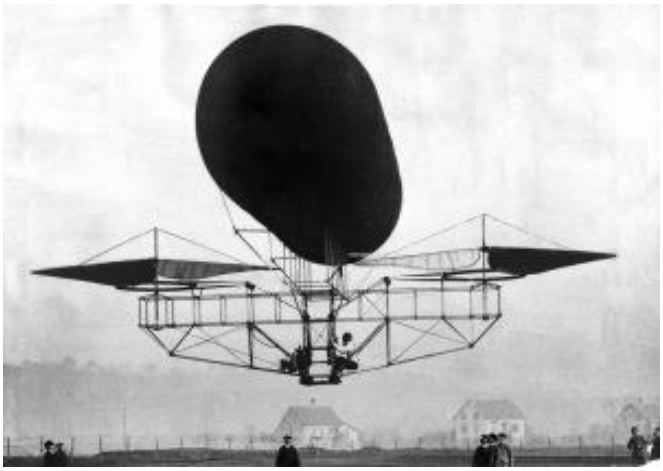
Hélicostats

Peter Lobner, 24 August 2021

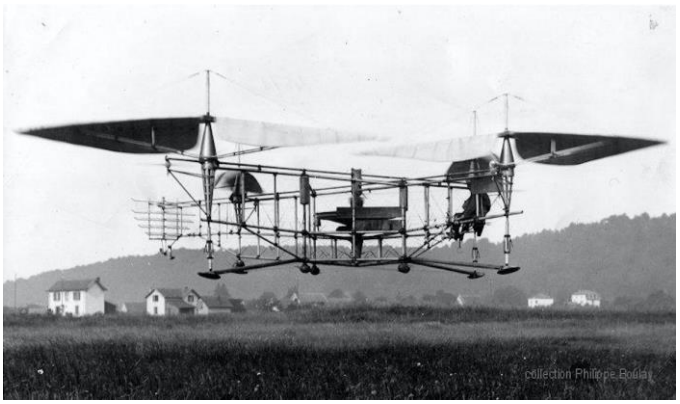
1. Introduction - Étienne Oehmichen and the first Hélicostat

Étienne Oehmichen was a French engineer and pioneering helicopter designer. He made his first successful flight on 18 February 1921 in a helicopter / aerostat hybrid airship of his own design.



Oehmichen's 1921 helicopter / aerostat hybrid with two rotors and a 140 m^3 (4,944 ft^3) hydrogen-filled aerostat for stability and aerostatic lift. Source: IMechE Archive and Library

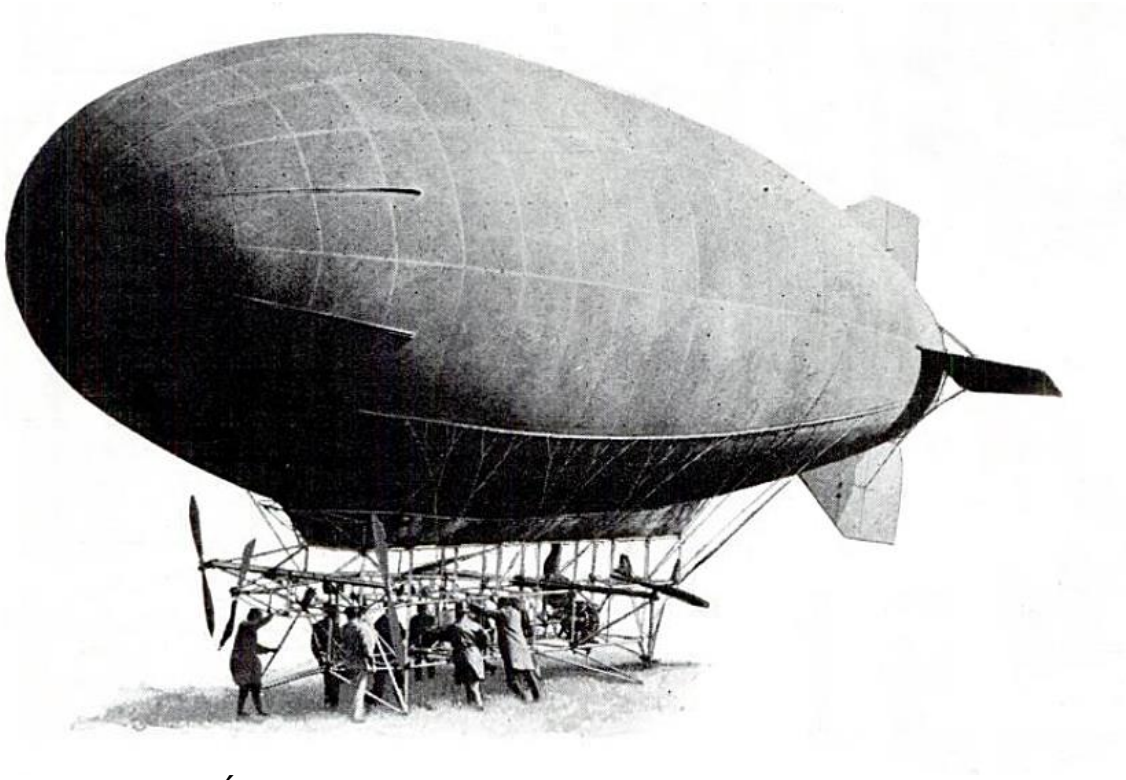
On 4 May 1924, Oehmichen became the first helicopter pilot to complete a triangular closed circuit of approximately 1 kilometer (0.62 mile) at Valentigney, France. The flight took 7 min. 40 sec. in his quad-rotor L'Hélicoptère Nº2, earning a 90,000 French Franc prize.



