Goodyear Aerospace Corp. - Quad-rotor heavy-lift helistats

Peter Lobner, updated 8 March 2022

1. Introduction

Goodyear Aircraft Corp. became Goodyear Aerospace Corp. (GAC) in 1963 and, over the next 25 years, continued the company's legacy of developing many different types of airships.

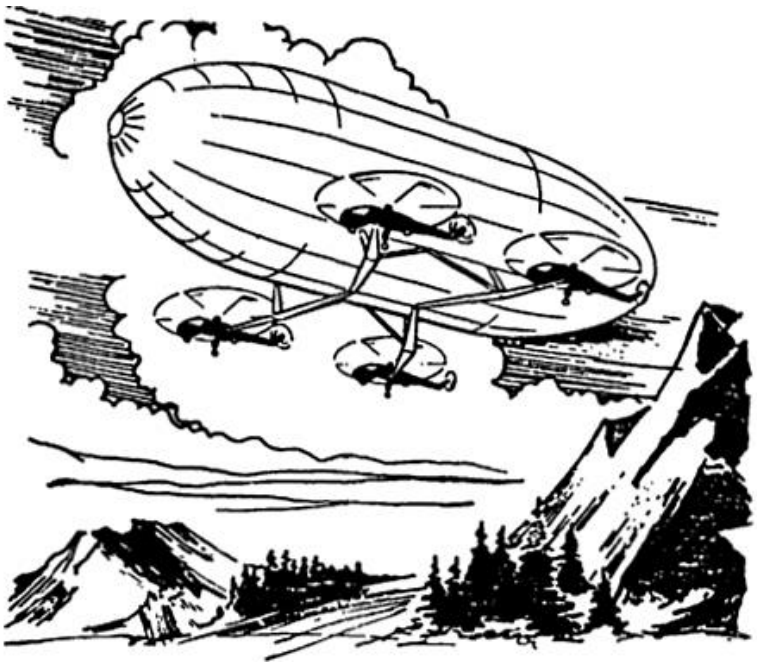
In 1975, the National Aeronautics and Space Administration (NASA) initiated a study called "Feasibility of Modern Airships – Phase I," and continued with additional Navy sponsorship for Phase II in 1976 – 77. Goodyear Aerospace was a contractor in both phases. In Phase II, Goodyear developed conceptual designs for a heavy-lift, quad-rotor helicopter / airship hybrid (a helistat) that could be scaled to carry external sling loads from 50 to 150 tons.

The aerostatic lift of the large gas envelope carries the empty weight of the helistat. The four fixed helicopter rotors were attached to a rigid frame beneath the gas envelope. The dynamic lift from the rotor system carries the weight of the load, including the weight of the payload, crew and fuel. The rotor system also provided flight control for vertical takeoff and landing (VTOL), hover and cruise flight.

