Helistats - Helicopter / Airship Hybrid Aircraft

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1. Introduction

There have been many different designs of helistats (airship / helicopter hybrid aircraft) in which the airship part of the hybrid aircraft carries the empty weight of the aircraft itself, and helicopter rotors deployed in some fashion around the airship work in concert to lift and propel the fully loaded aircraft and conduct load exchanges without the need for an exchange of ballast.

In this article, we'll take a look at the following.

- NASA heavy-lifter (USA,1975)
- Tentai III ducted fan helistat (Japan, mid-1970s)
- Kawasaki Heavy Industries (KHI) helistats (Japan, late 1970s)
- Jess hybrid lift air vehicle (Canada, 2007)
- Boeing lighter-than-air vertical load lifting system (USA, 2007)

The following additional helicopter / airship hybrids are addressed in separate articles:

- Aérospatiale – Hélicostat (France, 1920s & 1970s)
- Goodyear Dynastats and airline feeder (USA, 1970s)
- All American Engineering Aerocrane (USA, 1972 – 1999)
- Piasecki PA-97-34J & other quad-rotor helistats (USA, 1970s – 1980s)
- Aérospatiale – Obélix & Obélix II (France, mid-1970s)
- Goodyear quad-rotor heavy lift helistats (USA, 1975 – 1980s)
- AeroLift Inc. Cyclocrane & Cyclo-Cruiser (USA, 1978 – 1990)
- OKBV Kiev Albatros helistat (Soviet Union, circa mid-1980s)
- Myasishchev Design Bureau – VS-80 & VS-90 helistats (Russia, circa early 1990s)
- Bothe Helitruck (Germany / USA, 1980s) & semi-buoyant hybrid aircraft (2000s)
- Skyhook International & Boeing SkyHook JHL-40 / HLA (Canada & USA, 2008 – 2010)

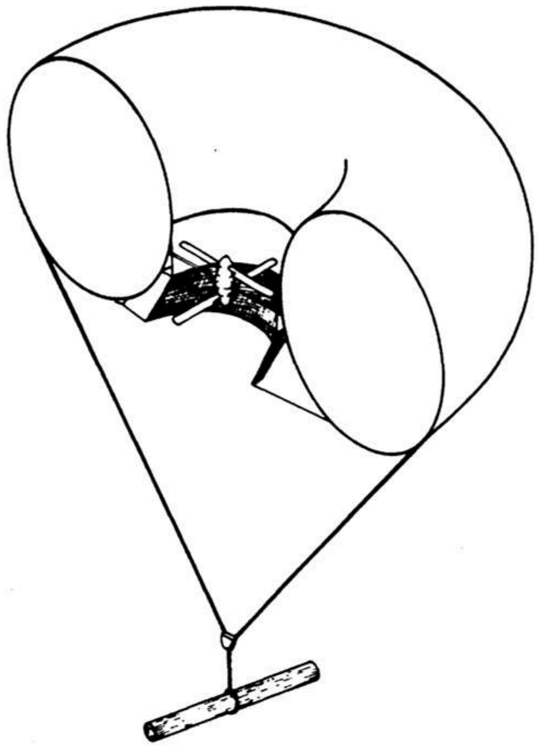
2. NASA Heavy-Lifter (USA, 1975)

NASA Heavy-Lifter concept, circa 1975. Source: NASA

In the mid-1970s the National Aeronautics and Space Administration (NASA) had a program to develop concepts for heavy-lift lighter-than-air (LTA) vehicles for possible civil and military use. One concept, called the “heavy lifter,” was a semi-buoyant hybrid vehicle with four helicopter rotor systems supported from a large rigid airship (dirigible) hull. At sea level, the gas envelope volume of 75,000 m^3 (2.5 million ft^3) would provide 83,550 kg (184,196 lb) of aerostatic lift. When loaded with cargo, a helistat is only semi-buoyant (it is heavier-than-air), thereby greatly simplifying ground handling requirements. The helicopter rotor systems provide the dynamic lift to carry heavy loads without also having to lift the whole weight of the vehicle. In addition, the helicopter system enables the helistat to precisely hover above a destination for in-flight cargo pickup or delivery.