L'Hélicoptère Nº2, with four rotors and no aerostat, first flew in 1922. Source: Collection Phillipe Boulay via This Day in Aviation

In 1931, Oehmichen flew his fourth machine, a helicopter / aerostat hybrid design he called the Hélicostat. A 550 m^3 (19,423 ft^3) aerostat containing 400 m^3 (14,126 ft^3) of hydrogen provided 50% of the lift. The hélicostat was powered by a 40 hp Salmson engine driving two tractive propellers with variable and reversible pitch, and two

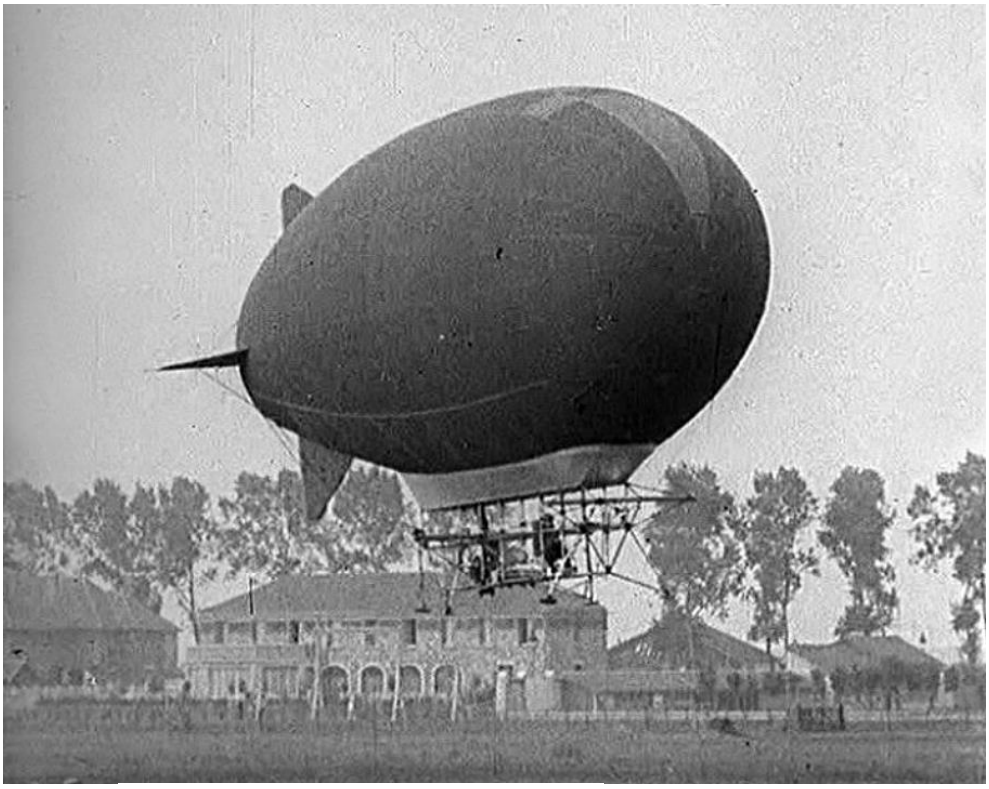
propellers with slanted shafts that provided vertical thrust. The Hélicostat demonstrated good maneuverability and could hover and take off and land without a ground crew. It completed 200 hours of flying in all types of weather, including a 30 minute demonstration of hovering at an altitude of 300 meters (984 ft). This was a much more sophisticated version of his 1921 helicopter / aerostat hybrid airship. Oehmichen's 1931 Hélicostat was the forerunner of modern Hélicostats and helistats.