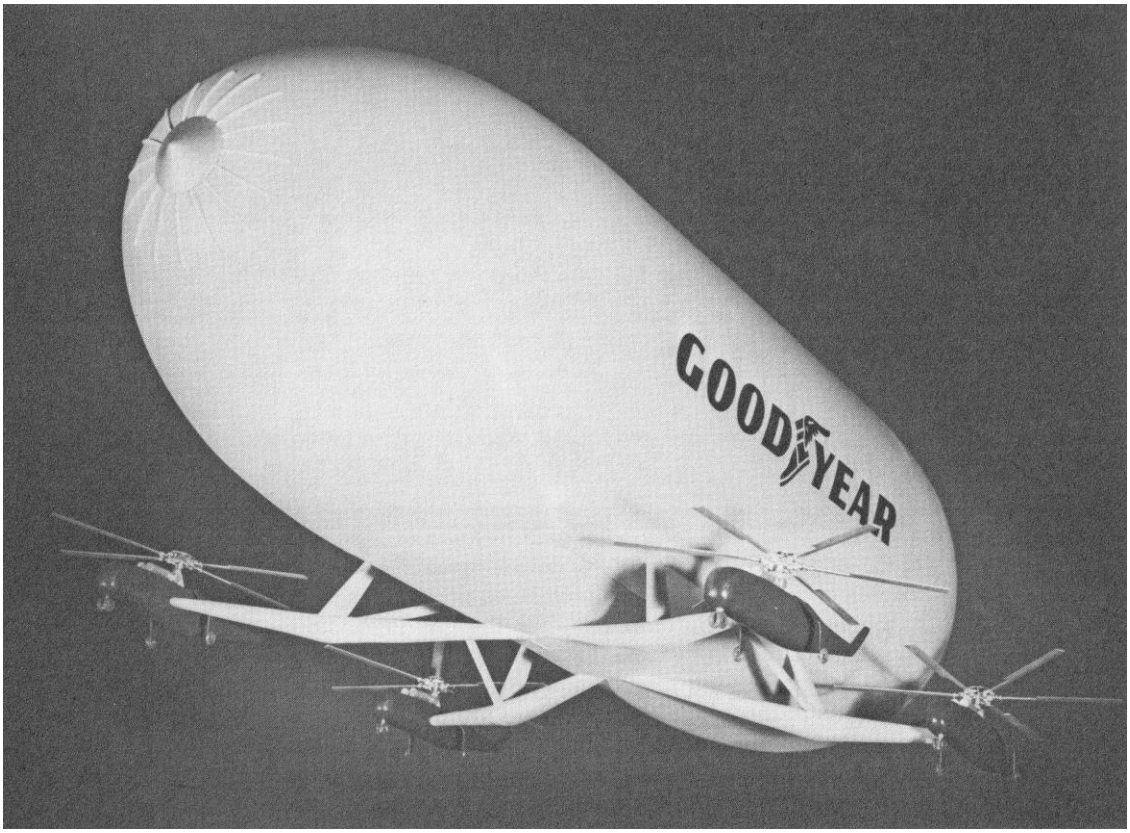
After the NASA / Navy Phase II study, Goodyear continued developing their HLA helistat design for about a decade.

2. The heavy-lift quad-rotor

The basic configuration of the Goodyear's Phase II HLA helistat was quite similar to contemporary Piasecki helistat designs. Goodyear's initial design used the largest helicopters available, the Sikorsky CH-54B Flying Crane. As shown in the following diagram, four whole CH-54B helicopters were attached by outriggers to a rigid frame under the lifting gas envelope. The helicopters were retained in their operational configuration to the extent practical in order to minimize the cost of the first HLA demonstration vehicle.

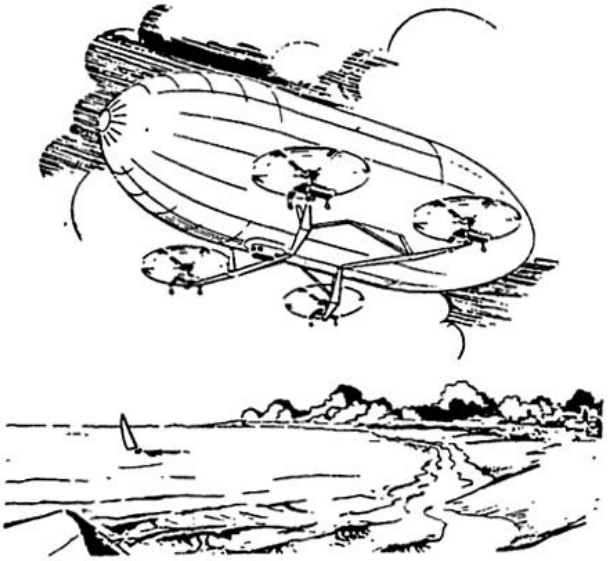


Goodyear's initial design concept for the HLA helistat, with four Sikorsky CH-54B helicopters in their operational configuration.
Source: NASA CR-151917 (1976)