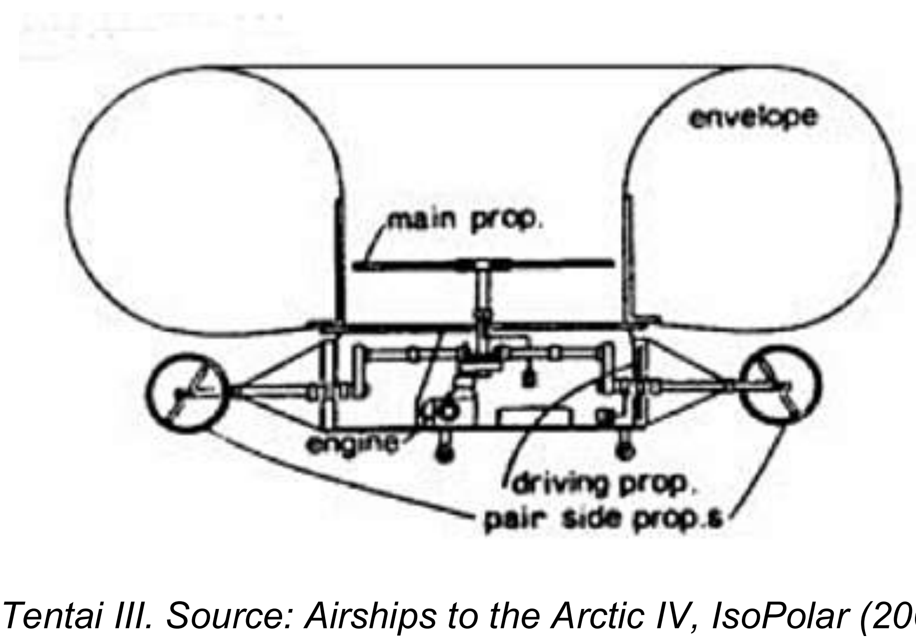
This short-haul heavy lifter concept could provide the lifting capacity needed to deliver heavy power generating equipment of other industrial equipment, particularly when its destination is a remote area not served by other heavy transportation systems.

3. Tentai III ducted fan helistat (Japan, mid-1970s)



Source: NASA Tech Memo 86672, Section 2.2 (1984)

Tentai III was a Japanese design for a ducted fan helistat with a toroidal lifting gas envelope surrounding a single main rotor that drew air in from the top of the torus and exhausted through the bottom of the torus to generate dynamic lift. Separate ducted propulsors below the torus provided propulsion and directional control. The general arrangement of Tentai III was similar to the accompanying diagram showing a 1974 design by J.B. Nichols and D.B. Doolittle, which also combined helicopter and toroidal balloon elements.



Tentai III. Source: Airships to the Arctic IV, IsoPolar (2007)

4. Kawasaki Heavy Industries (KHI) helistats (Japan, late 1970s)

In the late 1970s, studies sponsored by Japan's Ministry of International Trade and Industry (MITI) determined that two types of airships would be useful: a heavy lift airship to transport cargos in the 20 - 100 ton range and a short-haul passenger airships linking medium-sized cities about 300 km (186 miles) apart.

