

Lockheed Martin - P-791 hybrid airship

Peter Lobner, updated 12 February 2022

1. Introduction

Starting in the 1990s, Lockheed Martin's Advanced Development Programs (the Skunk Works) in Palmdale, CA, studied various concepts for large, cargo-carrying airships.

In mid-2005, Lockheed Martin and Aeros Aeronautical Systems Corp. (Aeros) were selected as the two contractors to conduct Phase I of the Defense Advanced Research Projects Agency's (DARPA's) Project WALRUS, which sought to develop new technologies and design concepts for a strategic, heavy-lift cargo airship. At that time, work on the P-791 hybrid airship already was in progress.

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

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

2. The P-791 technology demonstrator

The P-791 is a 120 foot (36.6 meter) long, tri-lobe, semi-buoyant hybrid airship that serves as a sub-scale technology demonstrator for future Lockheed Martin hybrid airships.

The P-791 is heavier-than-air and flies under the combined influence of the buoyant lift from helium (about 80% of total lift), vectored thrust from propellers, and aerodynamic lift from the hull and fins when in forward flight. The flexible composite fabric hull (the gas envelope) is slightly pressurized (pressure stabilized) to maintain its aerodynamic shape. The P-791 is not designed for vertical takeoff and landing (VTOL) or hover, since flight depends on about 20% of total lift being generated by aerodynamic lift from the hull and/or vectored thrust from the propulsion system.



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Stern quarter view showing the rear fins and one of two stern vector thrust units. Source: Al Sieb / Los Angeles Times / TNS



Flank vectoring thruster (left), stern vectoring thrusters (right). Source: Lockheed Martin



Profile view of the P-791. Source: Lockheed Martin



Bow view showing tri-lobe hull design and the two bow vector thrust units. Source: Screenshot from Lockheed Martin video.

The P-791 is designed for short takeoff and landing (STOL) and ground operations at unimproved sites using its air cushion landing system (ACLS). During takeoff and landing and when the P-791 is moving on the ground, the ACLS operates in “lift” mode. The four air cushion pads on the bottom of the airship allow it to float on cushions of air while using the vectored thrust propulsion system to move the airship over almost any type of surface (pavement, unimproved natural surface like dirt, sand, snow or ice or water).

The ACLS fans can be reversed and operated in “suction” mode, which enabled the airship to “grip” a solid surface and remain stationary during ground cargo handling or in windy conditions without the need for ground-based mooring / docking hardware or ballast. Operating the ALCS in suction mode helps compensate for changes in airship gross weight during load exchanges. It may still be necessary to adjust ballast before flight to compensate for the addition or removal of heavy loads.

You can see a short (3:23 minute) 2015 video, “Lockheed Martin P-791 Hybrid Air Vehicle,” with several good clips of the P-791 here: <https://www.youtube.com/watch?v=LZBhs-Srvwl>

You can see a short (3:43 min) 2017 video, “Air Cushion Landing System for Hybrid Airship - Skunk Works,” with details on the design and operation of the P-791 ACLS here: https://www.youtube.com/watch?v=Qi_sJ-k3kRI

3. Flight testing

The first flight of the P-791 took place on 31 January 2006 at Lockheed Martin’s facility in Palmdale, CA.

Airship magazine reported that the P-791 flew six times. Lockheed Martin claimed that all flight test objectives were successfully met.



Source: Lockheed Martin



Source: Lockheed Martin



Source: UAS calendar 2017

The P-791 was the basis for the design of a larger hybrid airship proposed by Lockheed Martin for the U.S. Army's Long Endurance Multi-Intelligence Vehicle (LEMV) program, which was won in 2010 by the competing Northrop Grumman / Hybrid Air vehicles (HAV) team with their HAV-304 hybrid airship.



Lockheed Martin LEMV design. Source: Lockheed Martin via Naval Airship Association Noon Balloon, winter 2009

The P-791 also was the basis for Lockheed Martin's commercial hybrid airship designs, the Sky Tug and the LMH-1, which are addressed in a separate article.

