Boeing – Megalifter semi-buoyant aircraft and sub-scale model

Peter Lobner, 27 February 2025

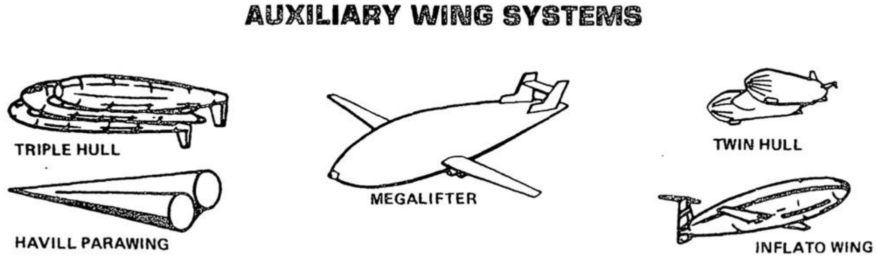
1. Introduction

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. The following six categories of airships were considered in the NASA study:

- Fully buoyant, conventional
  - Rigid airships
  - Non-rigid airships
- Partially buoyant, vertical takeoff and landing (VTOL), hybrid
  - Lifting body concepts
  - Combined / integrated concepts
- Partially buoyant, short takeoff and landing (STOL), hybrid
  - Lifting body concepts
  - Auxiliary wing concepts

Airship designs selected to represent each of the six categories were evaluated on three different mission profiles, short-range, transcontinental and intercontinental, with the airship sized for two different payloads, 50 and 100 tons (45.4 and 90.7 metric tons).

The Megalifter was one of the potential candidates included in the partially-buoyant, STOL auxiliary wing category. Other contenders in this category are shown in the following graphic.



Source: NASA CR-137691, Vol. I, Fig. 5-4 (1975)

The particular mission profiles are summarized in the following table.

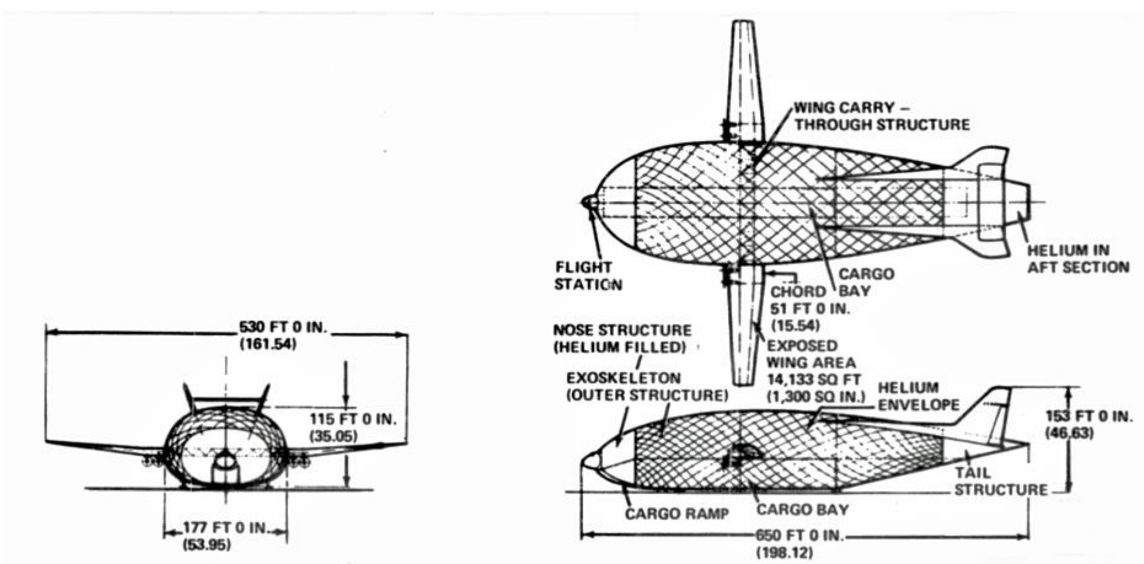
PARAMETER \ MISSION	SHORT RANGE	TRANSCONTINENTAL	INTERCONTINENTAL
RANGE (STILL AIR)	300 NM (556 km)	2,000 NM (3,704 km)	5,000 NM (9,260 km)
CRUISE ALTITUDE	2,000 ft ISA (610 m ISA)	13,000 ft ISA (3,962 m ISA)	2,000 ft ISA (610 m ISA)
CRUISE SPEED*	50, 100, 200 kt (25.7, 51.4, 102.9 m/s)	50, 100, 200 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 CR-137691, Vol. I (1975)