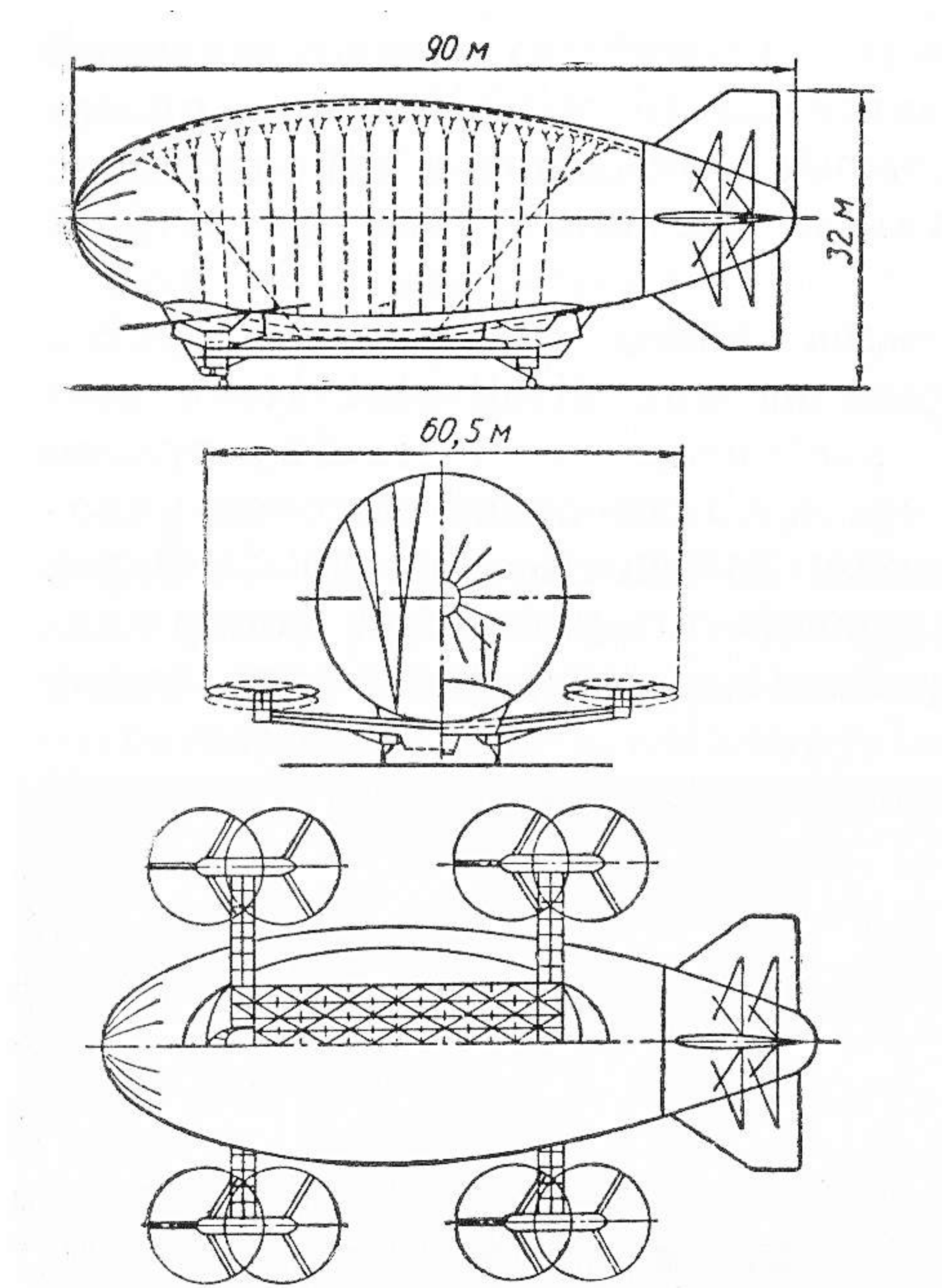
To meet these need, Kawasaki Heavy Industries (KHI) developed the following preliminary designs for a cargo-carrying helistat and a similar passenger-carrying helistat. Both helistats have a single, large non-rigid lifting gas envelope and a long, rigid longitudinal keel that houses the crew compartment, engine compartment, fuel and landing gear. Four cantilevered transverse truss structures extend from the keel and carry the helistat's rotor systems. of the cargo helistat and the passenger compartment was supported from the rigid keel

<u>KHI cargo helistat</u>

Toshiba Electric expressed early interest in a heavy lift airship that could support their construction of inland hydroelectric and geothermal power stations. The KHI helistat was developed with this role in mind. The payload handling gear was attached directly to the longitudinal keel, under the center of lift.

General characteristics of the KHI cargo helistat

Parameter	KHI cargo helistat
Length	90 m (295 ft)
Overall height	32 m (105 ft)
Overall width, including rotors	60.5 m (198.5 ft)
Lift gas	Helium
Takeoff weight	68 metric tons (74.8 tons)
Payload	30 tons (33 tons)
Propulsion system	8 x turboshaft engines rated @ 1,361 shp (1,015 kW) each, housed in the gondola, driving 8 x rotors via transmission shafts in the transverse truss beams
Speed, cruise	100 kph (62 mph)
Range	330 km (205 miles)



KHI cargo helistat. Source: Arie, “Dirigibles” (1986)

