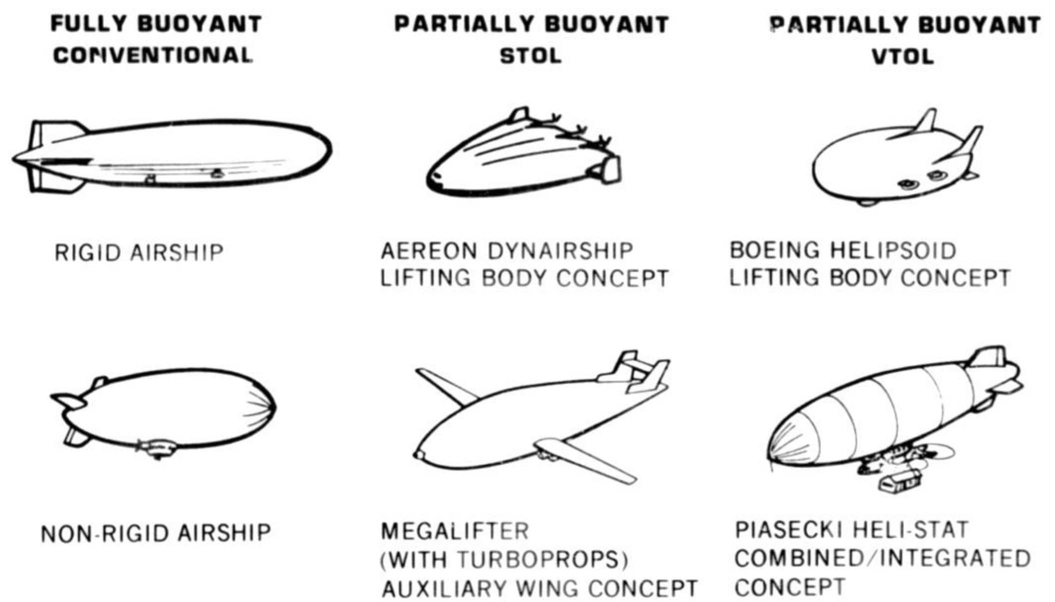
Boeing Vertol - Helipsoid

Peter Lobner, updated 12 February 2022

1. Introduction

In 1975, NASA sponsored a study named Feasibility of Modern Airships – Phase I with Goodyear Aerospace Corp. and Boeing Vertol Company as contractors performing studies of civilian roles for lighter-than-air (LTA) craft. Boeing Vertol examined the performance of the following six airship concepts on three civil transportation mission profiles: short range, transcontinental and intercontinental.



PARAMETER \ MISSION	SHORT RANGE	TRANSCONTINENTAL	INTERCONTINENTAL
RANGE (STILL AIR)	300 NM (556 km)	2,000 NM (3,704 km)	5,000 NM (9,260 km)
CRUISE ALTITUDE	2,000 ft ISA (610 m ISA)	13,000 ft ISA (3,962 m ISA)	2,000 ft ISA (610 m ISA)
CRUISE SPEED*	50, 100, 200 kt (25.7, 51.4, 102.9 m/s)	50, 100, 200 kt (25.7, 51.4, 102.9 m/s)	50, 100, 200 kt 25.7, 51.4, 102.9 m/s
RESERVES	50 NM (93 km) DIVERSION & 10% INITIAL FUEL	250 NM (463 km) DIVERSION & 10% INITIAL FUEL	250 NM (463 km) DIVERSION & 10% INITIAL FUEL
DESIRED PAYLOAD	50–100 TONS	50-100 TONS	100 TONS
DESIGN ALTITUDE (FOR HULLS, PROP/ ROTORS AND ENGINE SIZING)	5,000 ft ISA (1,524 m ISA)	15,000 ft ISA 4,572 m ISA	5,000 ft ISA (1,524 m ISA)

*CRUISE SPEED AT CRUISE ALTITUDE

Source: NASA report NASA CR-137691, Vol. I (1975)

The Boeing Vertol team study reported: “In every mission case analyzed, except for the 5,000 n.mi. range intercontinental mission, the Helipsoid concept appears superior by a wide margin and is therefore selected as the vehicle concept demonstrating the highest potential for a future airship.” The transcontinental freight mission, initially carrying a 50 ton (45,359 kg, 45 metric tons) payload over 2,000 n.mi. (3,704 km) was established as the most promising airship mission.” A conventional non-rigid airship performed best on the intercontinental mission.