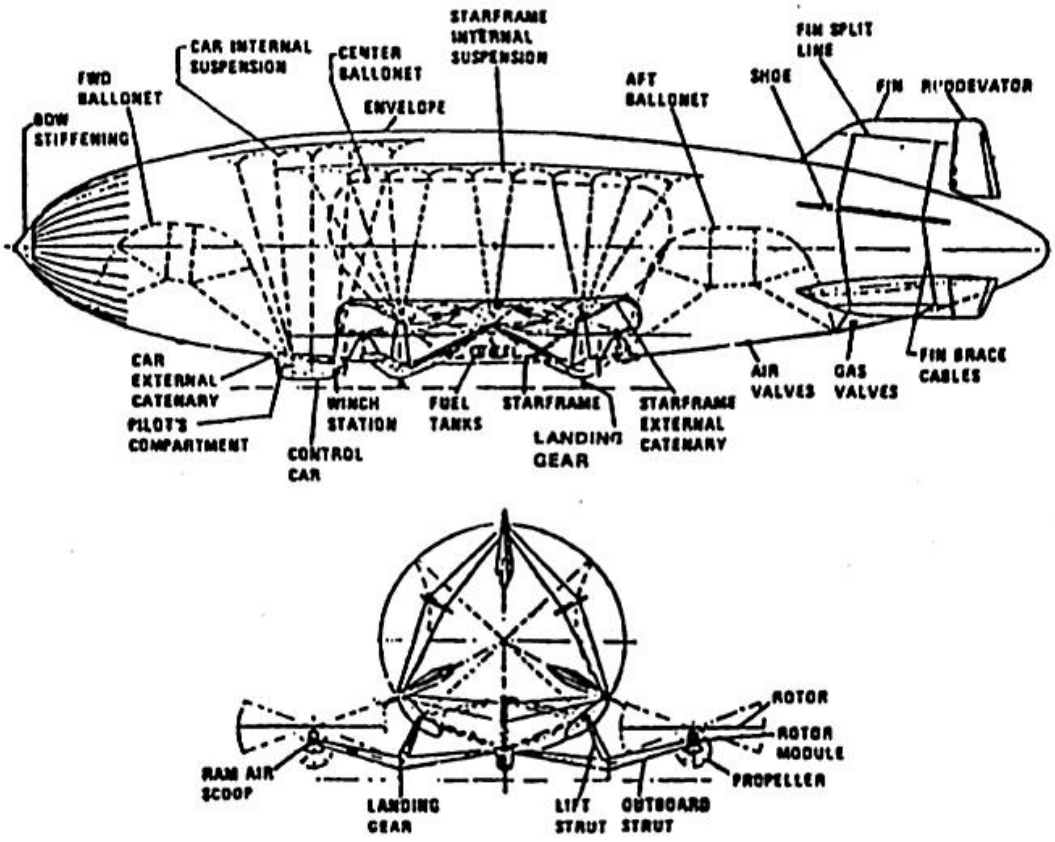
A model of the initial Goodyear Aerospace HLA helistat design concept circa 1976, with four CH-53B helicopters mounted on rigid frames under the gas envelope.
Source: Goodyear Aerospace via Airships for the Future (1976)

The helistat was controlled from the aft left helicopter by a command pilot. In addition to manual operating modes, the fly-by-wire control system offered automatic flight control and hover modes, with the hover capability enhanced by a Precision Hover Sensor System.