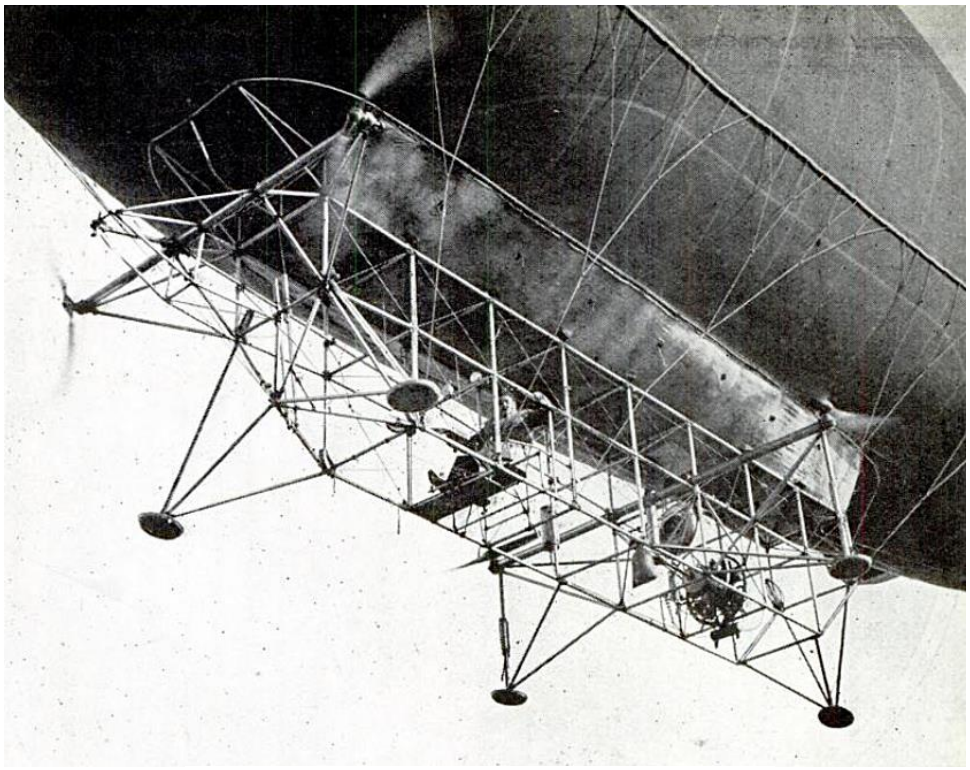
Étienne Oehmichen's 1931 Hélicostat.
Source: Popular Science, Nov. 1931

Oehmichen built a second Hélicostat in 1932. In spite of interest in the Hélicostat based on its demonstrated good performance, no subsequent orders were placed.

This type of craft was not seen again until the 1970s, when there was a general resurgence of interest in lighter-than-air (LTA) craft. In France, this resulted in the creation of the Association d'Etude et de Recherche sur les 'Aeronefs Allgs', or Aerall (http://aerall.org/navigateur.htm), which today is the leading industry advocate for the French airship industry.

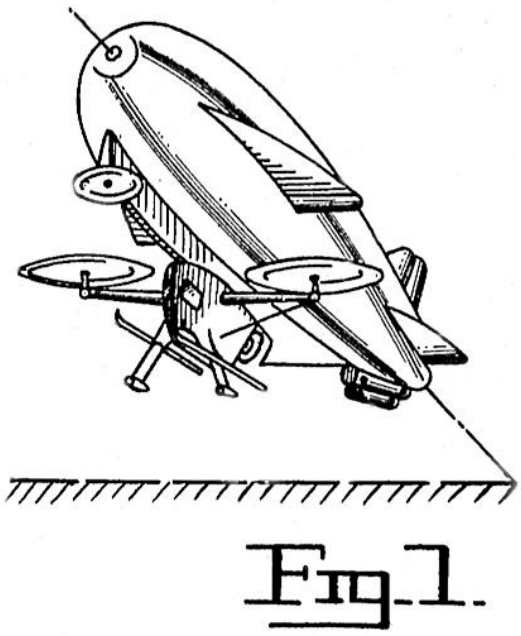


Oehmichen's 1931 Hélicostat in flight ay Orly.
Source: British PATHÉ historical collection



The gondola on the 1931 Hélicostat.
Source: Popular Science, Nov. 1931

On 8 October 1934, Étienne Oehmichen filed a patent application for a helicopter / aerostat hybrid air vehicle in which the gas envelope was filled with air instead of a lifting gas. In the patent application, Oehmichen noted: "The applicant has also found that it is possible to provide an envelope of a shape similar to that of dirigible balloons, which are simply filled with atmospheric air, provided with ailerons, having a suitably selected shape and position, impart to the whole qualities comparable with those of an ordinary aeroplane wing." The highly inclined aerostat shown in patent Figure 1 generated substantial aerodynamic lift, which was supplemented by dynamic lift from a pair of "sustaining propellers." An auxiliary propeller under the nose provided trim control, which also could be accomplished with movable ballast.



This patent was granted on 25 May 1937 as patent US208138A, "Aerial navigation apparatus," which is available at the following link: https://patents.google.com/patent/US2081381

Oehmichen did not fly such a vehicle. However, the general layout, with the substitution of lifting gas for atmospheric air in the aerostat, strongly resembles the layout of several single-hull, twin-rotor Hélicostats almost 40 years later.

3. The modern **Hélicostat, circa 1970s**

In the 1970s, the French aerospace manufacturer Aérospatiale (Aircraft and Helicopter Divisions) developed a range of helicopter / aerostat design concepts that were modern incarnations of Étienne Oehmichen's 1931 Hélicostat. In each, the aerostat carries the empty weight of the hybrid airship while the rotor system carries the variable weight the fuel and a payload that is carried as a sling load, suspended 30 meters or more under the airship. Hélicostat fuel consumption is estimated to be about 40% less than a helicopter carrying a comparable load.