KHI passenger helistat

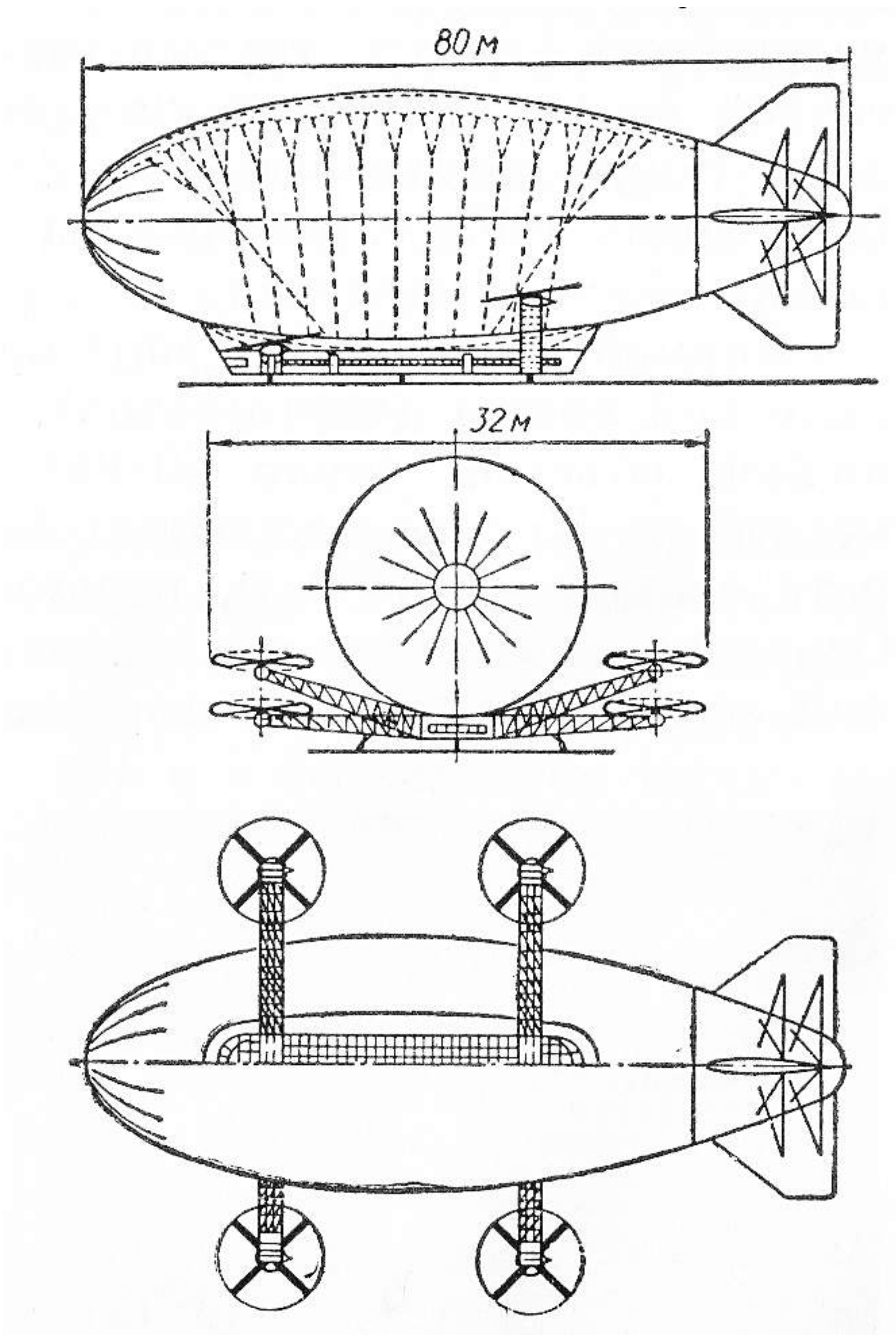
KHI's passenger helistat was targeted for "rib routes" that linked Japan's high-speed railway system with cities in mountainous regions and on small islands that where not directly served by the rail and regional fixed-wing air transport systems. Up to 120 passengers could be carried in a passenger compartment that was supported directly from the longitudinal keel structure.

General characteristics of the KHI passenger helistat

Parameter	KHI passenger helistat
Length	80 m (262 ft)
Overall width, including rotors	32 m (105 ft)
Overall height	30.5 m (100 ft)
Lift gas	Helium
Envelope volume	21,500 m^3 (759,265 ft^3)
Takeoff weight	32 metric tons (35.2 tons)
Passengers	120
Propulsion system	8 x turboshaft engines rates @ 600 hp (447.4 kW) each, housed in the gondola, driving 4 x 11-meter (36-ft), 4-bladed rotors via transmission shafts in the transverse truss beams
Speed, cruise	150 kph (93.2 mph)
Range	700 km (435 miles)
Altitude	3,000 m (9,843 ft)

The unit price for this helistat was projected to be $7.5 million for a production run of 10 aircraft. Operating costs were expected to be comparable to Japan's YS-11 small passenger aircraft on routes of 300 km (186.4 miles).