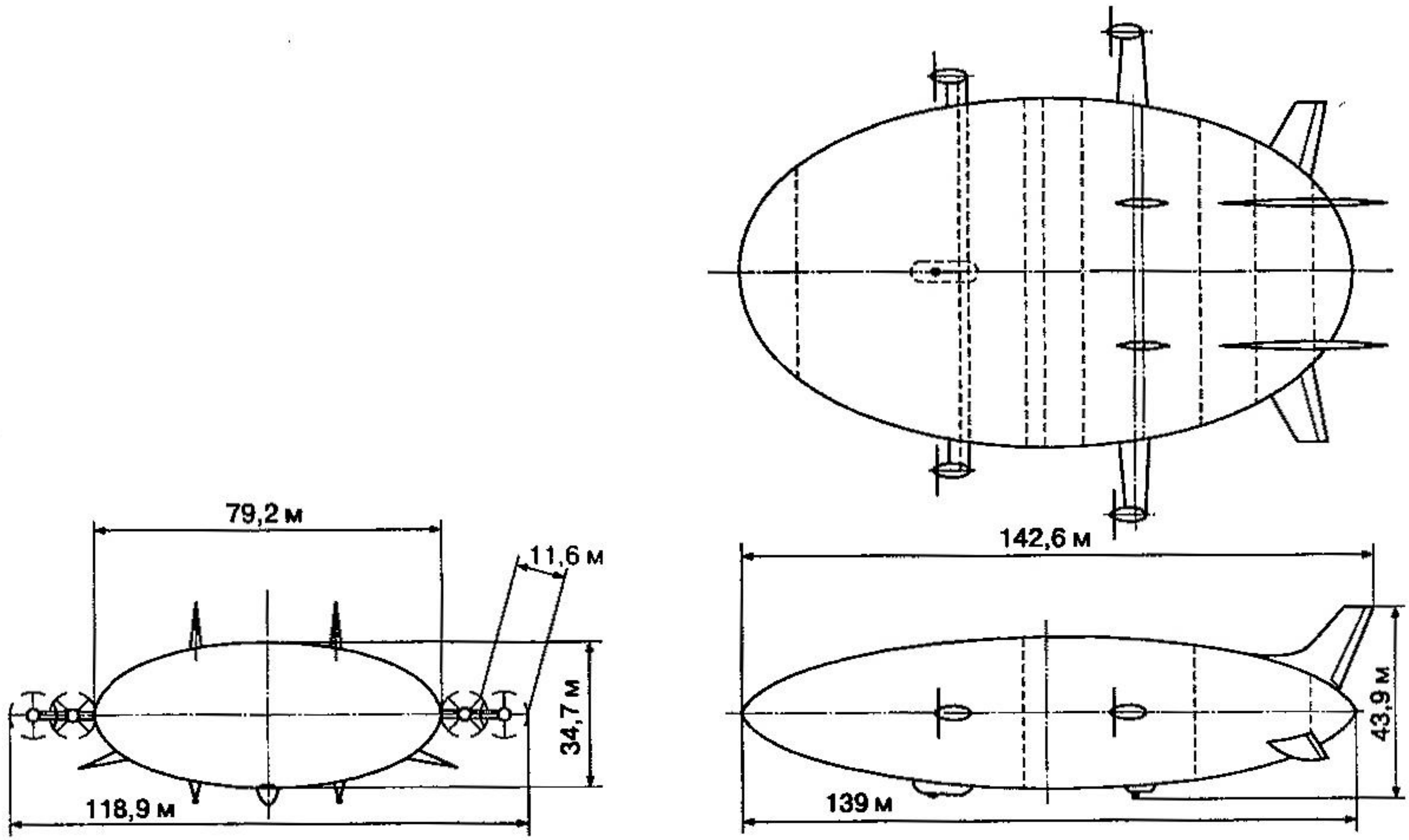
The study team concluded: “A partially buoyant lifting body concept such as the Helipsoid selection can provide superior productivity over all other concepts evaluated. In addition, a partially buoyant Helipsoid concept of the optimum buoyancy ratio has the potential to solve the critical problems facing a future airship development program, such as:

- Ballast and ballast recovery
- Low-speed controllability
- Susceptibility to wind / gusting
- Weather / icing constraints
- Ground handling / hangaring
- Direct / indirect operating costs

The team recommended that further study of the Helipsoid be included in Phase II of the NASA study. It was not.