A Hélicostats provides a high level of operational safety. For example, loss of all engines while carrying a full load results in a free-fall velocity of about 15 meters/sec (54 kph, 33.5 mph), limited by the buoyancy and drag of the large aerostat(s). When the suspended payload touches the ground, the Hélicostat vehicle (which is still 30 meters or more above) becomes neutrally buoyant and its descent rate shows quickly. It has been estimated that a Hélicostat would hit the ground at about 4.4 meters / sec (15.8 kph, 9.8 mph), and be cushioned by inflated shock absorbers built into its keel. The pilot also has the option to drop the load, in which case the Hélicostat immediately would be close to neutral buoyancy, with time to locate a safe landing site.

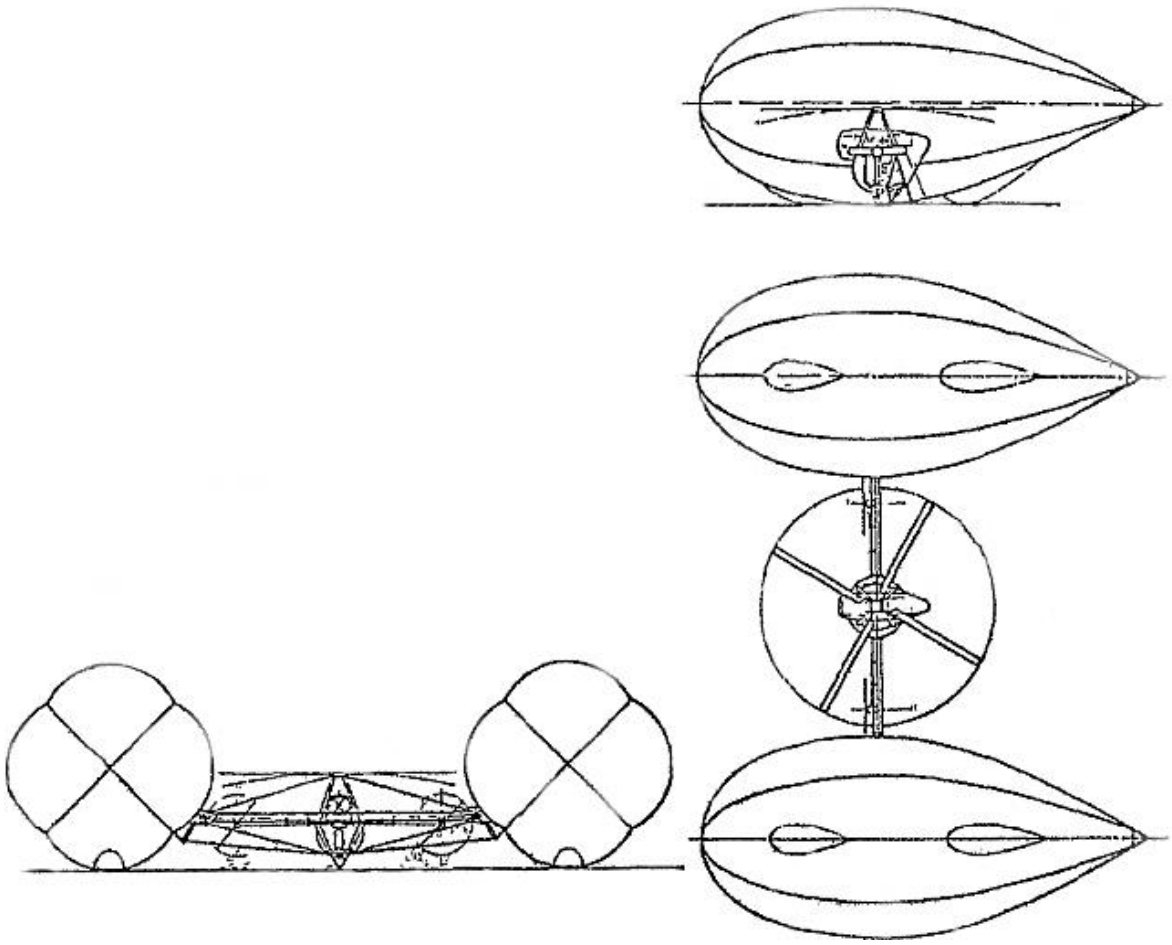
Aérospatiale developed Hélicostat design concepts with 1, 2 and 4 rotor systems and all with at least two engines.