KHI did not developed either of these helistat design concepts.



KHI passenger helistat. Source: Arie, "Dirigibles" (1986)

5. Jess Hybrid Lift Air Vehicle (Canada, 2007)

SkyHook International Inc. was a privately held firm founded by Peter Jess in Calgary, Alberta, Canada. Their primary business was in providing logistics support in remote Arctic regions. Before Peter Jess developed the concept for the SkyHook JHL-40 helistat, he developed a concept for a hybrid heavy-lift helistat with a spherical gas envelope. That design is described in patent US8167236B2, “Hybrid Lift Air Vehicle”, which was filed 27 August 2007 and granted on 1 May 2012. The patent was assigned to the Shell Technology Ventures Fund. You can read this patent here:
https://patents.google.com/patent/US8167236B2/en?oq=US8167236B2+
The related international patent WO2008/025139A1 is available here:
https://patents.google.com/patent/US8141814B2/en?oq=8%2c141%2c814

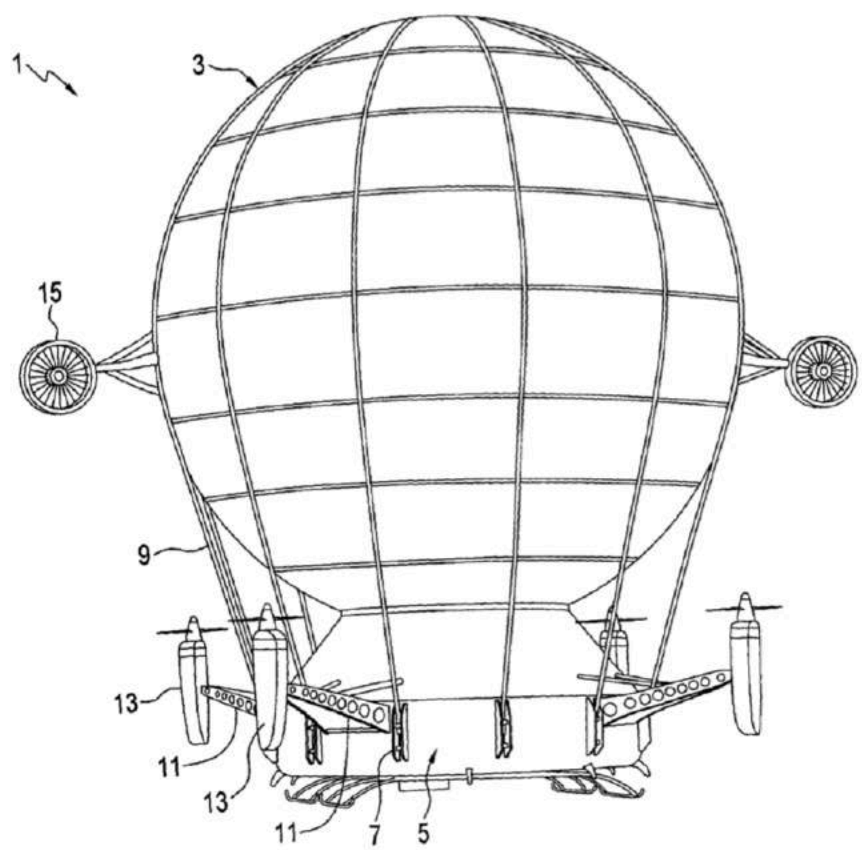


FIG. 1

General arrangement of the helistat. Source: Patent US8167236B2

The helistat, as shown in patent Figure 1, consists of a large, spherical lifting gas envelope (3), whose shape is maintained by internal gas pressure. The gas envelope is mounted above a circular airframe (5) to which most aircraft systems and the load handling system are attached. The load from the airframe is transferred to the gas envelope by means of cables (9) arrayed externally around the envelope. The airframe structure without the outer skin is shown in patent Figure 5A. Note the cockpit (19) under the airframe.