2. Helipsoid airship design and performance

The Helipsoid is a large, semi-rigid airship with a broad elliptical, lifting body gas envelope. The airship is propelled by four powerful, vectoring prop / rotors extending horizontally on stub wings from the midplane of the envelope. The vectoring prop / rotors function as large diameter propellers in the horizontal (cruise) position and, when rotated to the vertical position, function as helicopter-type rotors with collective control of dynamic lift in slow speed and vertical flight. The lifting body hull generates aerodynamic lift in forward flight and aerodynamic flight controls are provided by twin rudders and horizontal tail planes.



Helipsoid airship general arrangement and scale for an envelope volume of 200,000 m^3 (7,063,000 ft^3). Source: Boyko (2001)

The semi-buoyant Helipsoid was evaluated at buoyancy ratios (static buoyancy / max. gross weight) ranging from 30% to 75% (low to moderate buoyancy). Like the semi-buoyant Aereon Dynairship and the Ohio Airships Dynalifter, a Helipsoid can fly almost like a short takeoff and landing (STOL) fixed-wing aircraft. On the ground, it is relatively unaffected by light-to-moderate wind and gust effects and can taxi unassisted to a parking spot and be quite stable on the ground without the need for a ground crew.

With its powerful prop / rotors, the Helipsoid can, within certain gross weight limits, hover and make vertical takeoffs and landings (VTOL) with precise dynamic lift control.

Regarding ballast compensation and load exchanges, the Boeing Vertol team claimed: "Since weight losses due to fuel burnoff can be counteracted by aerodynamic trimming in cruise flight and prop/rotor collective pitch in low speed flight, no water recovery apparatus will be required. In addition (depending on the mission optimization), transfer of payload may also be accomplished without ballast - replacement systems."