Twin-hull, single-rotor logging Hélicostat

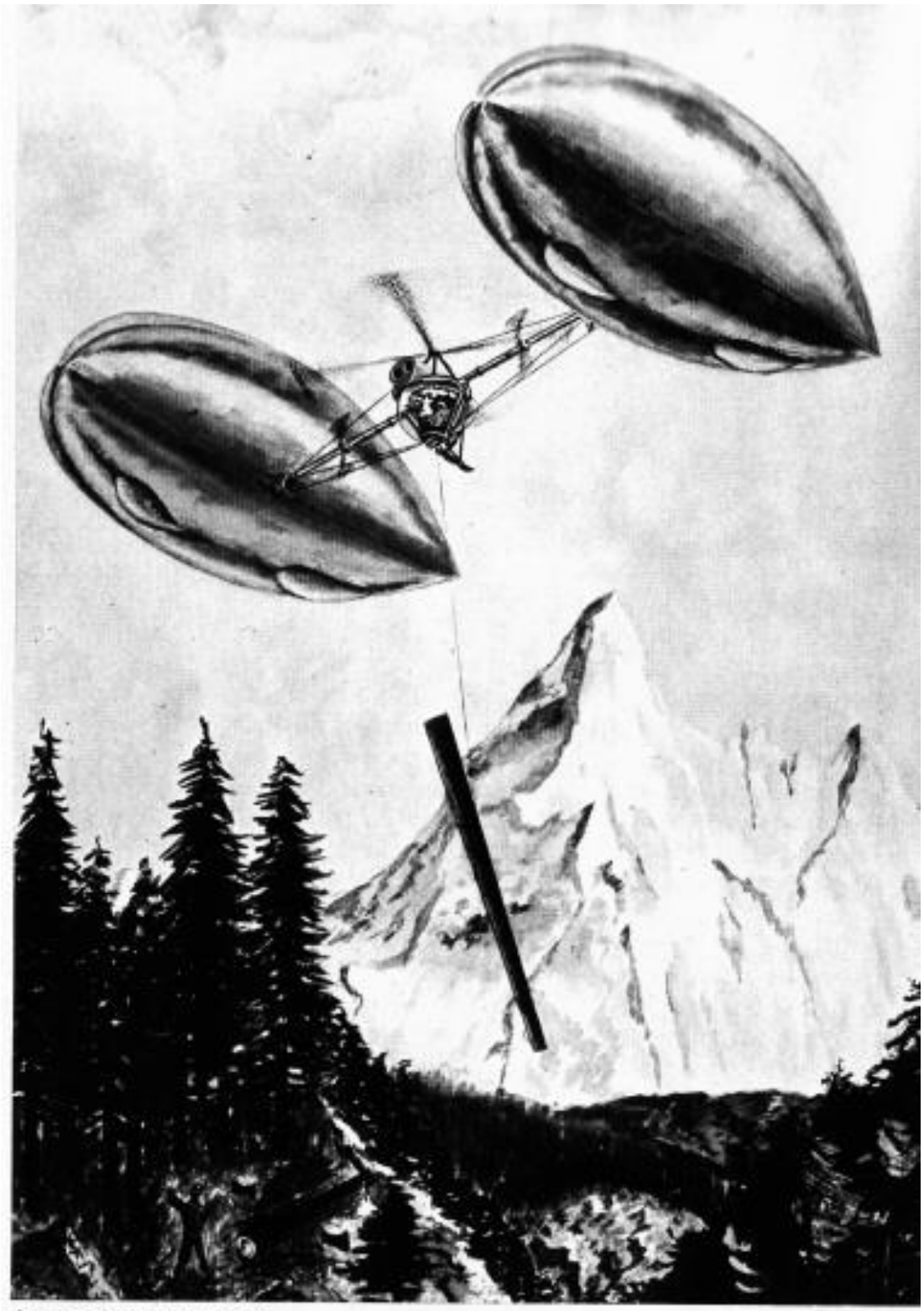
A twin-hull Hélicostat designed with low-cost, existing components was proposed by Aérospatiale as a low technical risk means for transporting 2 to 3 metric tons (2.2 to 3.3 tons) of logs from forest areas with difficult access. In 1975, the French forestry industry estimated that at least 350,000 usable metric tons of domestic timber could be recovered annually, reducing national fir and pine lumber imports by nearly 50% and thereby saving 350 million francs (about USD $82 million in 1975). With a readily available market, the investment risk seemed low.

The two non-rigid aerostat hulls are joined at their centers-of-buoyancy by a transverse truss framework that carries the single engine and rotor system, the cockpit and the cargo winch. Each aerostat contains several lift has cells and is pressurized with air to maintain its shape. The fabric aerostat hulls are reinforced at the junction with the truss attachment and distribute the loads from the truss into the upper surface of the envelopes. The hull has reinforced, inflatable landing cushions ahead and behind the transverse truss framework.

Aérospatiale estimated that a prototype could fly in two years.



Aérospatiale twin-hull, single-rotor logging Hélicostat.
Source: adapted from NASA-TM-7503 (1977)



Le projet Hélicostat.

Aérospatiale twin-hull, single-rotor logging Hélicostat.
Source "Les ballons du futur" de Pierre Balaskovic et François Moizard , ACE éditeur, 1983

