

Lockheed Martin P-791 hybrid airship

Peter Lobner, Updated 3 April 2021

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-SrvwI>

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. You can see a short video on the P-791 at the following link: <https://www.youtube.com/watch?v=CKAyJ3zKTus>

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, both photos: 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 P-791 is the striking similarity with ATG's SkyKitten technology demonstrator airship and the full-size SkyCat hybrid airship. Both use many of the same concepts as the P-791, 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

Several of Lockheed-Martin's airship technology patents awarded in the early 2000s describe features of an early hybrid airship design concept that was trademarked as the Aerocraft (not to be confused with the Aerocraft trademarked by Worldwide Aeros Corp.). The following patents are described in a separate article on the Lockheed Martin Aerocraft:

- US 5449129A - Propulsion system for a lighter-than-air vehicle
- US 6196498B1 - Semi-buoyant vehicle with aerodynamic lift capability
- US 6293493B1 - Pressure stabilized gasbag for a partially buoyant vehicle
- US 6315242B1 - Propulsion system for a semi-buoyant vehicle with an aerodynamic (hull)

Patent US 8016229 B2 - Retracting air cushioned landing system for air vehicles

Date of Patent: 13 September 2011

Inventors: Douglas H. Greiner, Stevenson Ranch, CA(US); John P. Morehead, Mountain View, CA (US); Renee Pasman, Palmdale, CA (US); Robert R. Boyd, Valencia, CA (US)

Assignee: Lockheed Martin Corporation

Available from Google patents here:

<https://patents.google.com/patent/US8016229/es>

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

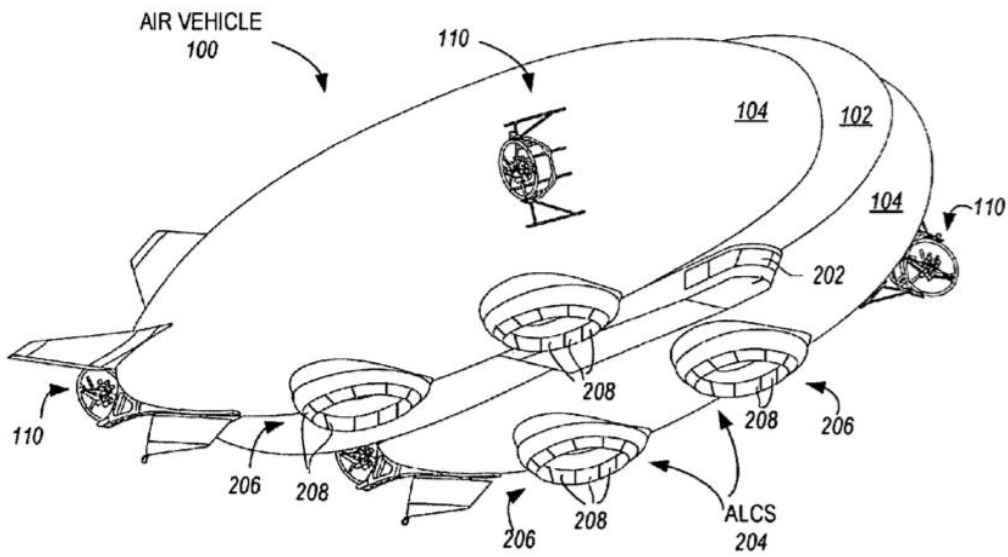


FIG. 2

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

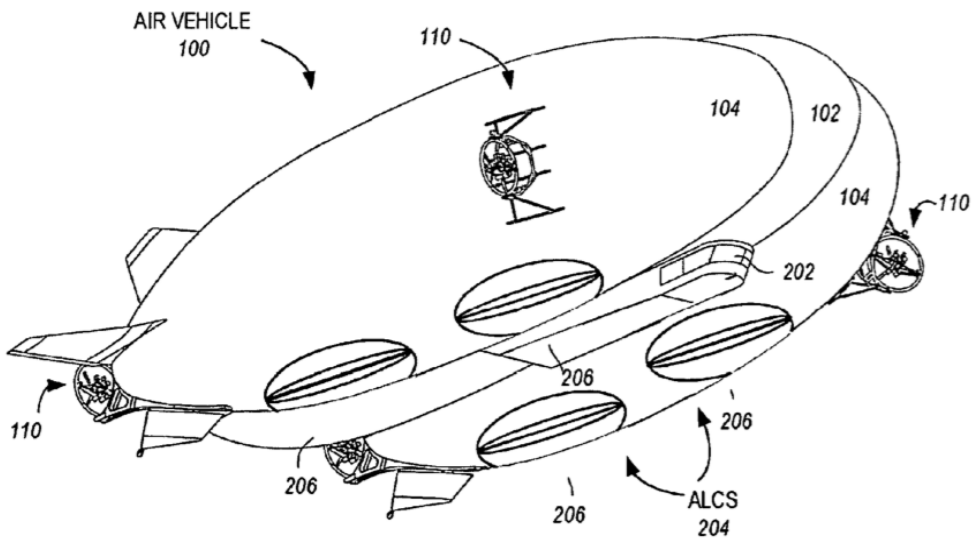


FIG. 4

Patent US 8167240B2 - Systems and methods for buoyancy management in an airship

Date of Patent: 1 May 2012

Inventor: Greiner, Douglas H Stevenson Ranch, CA 91382 (US)

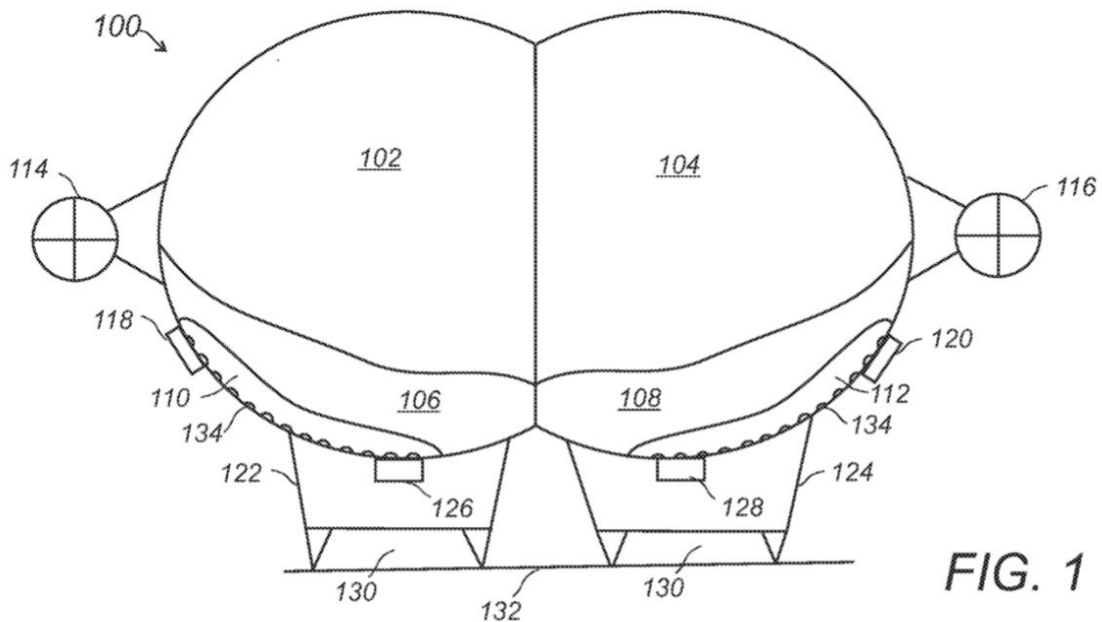
Applicant: Lockheed Martin Corporation

Available from Google patents here:

<https://patents.google.com/patent/US8167240B2/en>

Also covered by European patent EP 2230173A3, which is available here: <https://patents.google.com/patent/EP2230173A3/it>

This patent describes 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

Date of Patent: 22 July 2014

Inventors: John Morehead, Malcolm Cox, Charles Eden, Robert Boyd, Nicholas Piini

Current Assignee: Lockheed Martin Corp

Available from Google patents 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.