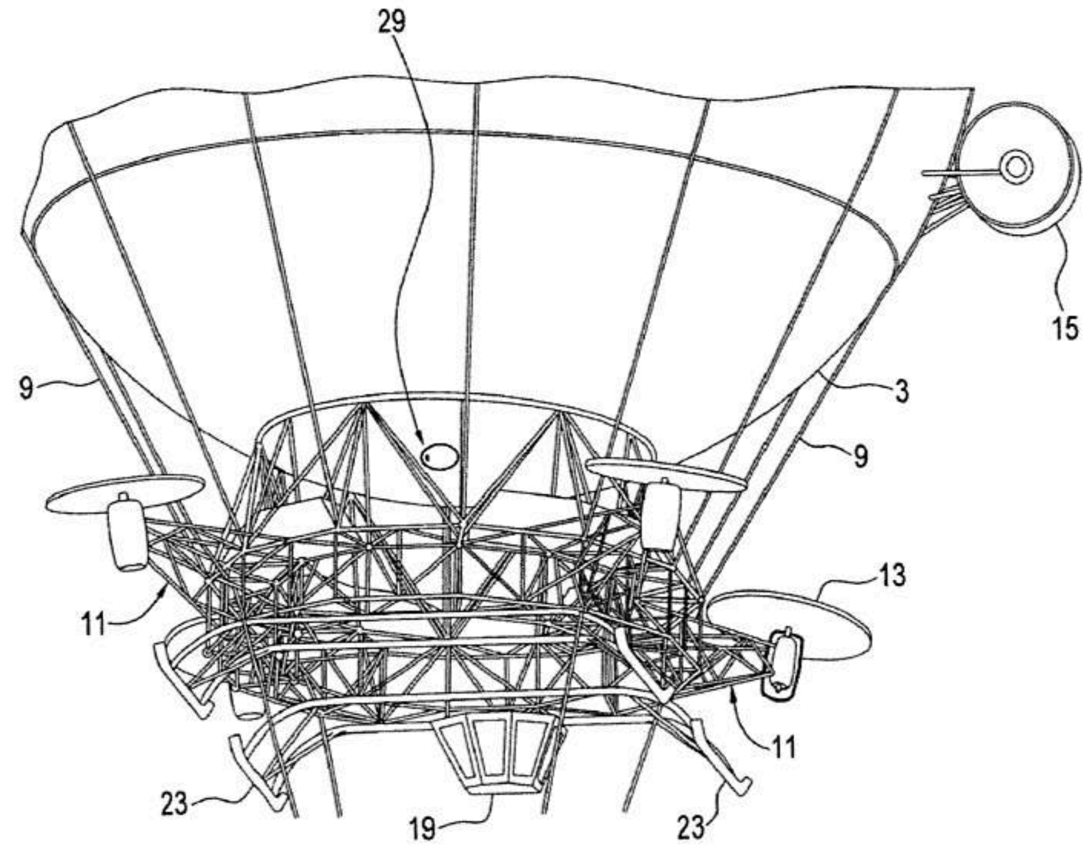


FIG. 5A

In patent Figure 5A. variable and reversible vertical thrusters (13) are positioned around the airframe. At least two variable and reversible lateral thrusters (15) are mounted on the flanks of the gas envelope or on truss arms attached and extending out from the airframe. Aerostatic lift from the lift gas offsets, or substantially offsets, the weight of the vehicle, while the vertical thrusters provide the power to lift and carry the payload. The lateral thrusters are used to maneuver the helistat and fly from one location to another.

The basic design of the helistat is scalable and models could be developed to handle loads of 20 - 40 metric tons (22 – 44 tons) over ranges of 50 – 100 nautical miles (92 – 185 km). Operating speed is expected to be in the range from 35 – 60 mph (56 – 97 kph). The helistat is designed to operate at an altitude of 3,000 to 6,000 ft (914 – 1,828 m) above the ground level at the departure point. For use in Arctic regions, the gas envelope could be heated to inhibit ice and snow accumulation.

To pick up a load, a neutrally buoyant helistat approaches into the wind and maneuvers in a hover to a precise geo-location, lowers cargo cables (21) that will be attached to the load, and then gradually applies power to the vertical thrusters to transfer the load to the helistat and then lift the load. The lateral thrusters move the helistat to the delivery location.