4. Patent lawsuit

On 18 March 2007, a civil litigation, "Lockheed Martin Corporation v. Jeffrey Munk et al." was filed claiming patent infringement by Jeffrey Munk, Skycat Ltd., and ATG related to their US patents US6880783 and US7040572. The Lockheed Martin P-791 was striking similar to ATG's SkyKitten technology demonstrator airship and the full-size SkyCat hybrid airship. These hybrid airships use many of the same design concepts, and, at the time, there were some who believed that the two programs were related. The lawsuit was terminated on 16 September 2008 with no declaratory judgment against the defendants.

5. Lockheed Martin's patents for hybrid airship technology

Lockheed Martin has an extensive portfolio of patents related to hybrid airship technology. Several of the patents awarded in the early 2000s describe features of early hybrid airship design concepts that predate the P-791. These are addressed in my separate article on the Lockheed Martin Aerocraft (not to be confused with the Aerocraft trademarked by Worldwide Aeros Corp.).

In this section, we'll look at the following Lockheed Martin patents that have a direct bearing on design features found in the P-791.

- US 8016229B2 and US 8177161B2 - Retracting air cushioned landing system for air vehicles
- US 8167240B2 and EP 2230173A3 - Systems and methods for buoyancy management in an airship
- US 8783602B2 - System and method for furling an air cushion landing system
- US 5333817A - Ballonet system for a lighter-than-air vehicle
- US 7448572B2 - Direct mounted propulsion for non-rigid airships

Patents US 8016229B2 and US 8177161B2 - Retracting air cushioned landing system for air vehicles

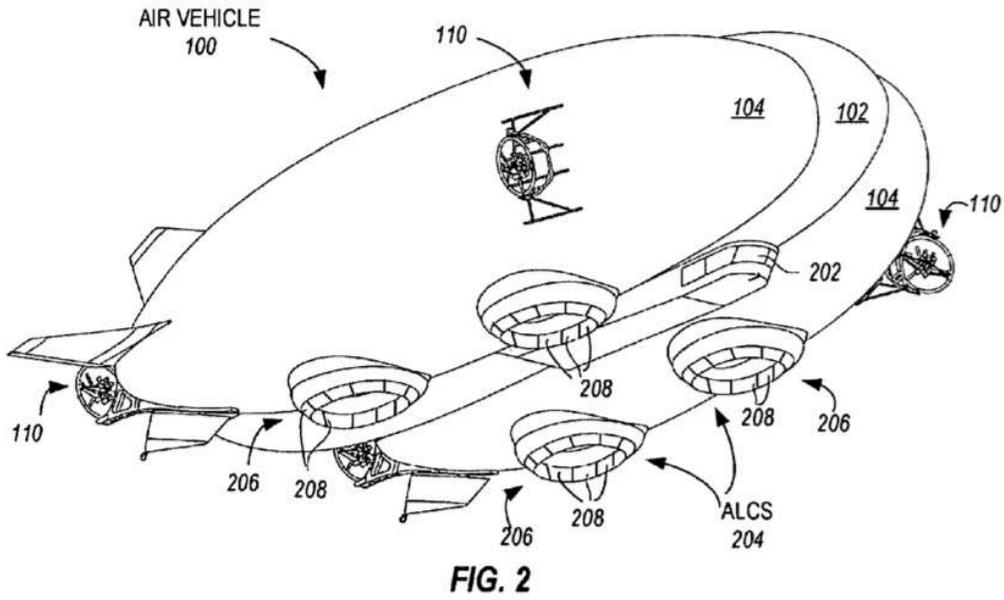
US 8016229B2

- Application filed: 7 July 2008
- Patent granted: 13 September 2011
- Assignee: Lockheed Martin Corporation
- Available here:
<https://patents.google.com/patent/US8016229/es>