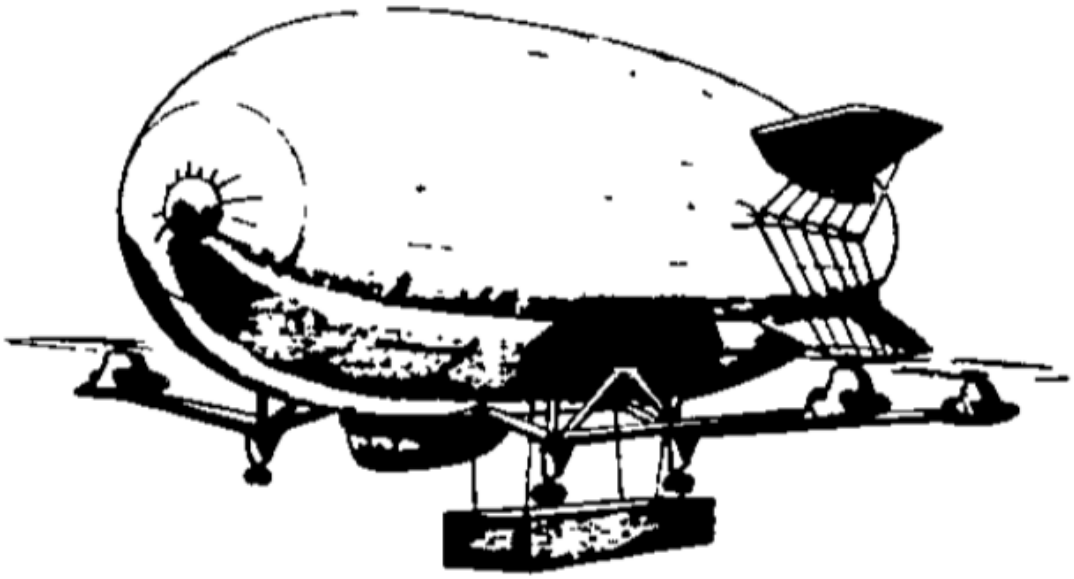
In the Phase II study, Goodyear anticipated that a production helistat would replace the helicopters with more compact, streamlined rotor installations, as shown in this Phase II diagram.

Source: NASA CR-151917 (1976)



Goodyear Aerospace HLA helistat cut-away drawing. Note separate rotors and propellers. UNIDO (1983)

By 1979, it was reported that the Goodyear Aerospace R&D funded airship programs were focused on heavy-lift airships and maritime patrol applications. The later Goodyear HLA helistat design concepts separated the functions of lift and propulsion by adding auxiliary horizontal-thrusting propellers for propulsion. These were shaft-driven from the associated engine modules that drive the rotors. The complete propulsion modules were optimized for high reliability and low maintenance and were de-rated relative to comparable, lighter weight, higher performance helicopter propulsion systems.



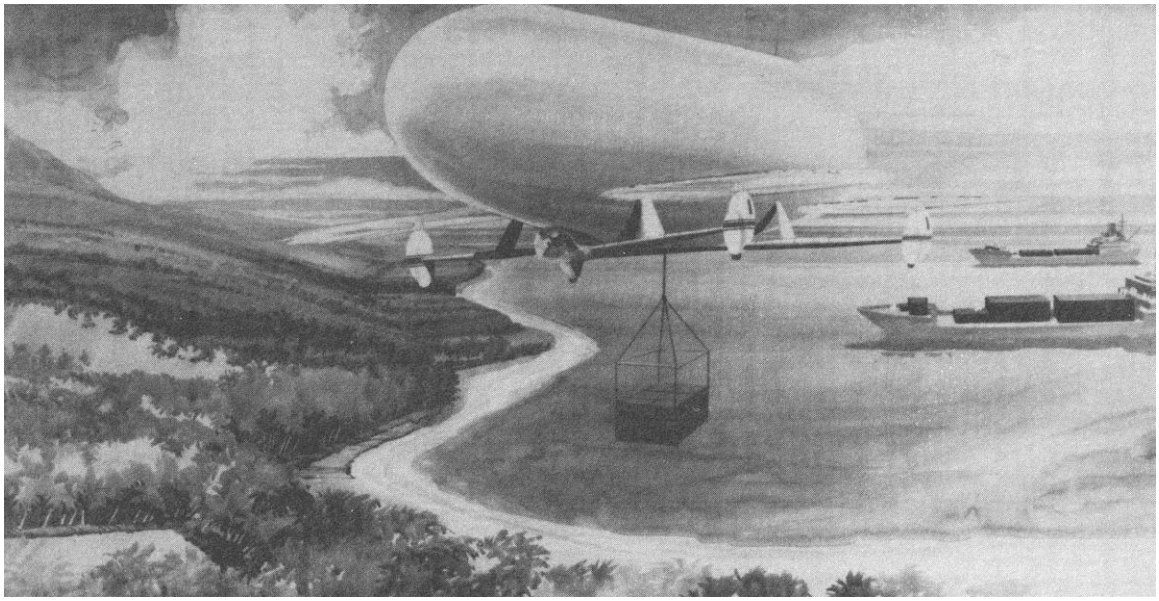
Goodyear Aerospace 1979 concept for a quad-rotor HLA helistat with separate rotors and auxiliary horizontal-thrusting propellers for propulsion. Source: AIAA Paper 79-1611 (1979) via NASA Technical paper 1921 (1981)