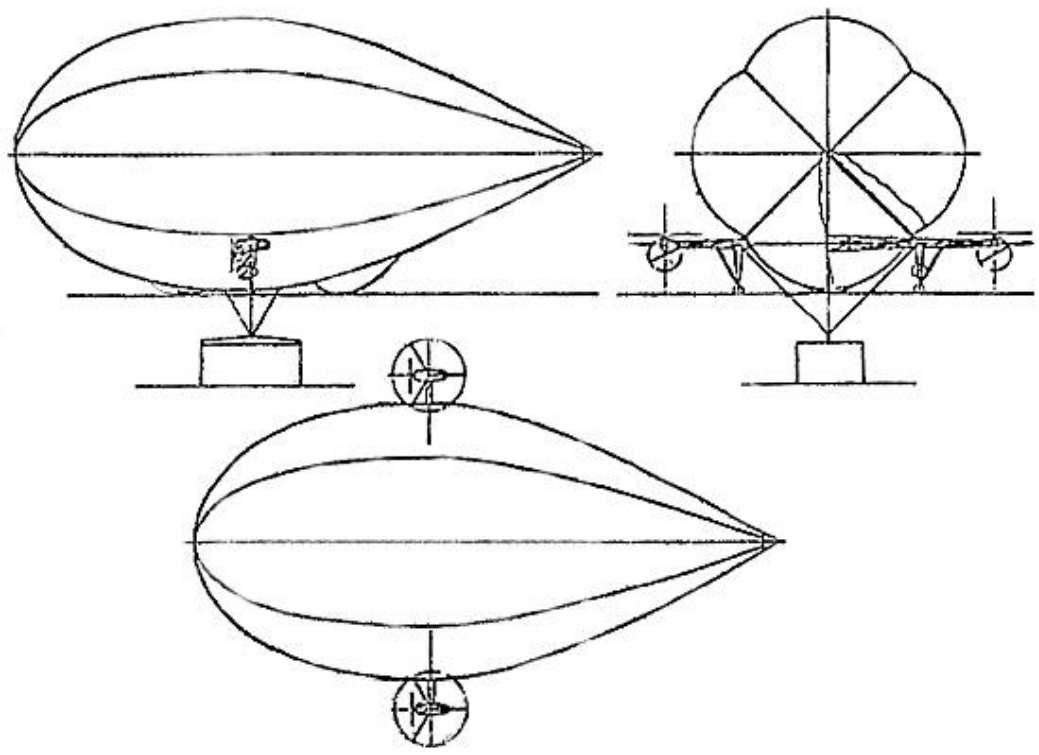
General characteristics of the logging Hélicostat

Parameter	
Airship type	Helicopter / aerostat hybrid, Hélicostat
Application	Logging in inaccessible areas
Length	26 m (85.3 ft)
Height	12 m (39.4 ft)
Width	36.5 m (119.8 ft), overall
Lift gas	Helium
Envelope volume	2 x 1,500 m^3 (52,972 ft^3) streamlined aerostats with internal lift gas cells, joined at their centers-of-buoyancy by a transverse truss framework.
Weight, empty	2,428 kg (5,353 lb), fully equipped, including pilot & equipment (carried by aerostatic lift)
Weight, ready to fly	2,835 kg (6,250 lb), including fuel @ 407 kg
Payload, including fuel	• With two engines: 3,000 kg (6,614 lb) • With one engine: 2,100 kg (4,630 lb)
Weight, maximum gross	5,428 kg (11,967 lb)
Propulsion system	2 x Lycoming IGSO-540-AID supercharged, horizontally-opposed, 4-cylinder piston engines @ 360 hp (268.5 kW) each, mounted on the transverse truss framework between the two gas envelopes: • 2 x Eurocopter AS365 Dauphin helicopter rotor • 2 x pusher-type variable pitch propellers, 3 m (9.8 ft) in diameter provide propulsion and yaw control • Total installed power: 720 hp (537 kW)
Speed, maximum	• With two engines: 90 kph (55.9 mph) empty, 86 kph (53.5 mph) loaded • With one engine: 61 kph (37.9 mph) empty, 54 kph (33.6 mph) loaded
Altitude, maximum	3,200 m (10,500 ft)

Source: adapted from NASA-TM-7503 (1977)

Single-hull, twin rotor cargo Hélicostats

Aérospatiale developed several design concepts for Hélicostats with a single large aerostat and twin rotors mounted on a transverse truss framework that supported two rotor systems, engines, and a control cabin at the airship's center-of-buoyancy. The following early design, with a four-lobed envelope, was described in 1977 in NASA-TM-7503.



Aérospatiale single-hull, twin-rotor cargo Hélicostat.
Source: adapted from NASA-TM-7503 (1977)