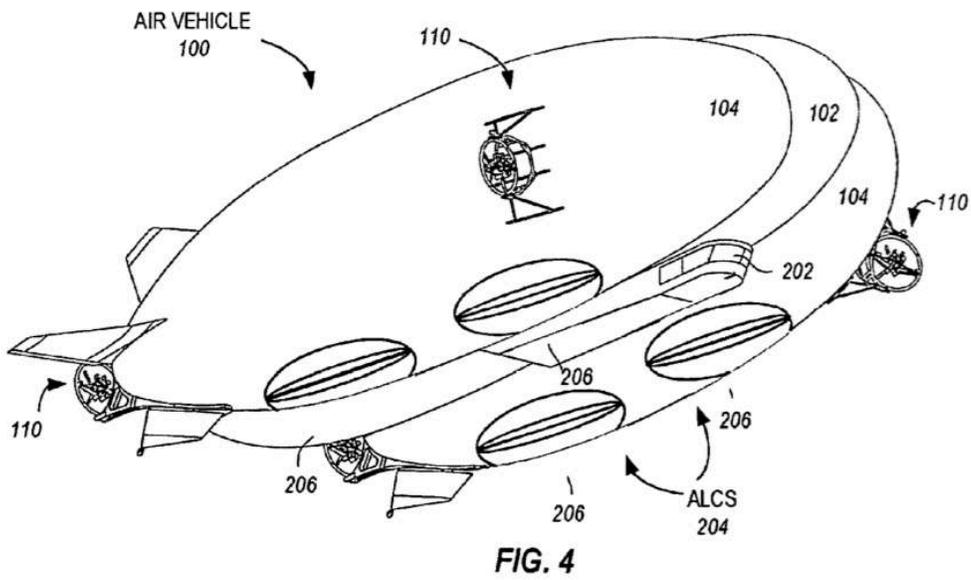
US 8177161B2

- Application filed: 10 June 2011
- Patent granted: 15 May 2012
- Assignee: Lockheed Martin Corporation
- Available here:
<https://patents.google.com/patent/US8177161B2>

This patent describes an extendable ACLS with streamlined covers that enclose the retracted ACLS units.



*Above: Hybrid airship with ACLS extended
Below: Hybrid airship with ACLS retracted & covers deployed*



Patents US 8167240B2 and EP 2230173A3 - Systems and methods for buoyancy management in an airship

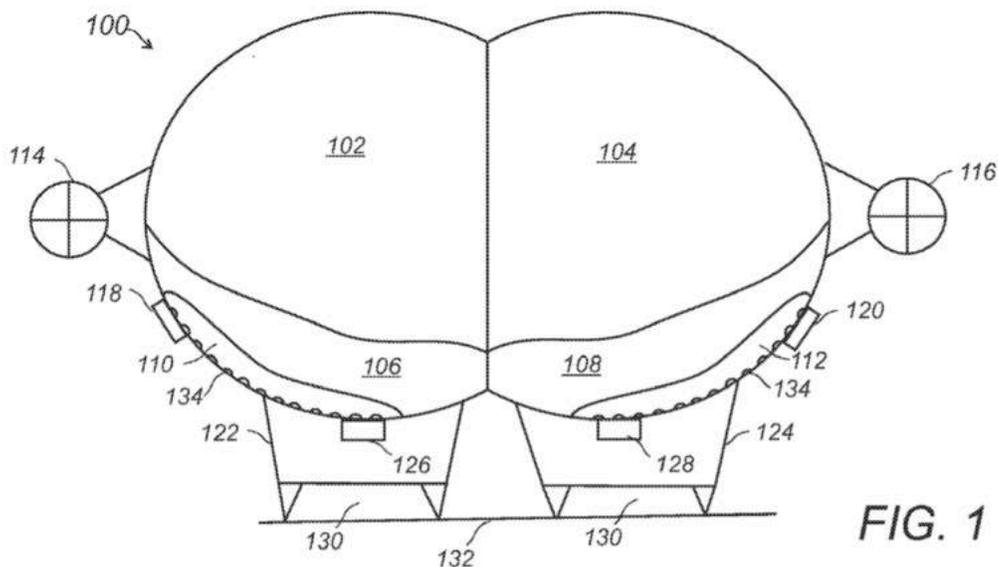
US 8167240B2

- Application filed: 13 March 2009
- Patent granted: 1 May 2012
- Assignee: Lockheed Martin Corporation
- Available here:
<https://patents.google.com/patent/US8167240B2/en>

EP 2230173A3:

- Application filed: 12 March 2010
- Patent granted: 30 November 2016
- Assignee: Lockheed Martin Corporation
- Available here:
<https://patents.google.com/patent/EP2230173A3/it>

These patents describe the operation of the ACLS in five different operating modes and the respective air pressures in the ballonets and the hull in each operating mode.