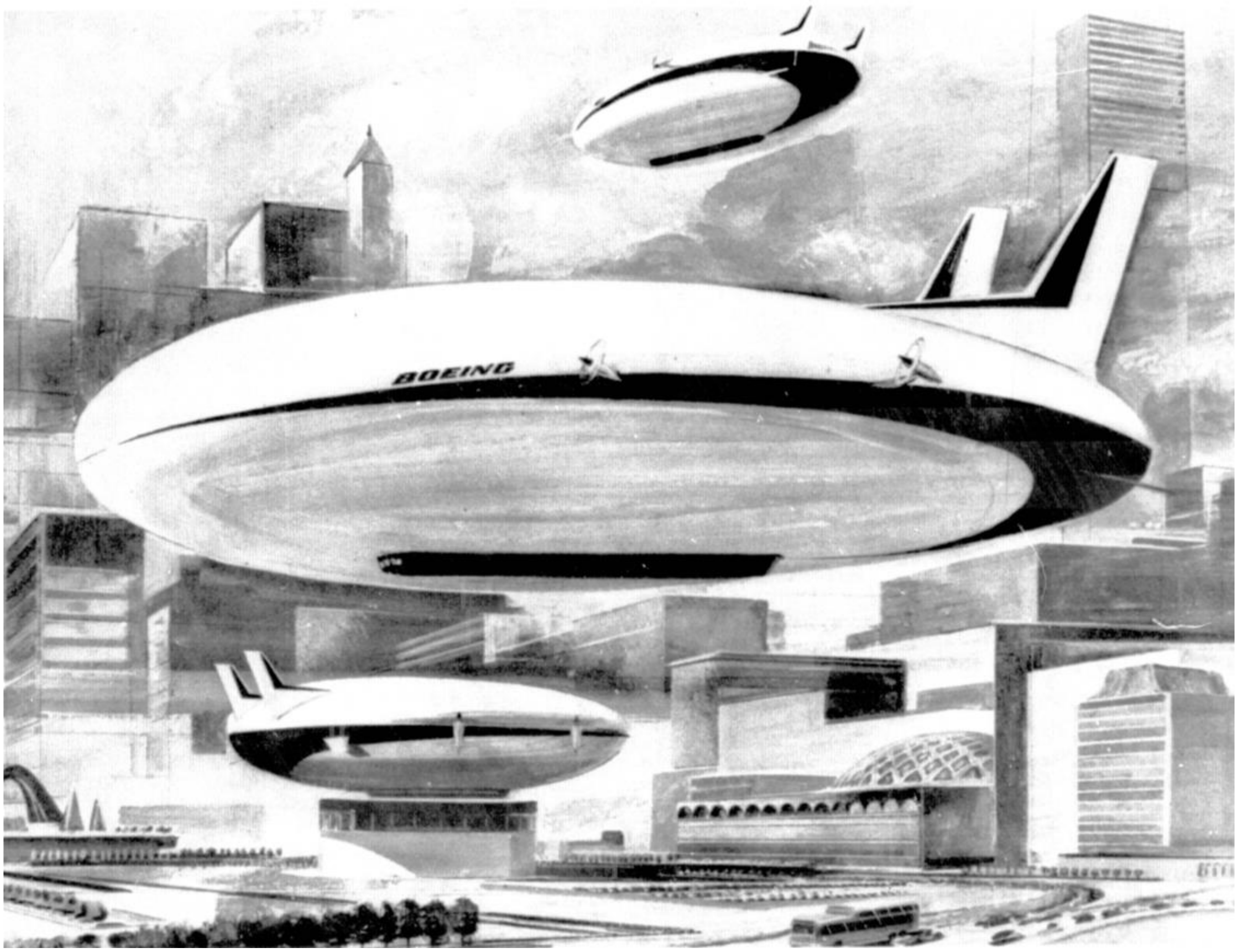
3. Parametric analysis

Using a computer code named CASCOMP (Comprehensive Airship Sizing and Performance Computer Program), the Boeing Vertol team performed the parametric analyses of six airship designs operating on three civil transportation mission profiles and several other Coast Guard and military mission profiles.

Commuter passenger service

This commuter airship concept assumed a 200 passenger, semi-buoyant, short-range Helipsoid commuter airship with a buoyancy ratio of 67%. Approximate volume was 2,000,000 ft^3 (57,000 m^3). The dynamic lift from the vectoring turboprop engines enable vertical takeoff and landing (VTOL).

With relatively frequent stops, the flight altitude is only 330 ft (100 m). The pilot-optional vehicle follows a fixed route lane guided by ground-located electronic beams sending signals to the autopilot in the airship. Each passenger station consists of a platform at an elevation of 66 ft (20 m) above the ground, with a staging area to enable rapid passenger debarkation and loading.



Helipsoid airship in commuter airline service.
Source: NASA CR-137691, Volume I (1975)

A fleet of 66 commuter airships with a maximum cruise speed of 100 mph (161 kph) would be required to deliver a traffic volume of 10,000 passengers per hour.

Navy missions

Several Navy missions were considered, including anti-submarine warfare (ASW) and airborne early warning (AEW) missions, much like those performed by the N-class blimps (ZPG-1, -2, -2W and -3W) from the mid-1950s until the Navy's LTA program was terminated in

1961. The ZPG-3W remains the largest non-rigid airship that has ever flown.

Coast Guard missions

USCG missions of interest were coastal surveillance with endurance up to 10 – 14 days, heavy utility with a broad trade-off between payload and range, and special missions with remotely-piloted LTA vehicles.