Once at the delivery location, the helistat establishes a hover at a precise geo-location and lowers the load to the ground. Power to the variable and reversible vertical thrusters is reduced and may be reversed if needed to fully transfer the weight of the load to the ground. When the lift cables are slack, they can be safely disconnected and retrieved by the helistat before flying off to its next destination.

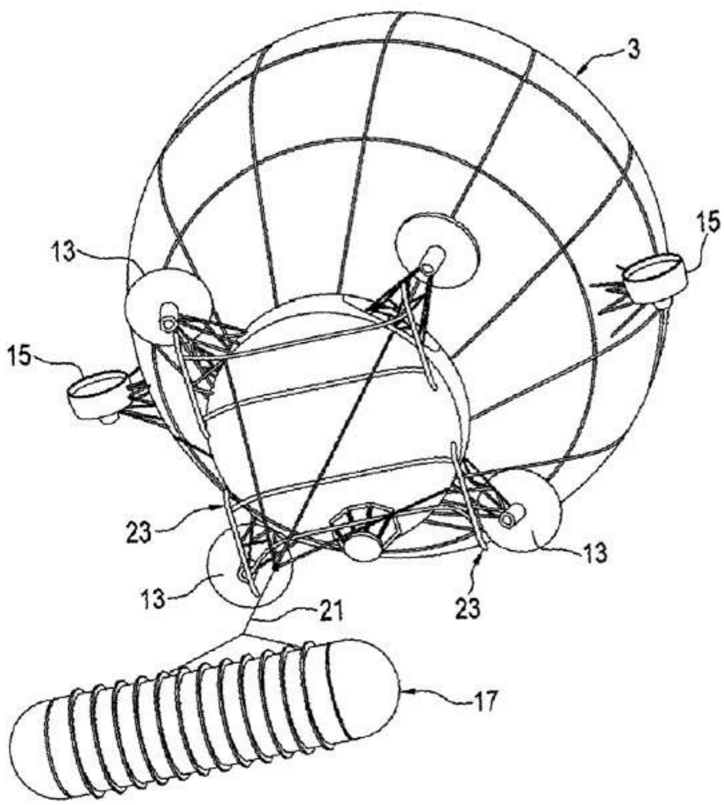


FIG. 4

The entire load exchange occurs while the helistat is airborne. With a helistat, there is no need to transfer ballast during a load exchange.

6. Boeing lighter-than-air vertical load lifting system (USA, 2007)

Before Boeing became a partner with SkyHook International in the development of the SkyHook JLH-40 helistat, Boeing Advanced Rotorcraft Systems was developing their own concepts for a heavy-lift helistat. One Boeing helistat concept is described in patent US8141814B2, "Lighter-than-air vertical load lifting system," which was filed on 26 November 2007 and granted on 27 March 2012. You can read this patent here:
https://patents.google.com/patent/US8141814B2/en?oq=8%2c141%2c814

The Boeing helistat described in the patent is relatively compact and simple design for an aerial lifting system that is capable of transporting very heavy loads to remote locations. The helistat consists of a non-rigid, blimp-type gas envelope that is surrounded, in part, by a rigid structural shell on which all of the aircraft systems are installed. The gas envelope provides neutral buoyancy for the aircraft itself, including the structural shell, engines, fuel tanks, tandem rotors and transmissions, crew accommodations and the cargo handling system for carrying a suspended load.

The structural shell benefits from the tandem rotor design of the Boeing helistat and is claimed to be lighter than the frame and truss structures typically found in quad-rotor helistat designs, like the Piasecki PA-97. The structural shell is designed to transfer the weight of the suspended load directly to the locations of the tandem rotors, thus avoiding unnecessary stress on the gas envelope.

The tandem rotor system only carries the weight of the cargo. The rotor controls can be similar to standard tandem helicopter rotor controls.

Patent Figure 1A is a profile view of the Boeing helistat. The non-rigid (blimp) gas envelope (10) is partially enclosed by a rigid structural shell (50) that supports the engines (100), tandem rotors (200), cockpit (52) and retractable landing gear (54). The propulsion train consists of tandem rotors (200), two engines (200), two transmissions (120) and drive shaft (140) to deliver power to the front transmission and rotor. The cargo (20) is carried as an external sling load suspended by cables (32) from four cargo hooks (30) on the rigid structural shell.