The fans (118, 120) supply higher pressure air via ducts (110, 112) to the ballonets (106, 108) and via control valves (126, 128) into the ACLS chambers (122, 124)

Patent US 8783602B2 - System and method for furling an air cushion landing system

- Application filed: 17 April 2012
- Patent granted: 22 July 2014
- Assignee: Lockheed Martin Corp
- Available here: <https://patents.google.com/patent/US8783602>

The patent describes a furling system that creates a streamlined cover for a deployable air cushion landing system while the airship is in flight.

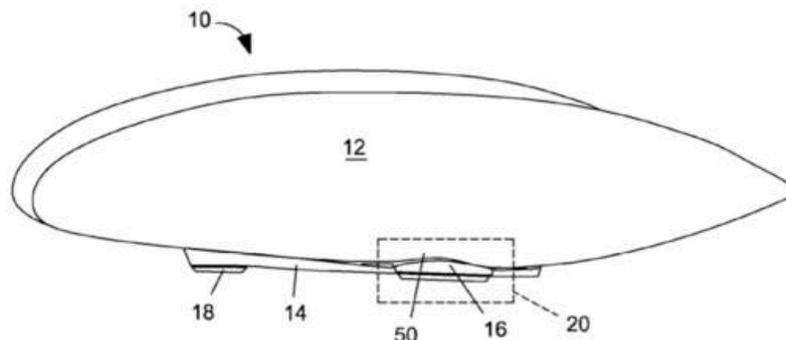


FIG. 1

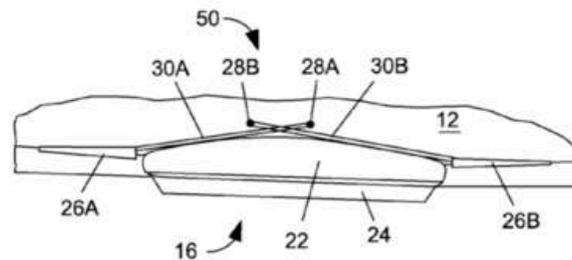


FIG. 2

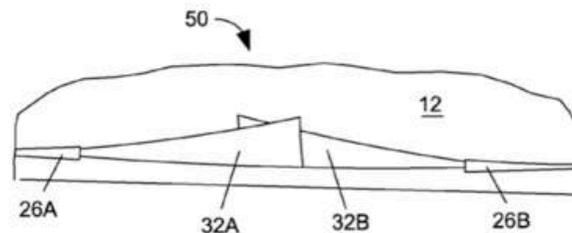


FIG. 3

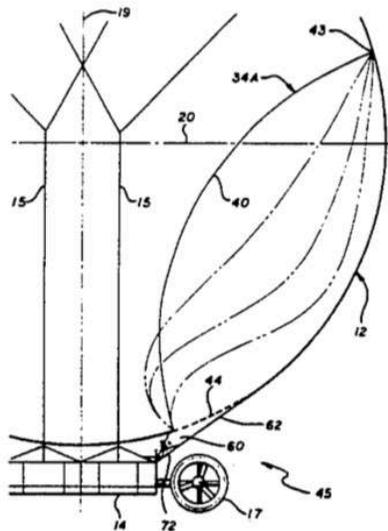
*Fig. 2 shows ACLS extended and furling system stowed.
Fig. 3 shows ACLS retracted and furling system deployed*

Patent US 5333817A - Ballonet system for a lighter-than-air vehicle

- Application filed: 22 November 1993
- Patent granted: 2 August 1994
- Assignee: Lockheed Martin Corp
- Available here:
<https://patents.google.com/patent/US5333817A/en>

This patent describes an improved ballonet system that has the following attributes:

- It is independent from other systems of the vehicle (including the ACLS).
- The volume of air in each ballonet can be individually varied.
- It provides rapid filling and venting of the individual ballonets.

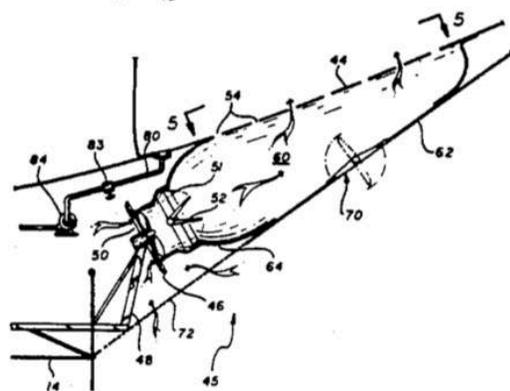


In a hybrid airship with ballonets installed left and right, and fore and aft, the ballonets can be used individually to adjust the roll angle and the pitch angle of the airship.

