-revived-as-civil-cargo-lifter/99025.article>
- “Canadian Company Buys Commercial Rights for SkyTug from Lockheed Martin,” 28 March 2011:
<https://www.uasvision.com/2011/03/28/canadian-company-buys-commercial-rights-for-skytug-from-lockheed-martin/>
- Lewis Page, “Airship 'Sky Tugs' ordered from Lockheed for Canadian oilfields,” TheRegister.com, 28 March 2011:
https://www.theregister.com/2011/03/28/p791_ordered_for_canadian_oilsands/
- “Recent Development Efforts for Military Airships,” Pub. No. 4239, Congressional Budget Office, November 2011:
<https://www.cbo.gov/sites/default/files/cbofiles/attachments/11-01-Airships.pdf>
- “Enter the SkyTug,” How It Works, 11 February 2012:
<https://www.howitworksdaily.com/enter-the-skytug/>

Other Modern Airships articles

- *Modern Airships - Part 1:* <https://lynceans.org/all-posts/modern-airships-part-1/>
 - Lockheed Martin - Aerocraft hybrid airship
 - Lockheed Martin - P791 hybrid airship
- *Modern Airships - Part 2:* <https://lynceans.org/all-posts/modern-airships-part-2/>
- *Modern Airships - Part 3:* <https://lynceans.org/all-posts/modern-airships-part-3/>