General characteristics of single-hull, twin rotor Hélicostat

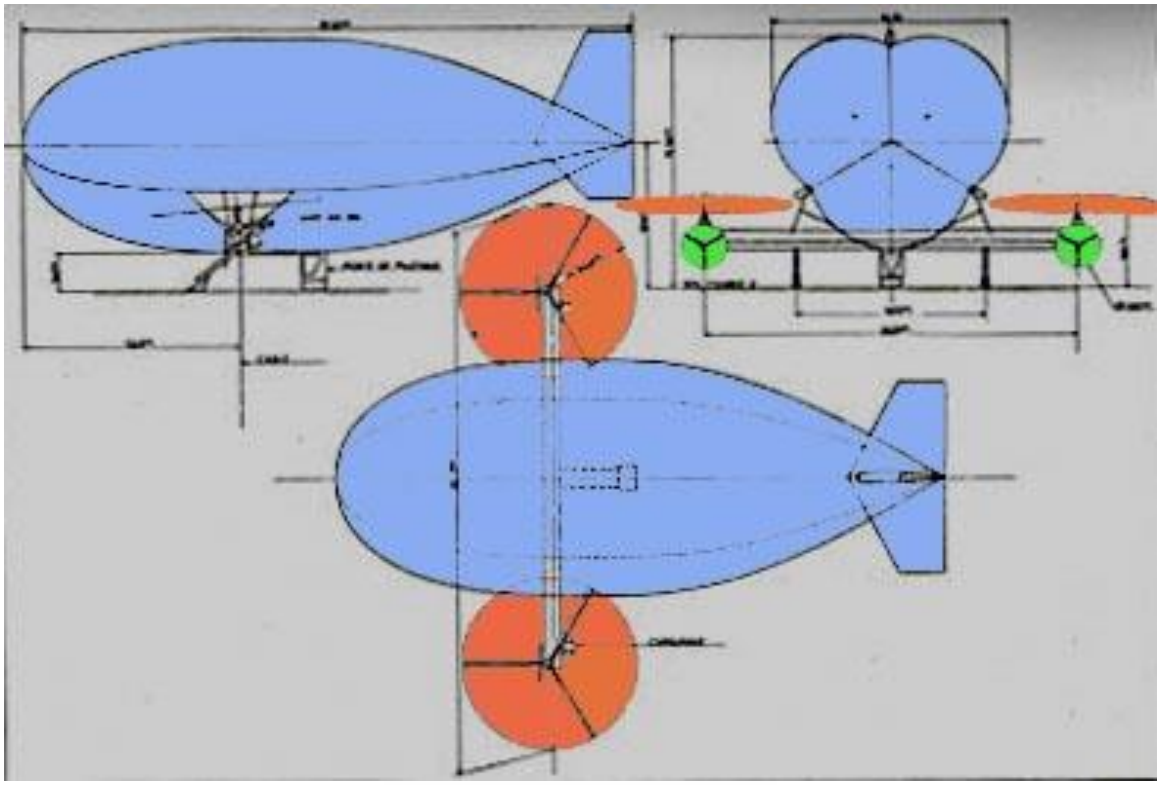
Parameter	
Airship type	Helicopter / aerostat hybrid, Hélicostat
Application	General cargo carrier
Length	71 m (233 ft)
Height	33.5 m (119.9 ft), envelope only
Width	• 33 m (108.3 ft), envelope only • 48 m (157.5 ft), including rotors
Lift gas	Helium
Envelope volume	About 30,000 m^3 (1,060,000 ft^3), single four-lobed envelope
Payload	17 metric tons (18.7 tons)
Total weight	30 metric tons (33 tons)
Propulsion system	2 x Eurocopter AS350 Écureuil helicopter rotor and engine systems • Each rotor was powered by a Turbomeca Ariel / Lycoming LTS101 turboshaft engine @ about 650 hp (485 kW) each. • Total installed power: 1,300 hp (970 kW).

Source: adapted from NASA-TM-7503 (1977)

Later designs of the single hull, twin rotor Hélicostat adopted a three-lobe envelope design and compound lifting rotor / forward propulsion propeller, as shown in the following illustrations.

Source: 1977 Aérospatiale brochure via Secret Projects

Source : "Les ballons du futur" de Pierre Balaskovic et François Moizard , ACE éditeur, 1983



