

Flying Whales - rigid airships

Peter Lobner, updated 10 March 2022

1. Introduction

The LCA60T (Large Capacity Airship, 60 Tons) is a rigid, heavy-lift, cargo airship being developed by the French firm Flying Whales. The original concept for this airship was developed in 2012 to meet the needs of the French Public Forest Office (ONF, Office National des Forêts) for the extraction of timber in hard-to-reach forest areas. However, the airship's abilities to carry very large, heavy loads and to perform load exchanges while hovering over a remote delivery site open much broader market opportunities to help solve complex logistics issues in many landlocked and undeveloped regions around the world. The corporate motto is "connecting the land-locked world to the global economy."



In March 2018, Flying Whales' chief executive officer, Sébastien Bougon, reported that the company has already secured about € 200 million (\$246 million) in capital. Investors include the French state fund Bpifrance, which invested € 25 million, China's state-owned aviation company AVIC General, which owns about 25% of Flying Whales, and China's Ministry Of Science and Technology (MOST). France's ONF and the Nouvelle Aquitaine region in the southwest of the country also are backing the project. In June 2019, the Canadian province Quebec announced that it planned to invest \$30 million in Flying Whales, \$22 million in share capital and \$8 million in a new Quebec subsidiary.

After a major redesign in 2020 - 2021, the maiden flight of the LCA60T prototype has slipped from 2021 to perhaps 2024, with certification in 2026, or later. Flying Whales has announced its intentions to go public with an initial public offering, which would be greatly enhanced with a successful flight test program.

The Flying Whales website is here: <http://flying-whales.com/en>

2. Key patents

Flying Whales has been granted several patents related to the design and operation of their original LCA60T design. Five patents of particular interest are described briefly in this section. The general principles in these patents likely apply to the new airship design unveiled in 2021. Links to these patents, and more, are listed at the end of this article.

Hybrid airship: US2020/0283170A1

This patent describes the basic design of a hybrid airship similar in design to an LCA60T. As with other hybrid airships, lift is the sum of aerostatic lift from helium, aerodynamic lift from the hull in forward flight, and dynamic lift from thrust vectoring propulsors. The patent also describes the onboard electric power system.

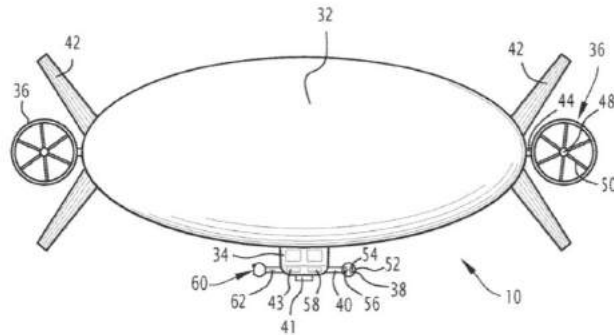


FIG. 2

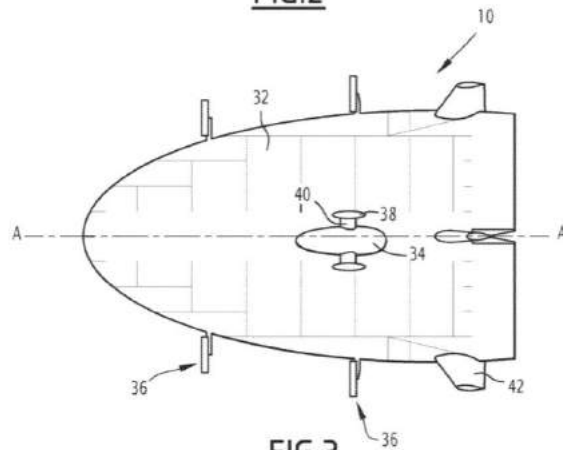


FIG. 3

*The gas envelope (32, the hull), rudders (42),
electric motor driven thrust vectoring propulsors (36),
gondola (34), generator pods attached to the gondola (38)*