Each ballonet (40) is located along the outside of the gasbag (12).

Fan (46) pressurizes the ballonet.

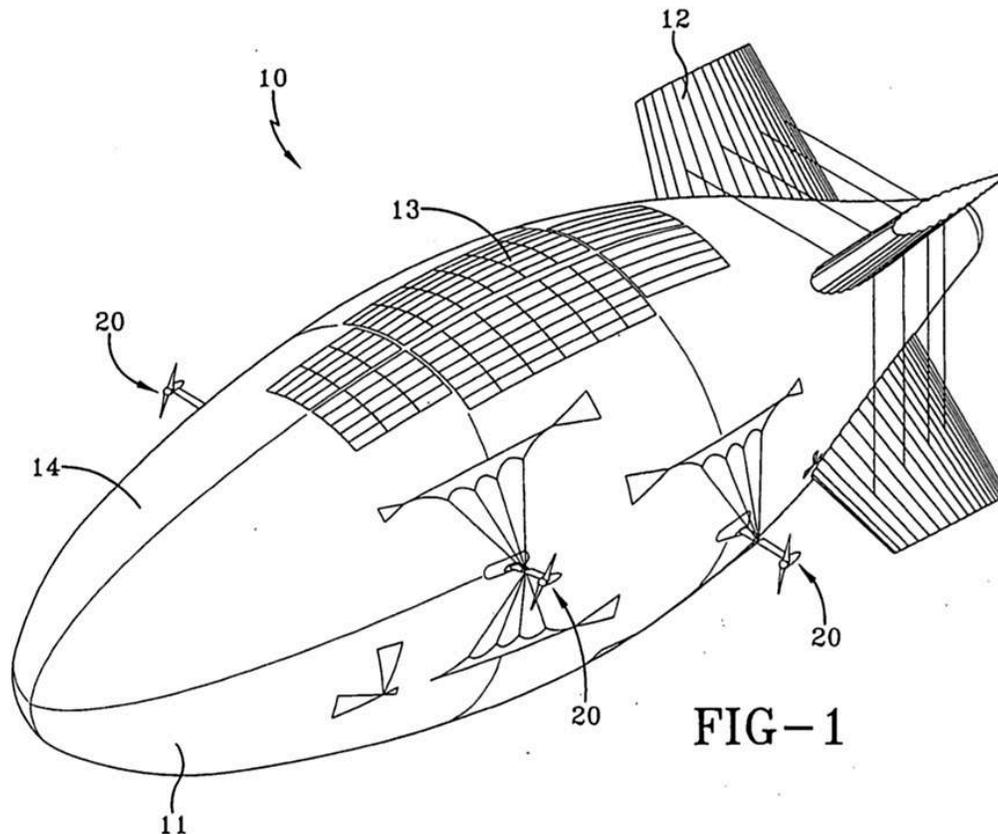
Butterfly valve (70) depressurizes the ballonet.