The Phase I initial screening led to the selection of the Megalifter to represent the partially-buoyant, STOL auxiliary wing category.

2. The NASA-sponsored 1975 analysis of the Megalifter concept

The Megalifter semi-buoyant STOL aircraft in the NASA-sponsored study was based on the "guppoid-shaped" concepts developed in 1972 by Frank M. Clark and the Megalifter Company. One such design concept is shown in the following diagram.

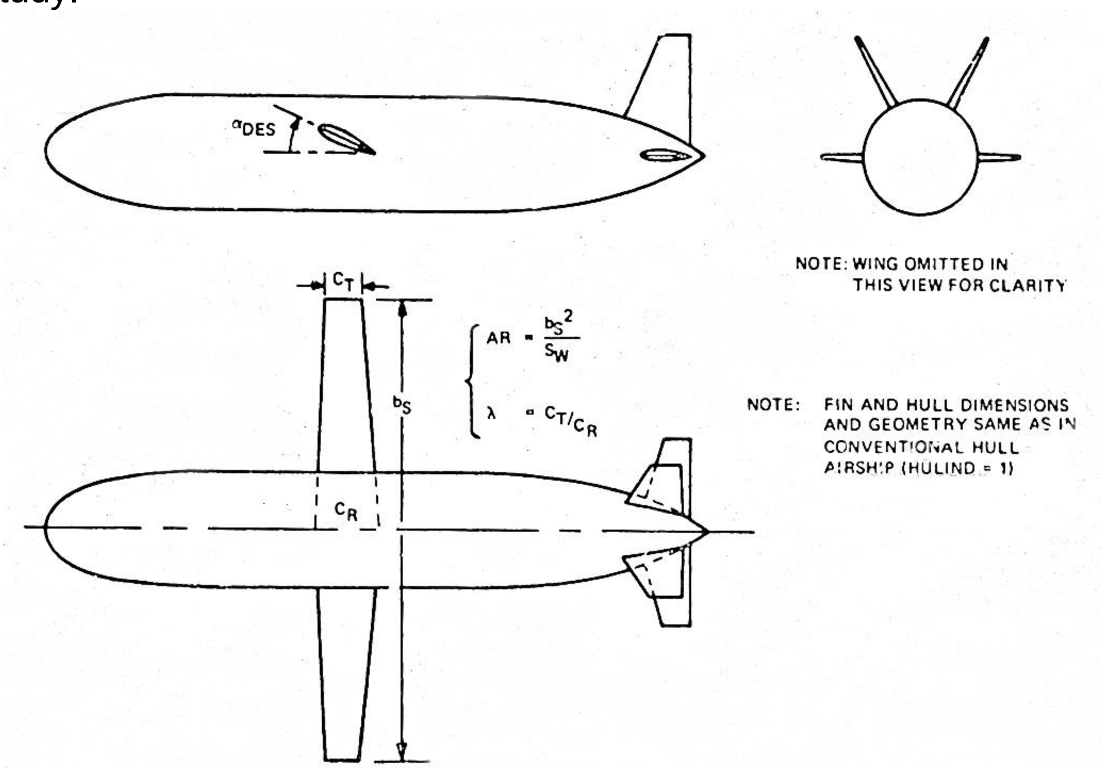


Three-view diagram of a Frank M. Clark Megalifter concept.
Source: NASA CR-137691, Vol. 1, Fig. 5-48 (1975)