Stabilizing an airship: US2018/015726A1

This patent describes an automated control system for monitoring the wind conditions and managing the thrusters and control surfaces positioned around the airship to precisely maintain the airship's geo-location. For example, patent Figures 2 and 3 show the arrival of a gust of wind (3) and the subsequent automatic response. LIDAR sensors (2) transmit signals (22) to monitor the wind field around the airship. Based on detected conditions, a central computer (CPU, 5, 6) determines if corrective actions are needed from the actuators (4), which include engines (41) and control surfaces (42). The engines at the bow and stern (411) are fixed, reversible engines that provide lateral (sideways) thrust. The port and starboard mid-ship engines (412) are vectorable and reversible. They can provide fore/aft and up/down thrust by rotating in a plane perpendicular to the long axis of the airship.

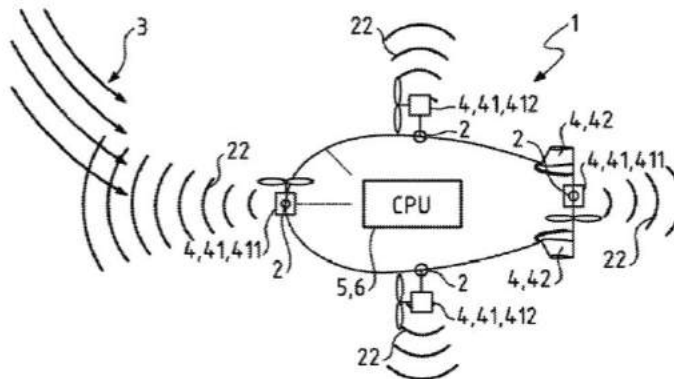


FIG.2

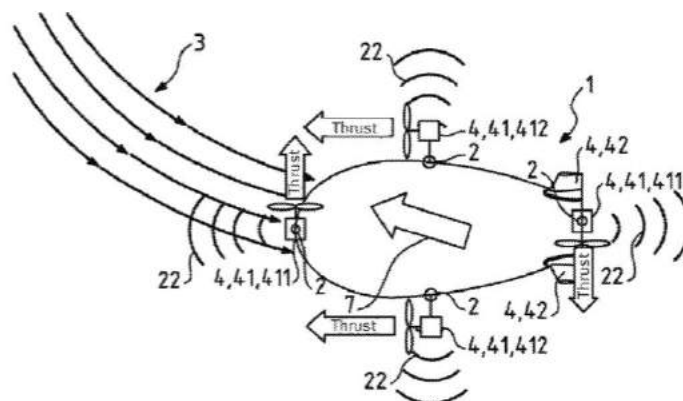
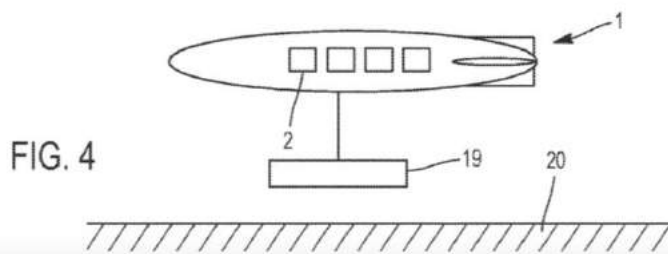
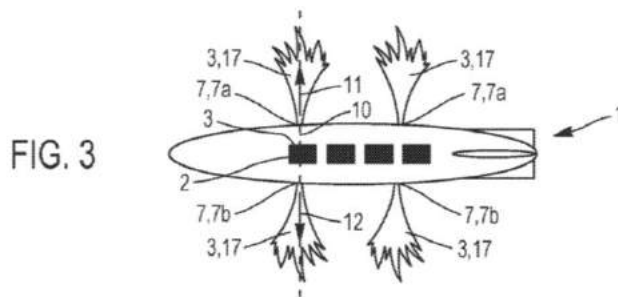
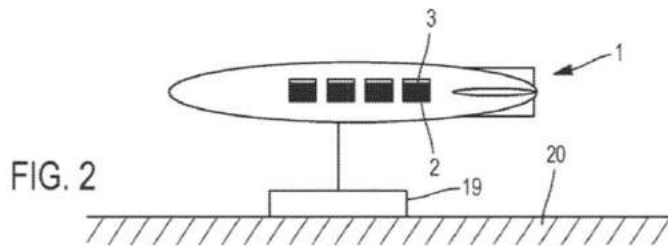
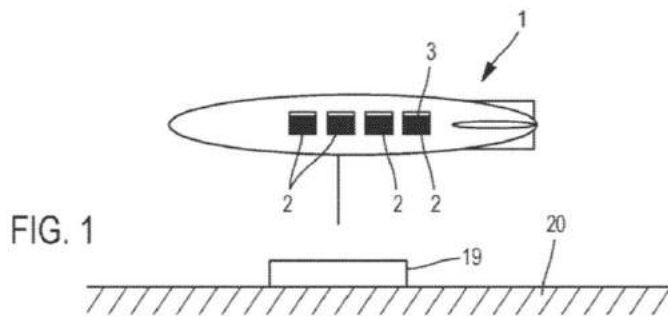