Example Helipsoid design parameters

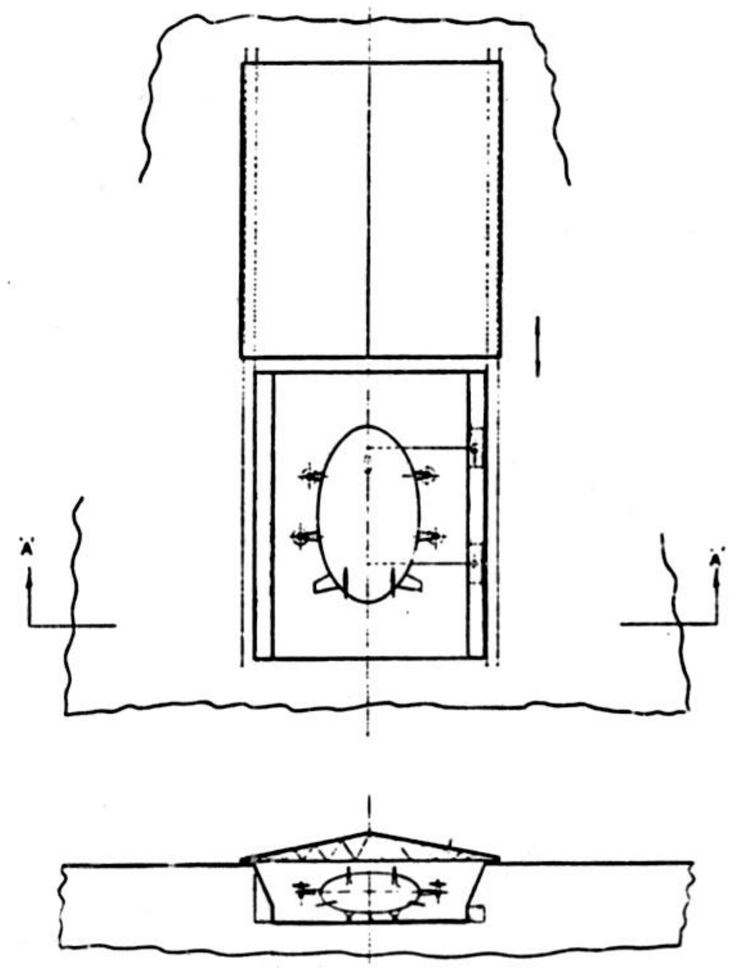
The CASCOMP parametric analysis produced the following results that are an example of Helipsoid characteristics tailored for selected civil passenger and a Coast Guard missions.

	Passenger Mission (Payload 100,000#)		USCG (Short) ATN MSN (Payload 50,000#)	
Buoyancy Ratio →	.5	.7	.5	.7
Volume ft^3 (m^3)	2.45×10^6 (69.384×10^3)	2.56×10^6 (72.499×10^3)	1.10×10^6 (31.152×10^3)	1.05×10^6 (29.736×10^3)
Gross Lift lb (kg)	274,068 (124,317)	287,068 (130,214)	123,190 (55,879)	119,190 (54,065)
Empty Wt lb (kg)	128,000 (58,061)	145,000 (65,772)	50,000 (22,680	51,000 (23,134)
Mission Fuel lb (kg)	42,000 (19,051)	38,000 (17,237)	18,000 (8,165)	13,000 (5,897)
Installed Power HP	14,100	11,500	8,700	7,000
Length ft (m)	322 (98.1)	369 (112.5)	254 (77.4)	289 (88.1)
Width (Span) ft (m)	184 (56.1)	209 (63.7)	147 (44.8)	164 (50.0)

Source: NASA CR-137691, Volume I (1975)

4. Novel airship hangar design concept

The Boeing Vertol team developed a concept for a below-grade hangar with a sliding roof structure. With some limitations on its maximum weight, the Helipsoid should be able to operate as a VTOL craft and land into and takeoff directly from the hangar. The relatively low profile of the ellipsoid hull (relative to a conventional cylindrical hull) reduces the below-grade depth of the hangar.



Below grade airship hangar with sliding roof, designed for vertical takeoff and landing.
Source: NASA CR-137691, Volume I (1975)

5. For more information

- "Feasibility Study of Modern Airships – Phase I, Volume I – Summary and Mission Analysis," NASA CR-137691, Volume I, Boeing Vertol Company, May 1975: [NASA Technical Reports Server (NTRS) 19750024930: Feasibility study of modern airships, phase 1, volume 1. [structural design criteria/technology assessment]()
- "Description of CASCOMP – Comprehensive Airship Sizing and Performance Computer Program," NASA CR-137691, Volume II, Boeing Vertol Company, May 1975: https://core.ac.uk/download/pdf/42887077.pdf

* Y.S. Boyko, “Aeronautics: Tethered, Free, Managed,” p. 352 (in Russian), ISBN 5.8122-0233-8, Publishing house MGUP, Moscow, Russia, 2001

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