The Boeing Vertol analysts noted:

> “The hull may be shaped as shown (in the previous diagram) or may be that of a conventional rigid type (airship). However, structural integration of the large, lightly-loaded, light-weight (rigid) space frame of the airship (hull) with a highly-loaded wing providing approximately 50 percent of the lift *is* a major task. Although, superficially resembling an airplane, the fuselage structure must be extremely efficient in the structure weight / wetted area ratio -- about 10 to 15 times better than that of a typical airplane. The pure STOL approach is shown here with turboshaft engines and propellers deployed along the wing. Other layouts are possible if low speed control capability is desired.”

The simple representation of a semi-buoyant Megalifter, with a cylindrical fuselage similar to a conventional rigid airship, was used by Boeing Vertol in the parametric analysis for the NASA feasibility study.



Megalifter general arrangement evaluated in parametric analysis.
Source: NASA CR-137691, Vol. II, Fig. 2-1a (1975)

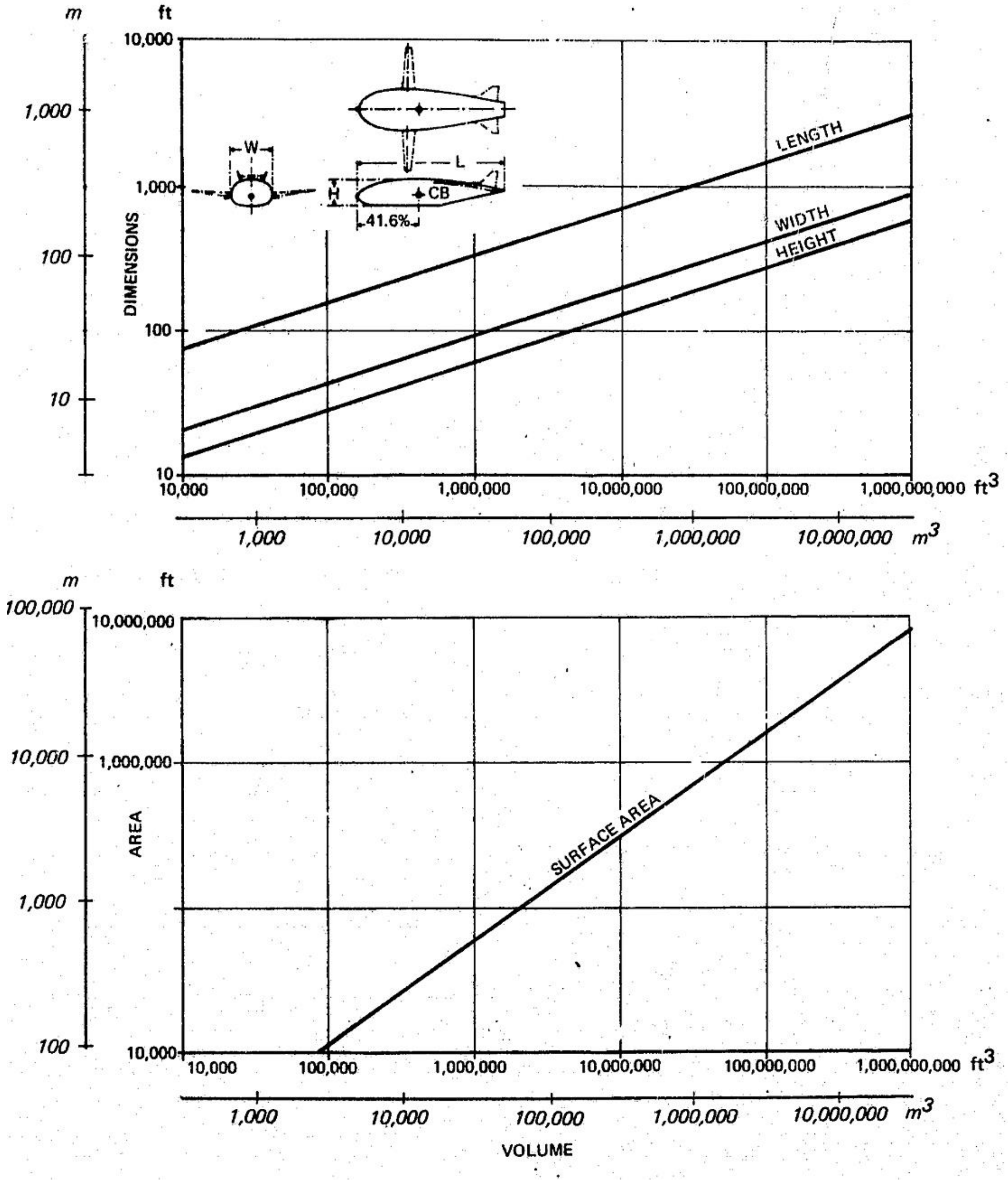
A computer code named CASCOMP (Comprehensive Airship Sizing and Performance Computer Program) was used to perform the parametric analyses of the six airship design concepts operating on the three civil transportation mission profiles and two different cargo loads. For each airship design concept / mission / cargo combination, this analysis developed basic airship scaling parameters and a figure of merit called the Maximum Specific Productivity (PV/E) that was used to establish a relative ranking of the six design concepts. Results for the Megalifter are summarized in the following table and scaling charts.