FIG.3

Deballasting: US10494076B2

This patent describes a process that can be used by an airborne airship (1) to pick up a heavy load (19) on the ground (20). As shown in patent Figures 1 and 2, the airship hovers over the load and lowers the lift cables, which are connected to the load.



In the overhead view in Figure 3, the hovering airship rapidly and symmetrically discharges pressurized water ballast, which falls to the ground as a fine rain. This increases buoyancy and allows the airship to bear the weight of the load.

In Figure 4, enough ballast has been discharged to allow the airship to lift off the ground with the suspended load, which will be hoisted up and secured before the airship proceeds to its next destination.

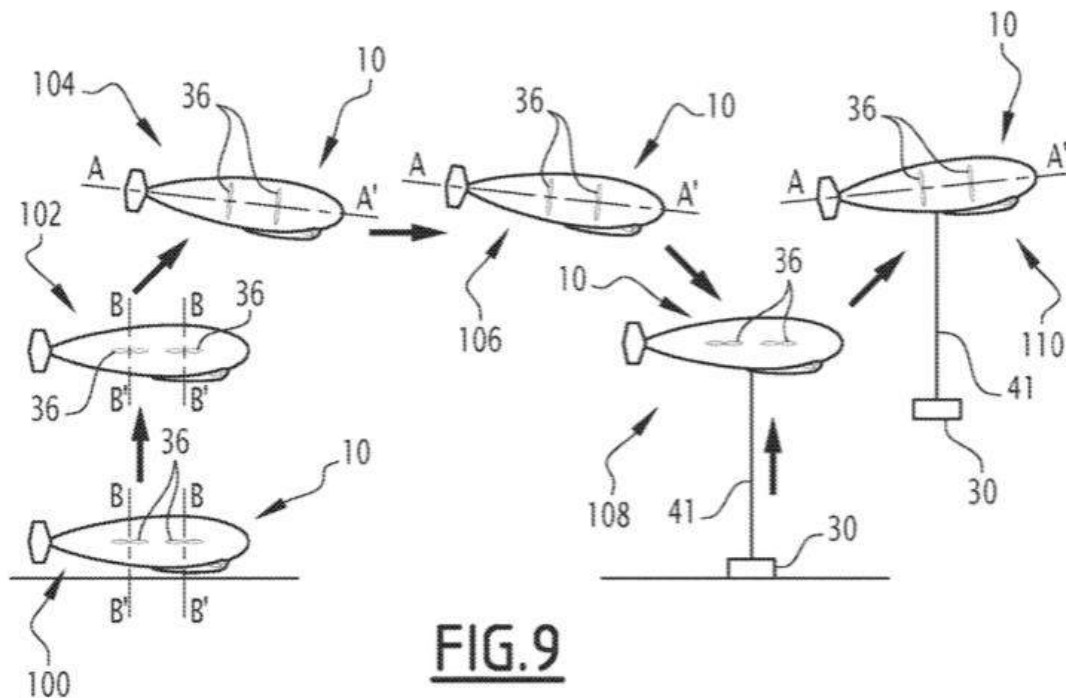
The water spray heads are directional and have flow controls. If the water discharge is not symmetrical, the airship will be pushed by the uneven reaction forces.