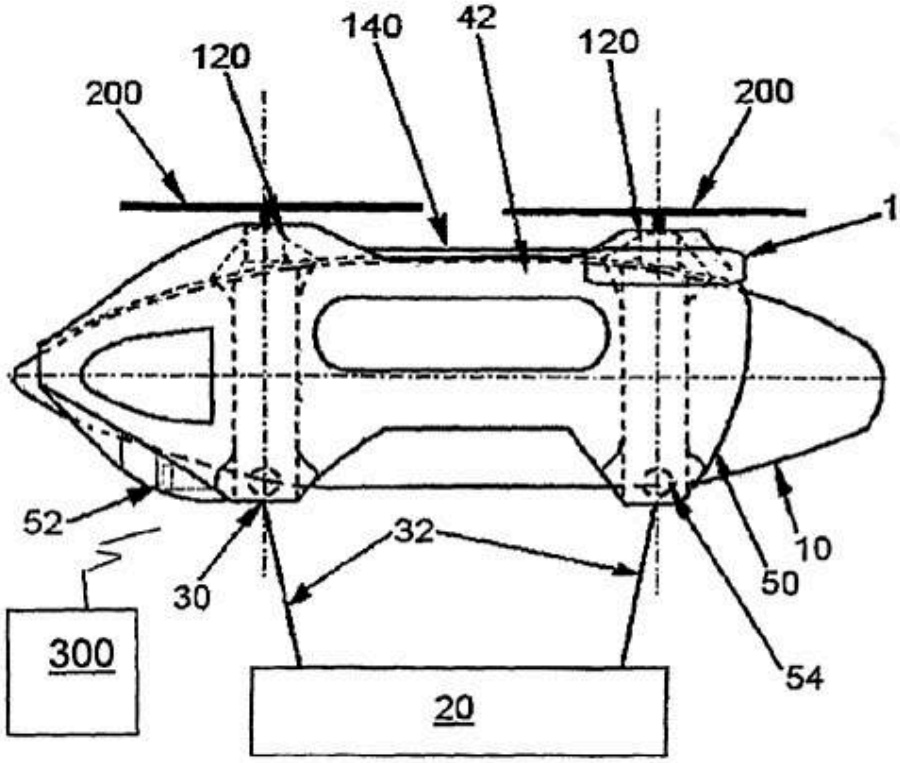


FIG. 1A

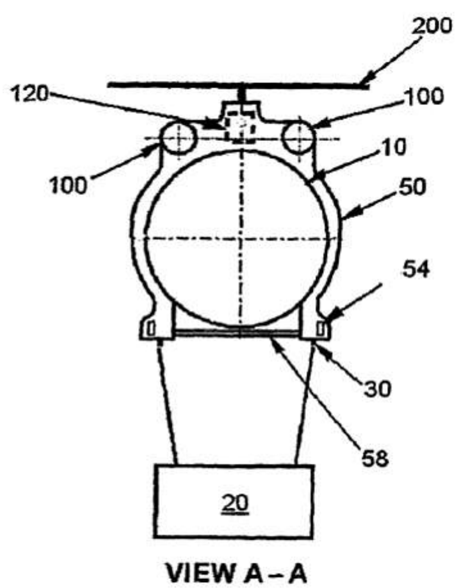


FIG. 1B

Patent Figure 1b is a cross-section view of the Boeing helistat. The gas envelope (10) is shown inside the rigid structural shell (50). The twin engines (100) flank the rear rotor (200). The cargo (20) is suspended by cables from four cargo hooks (30).
The gas envelope was expected to have an operating life of about 10 years with only minor maintenance.

Boeing did not build this helistat design.

7. For more information

- Mark Ardema, “Missions and Vehicle Concepts for Modern, Propelled, Lighter-Than- Air Vehicles,” NASA Technical Memorandum 86672, December 1984: https://ntrs.nasa.gov/api/citations/19850008448/downloads/19850008448.pdf
- Anthony J. Dolman, “Current and Possible Future Developments in Lighter-Than-Air (LTA) System Technology,” United Nations Industrial Development Organization (UNIDO), 1987: https://open.unido.org/api/documents/4793600/download/CURRENT%20AND%20POSSIBLE%20FUTURE%20DEVELOPMENTS%20IN%20LIGHTER-THAN-AIR%20
- M.Y. Arie, “Dirigibles” (in Russian), Publishing House "Naukova Dumka", Kiev, Ukraine, 1986

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