Optimal results from 1975 Megalifter parametric analysis *

Parameter	Short range mission		Trans-continental mission		Inter-continental mission
	50 ton payload	100 ton payload	50 ton payload	100 ton payload	100 ton payload
Max PV/E ** (Figure-of-merit)	125 knots (64.2 m/s)	180 knots (93 m/s)	90 knots (46.3 m/s)	92 knots (47.3 m/s)	48 knots (24.7 m/s)
Speed for above	200 knots (102.9 m/s)	200 knots (102.9 m/s)	150 knots (77.2 m/s)	154 knots (79.2 m/s)	75 knots (38.6 m/s)
Buoyancy ratio	0.35	0.35	0.35	0.35	0.75
Volume	1,680,000 ft^3 (47,600 m^3)	3,250,000 ft^3 (92,040 m^3)	4,800,000 ft^3 (135,936 m^3)	6,000,000 ft^3 (169,920 m^3)	11,000,000 ft^3 (311,520 m^3)
Gross lift	250,000 lb (114,000 kg)	490,000 lb (222,264 kg)	400,000 lb (181,400 kg)	660,000 lb (299,376 kg)	765,000 lb (347,000 kg)
Length, OA	400 ft (122 m)	500 ft (152.4 m)	570 ft (173.7 m)	610 ft (185.9 m)	745 ft (227.1 m)

* Data from “Feasibility Study of Modern Airships – Final Report – Phase I – Volume I”, CR-137691, Section 6.

**This index is known as Maximum Specific Productivity (PV/E) = (P, payload weight) x (V, speed) / (E, empty weight)



Megalifter scaling study results.
Source: NASA CR-137691, Vol. I, Fig. 5-43 (1975)

Conclusions related to the Megalifter concept are summarized below:

- These are very large air vehicles, with the short range versions measuring 400 – 500 feet (122 – 152.4 m) long, transcontinental versions measuring about 600 feet (183 m) long, and intercontinental versions approaching 750 feet (229 m) long.
- The minimum gross lift required for a specific payload increases with range. This is because the increased fuel required for the longer range increases the gross weight, and correspondingly, the size and drag of the airship.
- There is a rapid increase of power requirements as cruise speed increases. The best speed for maximum PV/E decreased as the range increased.
- The analysis considered two buoyancy ratios, 0.35 and 0.75. The lower buoyancy ratio produces a higher optimum PV/E at the minimum range and a lower optimum PV/E at intercontinental range. The reason is as follows: At short range the low buoyancy ratio is preferred because the airship can fly faster because the fuel requirement is a smaller fraction of the gross lift, resulting in a smaller wing size and weight. At the longer ranges, the fuel required becomes a much larger fraction of the gross lift and is minimized by flying at a significantly lower speed where the drag is reduced. At the lower speed a larger wing is required, necessitating an increase in the buoyant lift of the hull to counter the weight of the larger wing.

The simplified Megalifter model outperformed a conventional rigid airship in all mission profiles based on the computed Maximum Specific Productivity (PV/E) figure-of-merit. The analysis did not take credit for aerodynamic lift developed by the Megalifter's large, guppoid-shaped lifting body fuselage.

In the short-range and transcontinental mission profiles, the Helipsoid and the deltaoid Dynairship significantly outperformed the Megalifter. The NASA Phase I study concluded, "Helipsoid vehicles are selected as the most promising vehicle / mission combination for detailed study in Phase II." There was no further NASA-funded analysis of the Megalifter concept. However, Boeing continued to study the concept, and in the late 1990s, built a subscale flying model of a Megalifter, which is described in the following section.

3. Boeing subscale semi-buoyant Megalifter hybrid aircraft

The Oakland Aviation Museum (OAM) exhibits a dynamically-scaled model of a Boeing heavy-lift, long-range, semi-buoyant air transport concept that has a strong resemblance to the Megalifter concept that Boeing Vertol evaluated in the 1975 NASA-sponsored study.

The scale model originally was built in the late 1990's by William Watson of Simi Valley, California, for The Boeing Company. It has a lightweight, dirigible-style rigid airframe with a high aspect ratio main wing and conventional horizontal and vertical stabilizers and control surfaces. The 1/50th-scale model is 20 feet (6.1 m) long, 14 feet (4.3 m) in wingspan and weighs 21 pounds (9.5 kg). It has a single, tail-mounted propeller and reportedly is ready to fly. OAM reports that the model was first test-flown in July 2000.

The original exterior skin was called Micafilm, which has been out of production for a long time. A heat-activated adhesive was painted on the aerostructure, and then many individual panels of semi-opaque white Micafilm were ironed and heat-shrunk. There were many panels on the nose and tail components due to the compound curves and the inability of the Micafilm to conform to sharp curvature.

In 2022, OAM made the decision to remove the original Micafilm, which was deteriorating and delaminating from the aerostructure. The new covering material is called Doculam, which originally was developed for laminating large documents. It is semi-transparent due to the heat-activated adhesive. When the Doculam is ironed on and heat-shrunk it turns clear. This allows the intricate airframe structure of the Megalifter model to be clearly seen. The OAM restoration was performed under the leadership of Jeff Whitney.

Boeing 1/50th Scale Model Hybrid Aircraft on display at OAM. Source: OAM

Boeing 1/50th Scale Model Hybrid Aircraft on display at OAM. Source: OAM

4. For more information

- "Feasibility Study of Modern Airships – Phase I, Volume I – Summary and Mission Analysis," NASA CR-137691, Section 5.3.1.4, "Guppoid (Megalifter) Concept," Section 5.4.3.4, "Megalifter Parametric Results," and Section 6, "Selection of Vehicle / Mission Candidates," Boeing Vertol Company, May 1975: https://ntrs.nasa.gov/api/citations/19750024930/downloads/19750024930.pdf
- "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

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Aereon Corporation - Dynairship semi-buoyant hybrid aircraft
    - Boeing Vertol – Helipsoid semi-buoyant hybrid airship
    - Megalifter Co. – Megalifter semi-buoyant hybrid aircraft
    - Piasecki Aircraft Corporation (PiAC) - Helistat

- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/