Airship / Helicopter Hybrid Aircraft (Helistat)

Peter Lobner, 13 August 2019

There have been many different designs of airship / helicopter hybrid aircraft (a helistat) in which the airship part of the hybrid aircraft carries the weight of the aircraft itself and helicopter rotors deployed around the base of the airship work in concert to propel the aircraft and to lift and deliver heavy payloads without the need for an exchange of ballast.

In this section, we’ll take a look at one heavy-lift helistat that actually flew and several other heavy-lift helistat patents and concepts.

**Piasecki PA-97 (1980 – 1986)**

Frank Piasecki filed a patent application for a “Helicopter and Balloon Aircraft Unit” on 17 March 1958 and received Patent US 3,008,655 on 14 November 1961. This patent described an early concept for a helistat with a large, spherical helium balloon coupled to two tandem rotor helicopters. This configuration is shown in the following figure.
As described in the patent,

“The present invention relates in general to helicopters, and more particularly to an assembly of a plurality of interconnected helicopters and a balloon forming an aircraft unit particularly suitable for transporting heavy loads…… beyond the normal capability of helicopters.”

You can read Patent US 3,008,655 here:

https://patents.google.com/patent/US3008665

On 12 October 1979 Frank Piasecki and Donald Meyers filed a patent application for a “Vectored thrust airship,” which was a more advanced design for a helistat. They received Patent US 4,591,112 A on 27 May 1986. This patent describes the basic design and operation of this helistat as follows:

“An airship with provisions for vectored thrust provided by a plurality of controllable pitch rotor thrust producing units attached to the elongated aerostat hull spaced from and on opposite sides of the center of overall mass of the airship. The pitch control systems for the rotors of all thrust units include collective and cyclic pitch controls of the main, horizontally rotating lifting rotors and the control systems are interconnected to be operable by a master control which establishes both similar and differential pitch settings of the rotors of selected thrust units in a manner to establish vectored thrust in directions which establish the required amounts of vertical lift, propulsion thrust, trim and control forces to control all flight aspects of the airship.”

You can read Patent US 4,591,112 A here:

The patent includes several helistat design concepts, including the following:

One helistat configuration described in Patent US 4,591,112 A
The first large US helistat to fly was the Piasecki PA-97, which was built under a 1980 Navy contract for the Forest Service to demonstrate a heavy vertical airlifter for harvesting timber from inaccessible terrain. The basic design is very similar to the one in Patent US 4,591,112 A, Figures 7 and 8.

![Piasecki helistat concept in forestry service. Source: Wikipedia / Piasecki](image)

The PA-97 was a very large hybrid airship comprised of a retired Navy ZPG-2W blimp envelope (which formed the helium-filled aerostat) and four Sikorsky H-34 helicopters without their tail sections, connected beneath the blimp via a rigid framework. The 343 foot (105 m) long PA-97 first flew on 26 April 1986 and made several successful test flights.
The PA-97 was destroyed in a crash immediately upon takeoff on 1 July 1986, after a vibration-induced structural failure resulted in the starboard-aft helicopter breaking free from its mounting and its rotors cutting the aerostat’s gas envelope. Development of the PA-97 was discontinued shortly thereafter.
**Rotor-Aerostat Composite Aircraft patent (USA, 2000)**

US Patent 6142414A; Rotor-Aerostat Composite Aircraft; published 7 November 2000; applicant: Donald B. Doolittle; assignee: All American Industries, Inc., Wilmington, DL; available here:


**Abstract:** “A composite aircraft comprising an aerostat containing a lighter than air gas, and a rotor assembly mounted to and below the aerostat, via an axle. The aerostat provides buoyancy to lift the weight of the aircraft plus a significant portion of the payload connected to the aircraft. The rotor assembly statically connects to the aerostat in all aspects except rotationally about the axle, and provides the remaining lift and propulsion to the aircraft and payload.”
Hybrid aircraft patent (Canada, 2002)


Abstract: “A hybrid aircraft having VTOL R-VTOL and S-STOL capabilities having a lifting body hull (1) and four wing sections (20) arranged in tandem which are pivotally moveable about their neutral axis. Each wing section has mounted thereon a pivotal propeller-rotor (21) assembly for providing thrust substantially in a range between horizontal and vertical. The wings and propellers are integrated to the hull by an outrigger designed to be very stiff and to distribute forces from the wings and propellers from the hull. The hull is shaped to provide aerodynamic lift in an airstream and to facilitate construction by minimizing the number of panels of differing curvature required. The hull is formed of a pressure-tensioned frame covered with semi-rigid panels, a lower cladding frame and bow and stem cladding nose cones. ....... A turbo-electric drive system can be used to drive the aircraft.”