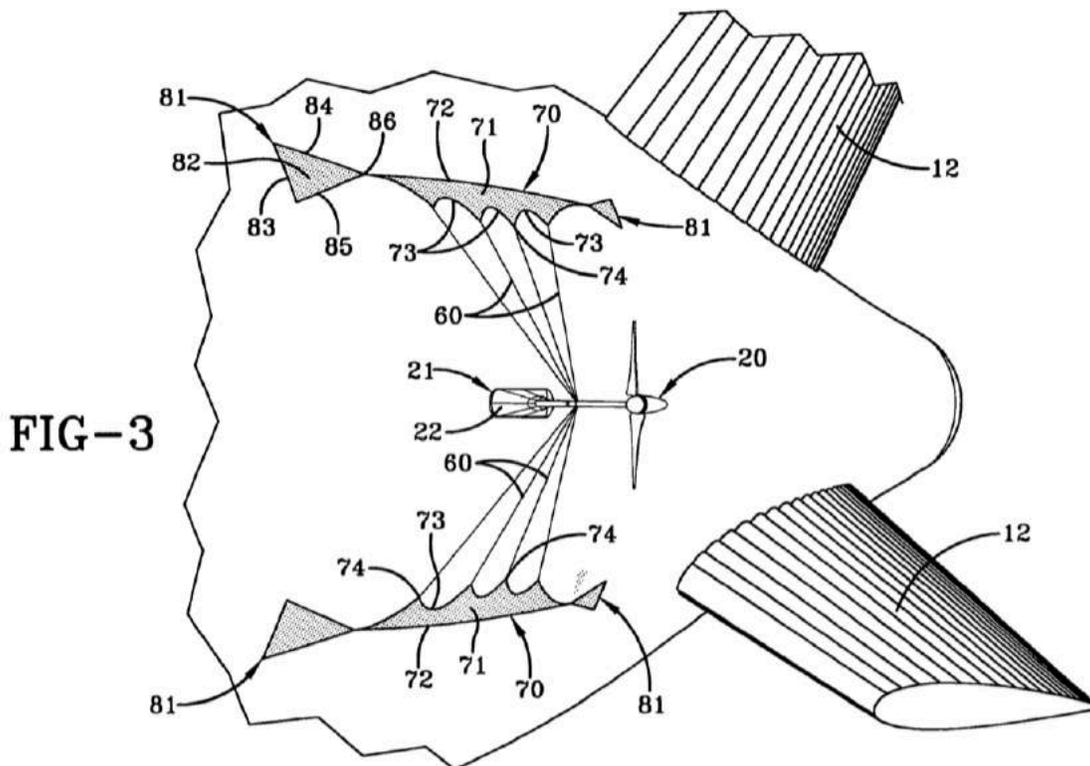
Patent US 7448572B2 - Direct mounted propulsion for non-rigid airships

- Application filed: 5 October 2005
- Patent granted: 11 November 2008
- Assignee: Lockheed Martin Corp
- Available here: <https://patents.google.com/patent/US7448572>

The patent describes a means to attach a propulsion system for non-rigid, pressure-stabilized airships directly to a fabric skin and efficiently distribute applied loads into the skin. While patented in connection with an application for a high-altitude airship, the solution applies as well to a hybrid airship with a pressure stabilized hull, like the P-791.



Patent Figure 1 depicts a pressurized airship (10) with propulsors (20) attached to the hull (11) with a network of guy cables (60) connected to scalloped fabric mounting assemblies (70) that distribute loads into the hull.



Patent Figure 3 provides a closer look at the attachment for a single propulsion engine assembly (20), which is mounted at one end of an extension member that is secured to the hull at its base (21, 22). The engine assembly is supported by several guy cables (60) that are fastened to longitudinal scalloped fabric mounting assemblies (70) to distribute the applied load to a broad area of the hull.

This design is also addressed in European patent EP1772374 B1, "Non-rigid airship with direct mounted propulsion," which was granted on 7 July 2010 and is available here"

<https://patents.google.com/patent/EP1772374B1/en>

6. For more information

- “P-791 hybrid airship project,” Military Heat, 18 February 2008: <https://military-heat.bubble.ro/91/p791-hybrid-airship-project/>
- 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=6eb9dab54c9d>
- “New Lockheed airship takes short test flight,” Los Angeles Daily News, 15 February 2006: <https://www.dailynews.com/2006/02/15/new-lockheed-airship-takes-short-test-flight/>

Videos

- YouTube video, “Lockheed Martin P-791 Hybrid Air Vehicle,” (3:32 minutes), DefenseUpdate, 11 June 2015: <https://www.youtube.com/watch?v=LZBhs-Srvwl>
- Lockheed P-791,” (1:12 minutes, flight test clips), Daily Motion, 2007: <https://www.dailymotion.com/video/x4cnc6>

Other Modern Airships articles

- *Modern Airships - Part 1:* <https://lynceans.org/all-posts/modern-airships-part-1/>
 - Lockheed Martin Aerocraft hybrid airship
 - Lockheed Martin SkyTug and LMH-1 hybrid airships
 - Advanced Technologies Group (ATG) – SkyCat & SkyKitten
 - Hybrid Air Vehicles (HAV) & Northrop Grumman - LEMV
- *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/>