In operation, the aerostatic lift from the gas envelope would approximately balance the empty weight of the helistat. The rotors provide all the lift to carry a load up to 24 metric tons (26.4 tons). Just like with a helicopter, the HLA helistat load exchange is managed entirely by modulating the dynamic lift of the rotor system. There is no exchange of ballast during a load exchange. Since the lift gas carries the helistat's empty weight, Goodyear claims that the helistat can carry about twice as much payload as a helicopter for the same amount of fuel.

General characteristics of the Goodyear Aerospace HLA Helistat

Parameter	Goodyear Aerospace HLA helistat
Envelope length	136 m (446 ft)
Envelope diameter	33 m (108 ft)
Envelope volume	73,600 m^3 (2,600,000 ft^3)
Vehicle width	70 m (230 ft) overall, 53 m (174 ft) rotors folded
Vehicle height	38 m (125 ft) overall
Empty weight	about 59,874 kg (132,000 lb)
Ballonets	4 total (1 x fore, 1 x aft & 2 x lateral center)
Ballonet volume	18,400 m^3 (650,000 ft^3), 25% of envelope volume
Helium lift	about 58,512 kg (129,000 lb) @ 75% of envelope volume
Dynamic lift (payload)	24,000 kg (52,911 lb) from four rotors
Max. speed	120 kph (75 mph), limited by sling load

Goodyear Aerospace quad-rotor HLA helistat model, circa 1980. Source: Hochstettler, Modern Airships presentation



Rendering of a Goodyear Aerospace quad-rotor HLA helistat unloading off-shore ships. Source: Goodyear Aerospace via The Complete Book of Airships (1980)

Goodyear estimated that the development cost of the HLA helistat would be more than $150 million for the first vehicle, including a two-year, $20 million design and development phase. In production, Goodyear's target price was expected to be about $30 million, but that would depend on the number of ships produced. In their 1978 Alberta Study, Goodyear estimated that HLA helistat operating costs would be on the order of $6,000/hr for heavy lift operations and $ 4,800/hr for ferry flights.

3. The Twilight of Goodyear Aerospace Corp.

Goodyear Aerospace did not develop the quad-rotor HLA helistat.

In 1987, Goodyear Aerospace Corp. was sold to Loral Corp. and became a defense systems business unit in Loral until 1993, when it was sold to Lockheed Martin along with the rights to the former Goodyear blimp and airship designs.

In 2011 the Goodyear Tire & Rubber Company replaced its aging fleet of Goodyear Aerospace Corp. GZ-20A non-rigid airships (blimps) with modern Zeppelin NT model LZ N007-101 semi-rigid airships.

4. For more information

- "Feasibility study of modern airships, Phase II, Volume 1 - Heavy lift airship vehicle. Book 1: Overall study results," NASA CR-151917, Goodyear Aerospace Corporation, 1 September 1976: https://ntrs.nasa.gov/api/citations/19770016112/downloads/19770016112.pdf
- "Feasibility study of modern airships, Phase II, Volume I, Heavy lift airship vehicle, Book II: Appendices to Nook I," NASA CR-151918, Goodyear Aerospace Corporation, 1 September 1976: https://ntrs.nasa.gov/api/citations/19770016113/downloads/19770016113.pdf
- Mark Ardema, "Vehicle Concepts and Technology Requirements for Buoyant Heavy-Lift Systems," NASA Technical Paper 1921, Ames Research Center, 1981: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19810022643.pdf
- Anthony J. Dolman, "Current and Possible Future Developments in Lighter-Than-Air (LTA) System Technology," United Nations Industrial Development Organization (UNIDO), 1983: https://open.unido.org/api/documents/4793600/download/CURRENT%20AND%20POSSIBLE%20FUTURE%20DEVELOPMENTS%20IN%20LIGHTER-THAN-AIR%20

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