FIG. 6a
Hybrid Lift Air Vehicle patent (Canada, 2007)

US Patent 8167236 B2; Hybrid Lift Air Vehicle; filed 27 August 2007; published 6 March 2008; patent granted 1 May 2012; inventor: Peter Jess, Calgary, Canada; assignee: Shell Technology Ventures Fund; available here:


Abstract: “A hybrid lift air vehicle for lifting and transporting a payload to a delivery location, which comprises a helium or other lighter-than-air gas filled envelope mounted on an airframe. Variable and reversible vertical thrusters are positioned on the airframe, and at least two variable and reversible lateral thrusters are mounted on the envelope or mounted on truss arms attached and extending out from the airframe, Wherein, when the vehicle is connected to the payload for transport, the helium or other lighter-than-air gas supports or substantially supports the weight of the vehicle and the vertical thrusters are then continuously engaged to support the weight of the payload and to provide lift to the payload, Wherein the lateral thrusters are then engaged to effect lateral movement of the vehicle to the delivery location, Whereby, once at the delivery location, the lift provided by the variable and reversible vertical thrusters is reduced or reversed so as to allow the air vehicle to descend and the payload to again engage the ground surface, and where necessary, the variable and reversible vertical thrusters may be reversed to facilitate the unloading of the payload from the vehicle, the vehicle continuing to be kept aloft, once unloaded, by the helium or other lighter than air gas. In this manner, the vehicle utilizes the helium or lighter than air gas to offset or substantially offset the weight of the vehicle, the vertical thrusters providing the power to lift the payload.”
Improved Hybrid Lift Air Vehicle patent (Canada, 2009)


Abstract: “A hybrid lift air vehicle for carrying and transporting a load, comprising an envelope having a generally ellipsoidal shape adapted to receive a volume of lighter-than-air gas, at least two variable thrust vertical thrusters in secure engagement with the envelope and at least two variable thrust lateral thrusters in secure engagement with the envelope, means for temporarily securely engaging the load to the envelope wherein the volume of lighter-than-air gas has a buoyancy that offsets at least 25% of the weight of the air vehicle when unloaded, wherein the thrust from the at least two vertical thrusters may be varied to raise and lower the air vehicle and the load when engaged, and wherein the thrust from the at least two lateral thrusters may be varied to maneuver and transport the raised air vehicle and the load when engaged.”

![FIG. 3](https://patentimages.storage.googleapis.com/48/ac/66/c0375cae5e7db2/WO2009152604A1.pdf)

The SkyHook JLH-40 (JHL = “Jess Heavy Lifter”) is the commercial incarnation of the patented heavy lift helistat designed by Peter Jess and assigned to the Canadian firm SkyHook International, as described in WIPO International Publication Number WO 2009/152604 Al.

In July 2008, Boeing announced that it would team with SkyHook International to build the SkyHook JHL-40. For the SkyHook application, the helium-filled gas envelope will make the aircraft
neutrally buoyant. The rotor system will generate the lift needed to carry heavy loads. Lateral thrusters will provide cruise propulsion and precise positioning during load transfers.

The SkyHook JHL-40 was 302 feet (92 m) long, slightly shorter than the 1980s-vintage Piasecki PA-97. The SkyHook was designed to carry an external sling load of 40 tons (80,000 lb; 36,287 kg) at a speed of 70 knots over a range of 230 miles (370 km) without refueling. Without cargo, the SkyHook was expected to have a ferry range of 800 miles (1,287 km).
Load exchange was accomplished with the SkyHook hovering precisely over its destination with the coordinated rotor system managing the increase in lift needed during load pickup and the decrease in lift needed during load delivery. No exchange of ballast was needed during a load exchange.

The business case for a SkyHook JHL-40 operating in the Canadian high-North was based on the avoided cost and environmental benefits of not building roads or rails for ground transportation into these sensitive Arctic regions.

The JHL-40 was to be certified by Transport Canada and the U.S. Federal Aviation Administration, with the first aircraft expected to fly in the 2012 – 2014 time frame. However, the development program was cancelled in 2010 before the detailed design phase was completed.

Since the demise of the SkyHook program, there has not been another heavy-lift helistat program.