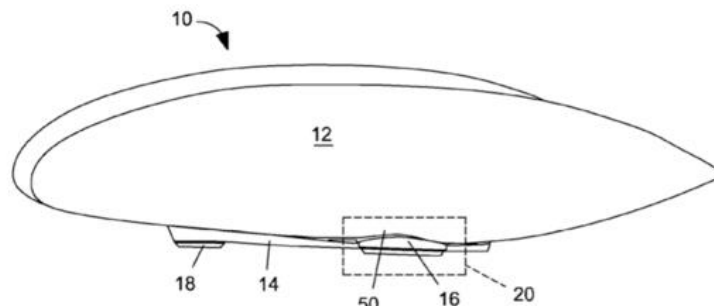


FIG. 1

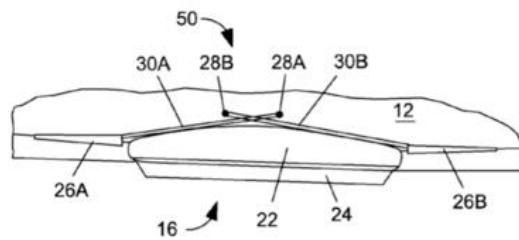


FIG. 2

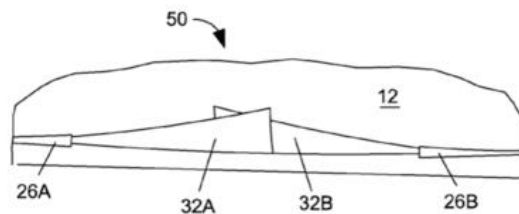


FIG. 3

*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

Date of Patent: 2 August 1994

Inventor: John B. Kalisz, Mark H. Wexler

Current Assignee: Lockheed Martin Corp

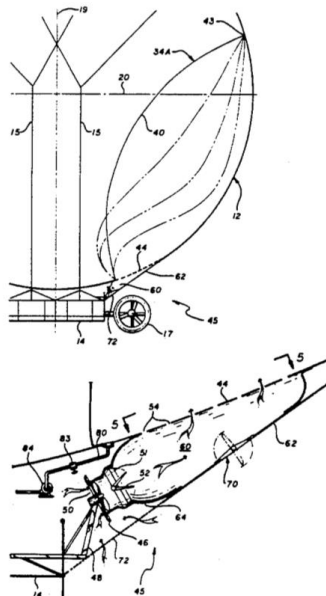
Available from Google patents here:

<https://patents.google.com/patent/US5333817A/en?q=US5333817A>

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 to be individually varied
- 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 side 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

Date of Patent: 11 November 2008

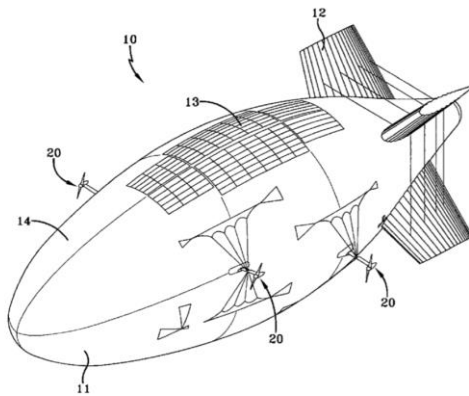
Inventor: Thomas L. Marimon, Jonathan Peritt, James E. Houmard

Current Assignee Lockheed Martin Corp

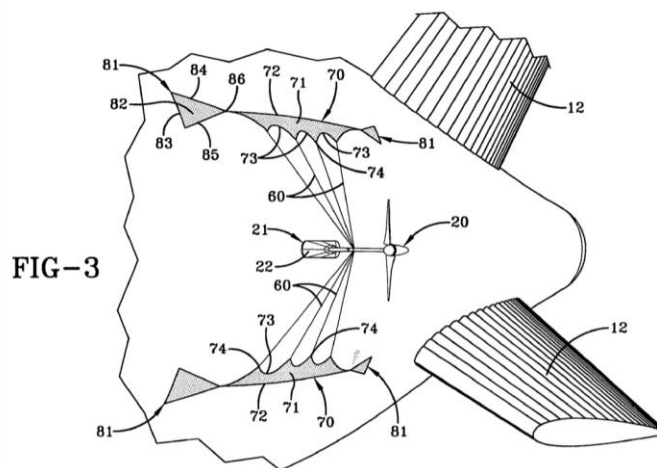
Available from Google patents here:

<https://patents.google.com/patent/US7448572>

The patent describes a means to attach a propulsion system for pressurized 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 altitude, the solution applies as well to a hybrid airship with a pressure stabilized hull.



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



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/>
- “The P-791 Hybrid Air Vehicle by Lockheed Martin,” GREGinSD, 25 October 2011:
<https://greginsd.wordpress.com/2011/10/25/the-p-791-hybrid-air-vehicle-by-lockheed-martin/>