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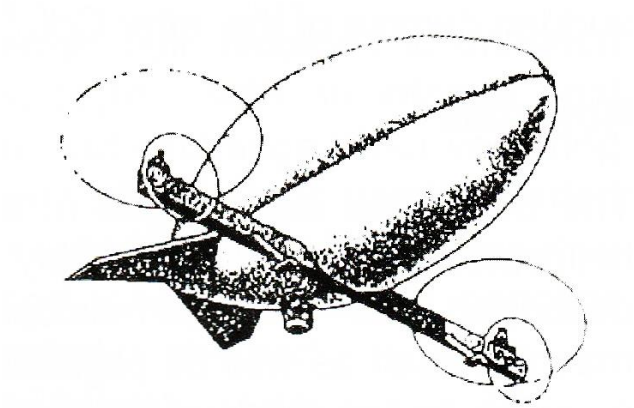
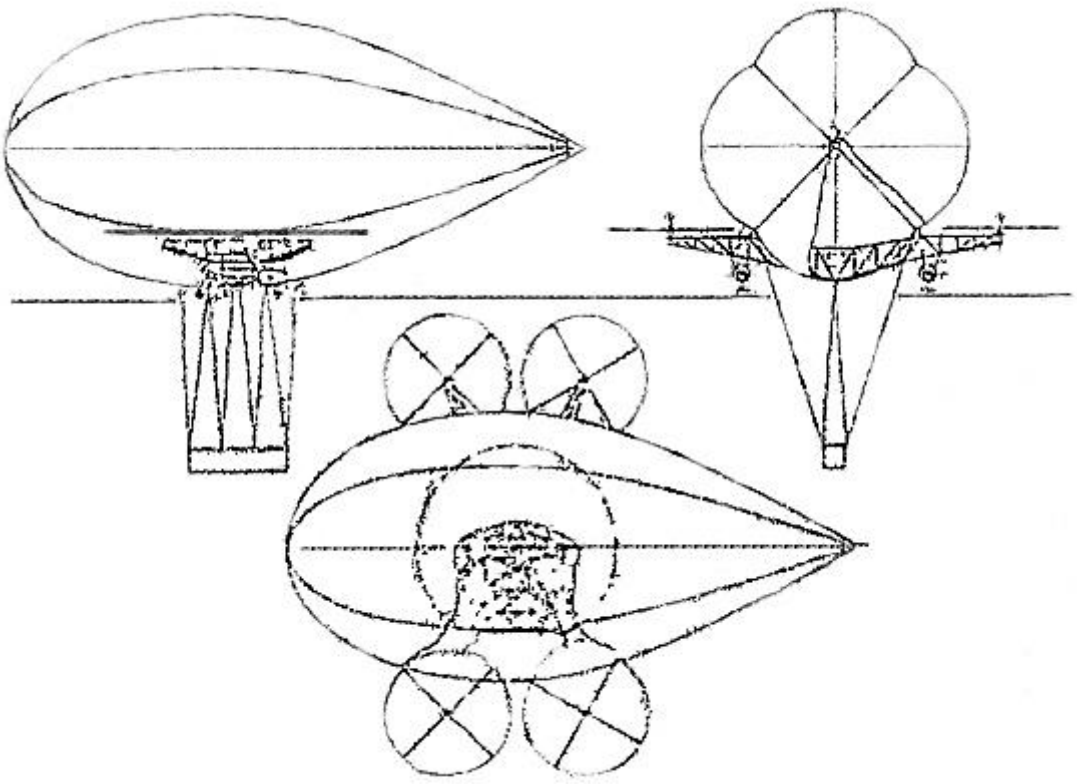


Source: E. Mowforth, “An introduction to the airship”

Single-hull, quad-rotor cargo Hélicostat

Known as the “port shuttle”, this 30 metric ton (33 ton) payload Hélicostat is intended for cargo shuttling operations, such as loading and unloading standard cargo containers from offshore ships to help alleviate cargo ship congestion in ports. This particular application requires high engine power to enable the operator to set payloads in place accurately in spite of 20 knot winds with 5 meter / second (18 kph, 11 mph) gusts from any direction.

The Port Shuttle has the same envelope size as the prior single-hull, two rotor example (from NASA-TM-7503). With four rotors and much higher installed power, the Port Shuttle is designed to lift a much larger payload: 30 metric tons (33 tons) vs. 17 metric tons (18.7 tons).



Aérospatiale single-hull, quad-rotor “Port Shuttle” cargo Hélicostat. Source: adapted from NASA-TM-7503 (1977)

General characteristics of the Port Shuttle Hélicostat

Parameter	
Airship type	Helicopter / aerostat hybrid, Hélicostat
Application	Heavy cargo carrier, port shuttle
Length	71 m (233 ft)
Width	• 33 m (108.3 ft), envelope only • 41 m (134.5 ft), to rotor centerlines • 56.3 m (185 ft), to rotor tips
Lift gas	Helium
Envelope volume	30,000 m^3 (1,060,000 ft^3) in a four-lobed envelope
Weight, empty	20.5 metric tons (22 tons)
Weight, payload	30 metric tons (33 tons) in maritime shipping containers 40 feet (12 meters) in length
Weight, maximum gross	54 metric tons (59.4 tons), with 3 metric tons (3.3 tons) of fuel and a 30 metric ton (33 tons) payload
Propulsion system	4 x Eurocopter AS332 Super Puma helicopter rotor and engine systems. • Each rotor is powered by a pair of Turbomeca Makila 1A1 turboshaft engines @ about 1,800 hp (1,342 kW) each, for a total of 3,600 hp (2,684 kW) per rotor • Each rotor can tilt slightly. • Total installed power is 14,400 hp (10,736 kW)
Speed, maximum	125 kph (77.7 mph)
Range	> 300 km (186 miles)
Endurance	3.5 hours

Source: adapted from NASA-TM-7503 (1977)

For more information

- “Helicopter Inventor Designs One-Man Blimp,” Popular Science, November 1931, p. 61: https://books.google.com/books?id=DygDAAAAMBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
- J. Morisset, "A New Hélicostat From SNIAS Helicopter Division,” NASA Technical Memorandum NASA TM 75063, December 1977 : https://ntrs.nasa.gov/api/citations/19780010098/downloads/19780010098.pdf

- “Le programme Hélicostat," which is included in "Les ballons du futur" de Pierre Balaskovic et François Moizard, ACE éditeur, 1983, reproduced online here: http://jb.aeronef.pagesperso-orange.fr/images/helicost.htm
- E. Mowforth, “An Introduction to the Airship,” Third Edition, revised and updated, p. 125, ISBN: 0-9528578-6-3, The Airship Association, 2007
- “Aérospatiale Hélicostat,” Secret Projects: https://www.secretprojects.co.uk/threads/aérospatiale-hélicostat.14641/

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