The patent describes the deballasting system as carrying 64 metric tons (70.4 tons) of water ballast in 16 tanks.

Method of transporting: US2020/0361589A1

This patent describes a complete load exchange process (a load pickup and delivery cycle) that can take place without discharging or taking on water or other ballast.

Load pickup



In Figure 9, steps 100 and 102, the light (unloaded) airship lifts off using aerostatic lift and dynamic lift from the propulsors (36), which are aligned vertically. Between Steps 102 and 104, the airship transitions to forward flight, with the propulsors rotated to deliver horizontal thrust and the hull is pitched down to compensate for aerodynamic lift and hold the light airship at the desired altitude until the destination is reached.

Between steps 106 and 108, the airship transitions from forward flight to hovering at zero speed above the load, where it uses only aerostatic lift and dynamic lift from the propulsors. When the load is connected in step 108, propulsor power is increased to deliver sufficient additional dynamic lift to pick up the load vertically. The cargo handling process is managed by a crewmember called a "loadmaster".

Between steps 108 and 110, the airship transitions to forward flight with the load suspended about 10 to 60 meters (33 to 197 ft) beneath the gondola. As aerodynamic lift increases, the propulsors are rotated to deliver horizontal thrust. The hull is pitched up to an angle of 0.5 to 5 degrees (up to 15 degrees is possible) to increase aerodynamic lift during forward flight, which can be in the range from 40% to 60% of total lift. The positive pitch angle enables the airship to carry heavier loads without needing a larger gas envelope or continuing to use the propulsors to generate dynamic lift.

This process was accomplished without discharging any water ballast as described in patent US10494076B2. However, it can only be used for loads that are within the dynamic lift capacity of the propulsors. Picking up and dropping off a maximum load still requires a discharge of water ballast.

Load drop-off

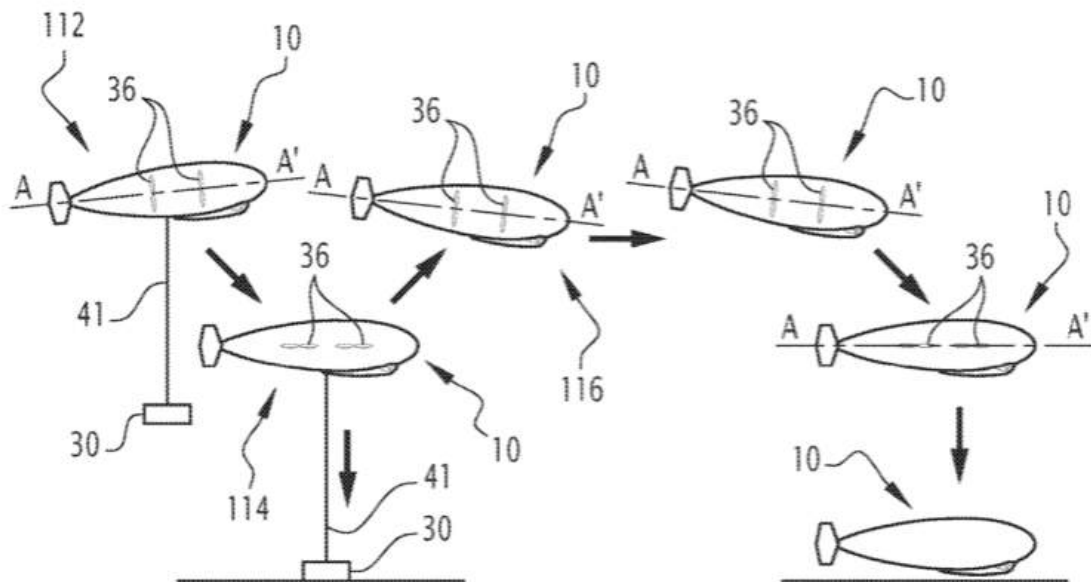


FIG.10

The loaded airship approaches its destination in horizontal flight in step 112 and transitions to a hover at zero speed above the destination in step 114. At this point the airship and the load are supported by aerostatic lift and dynamic lift from the propulsors. By

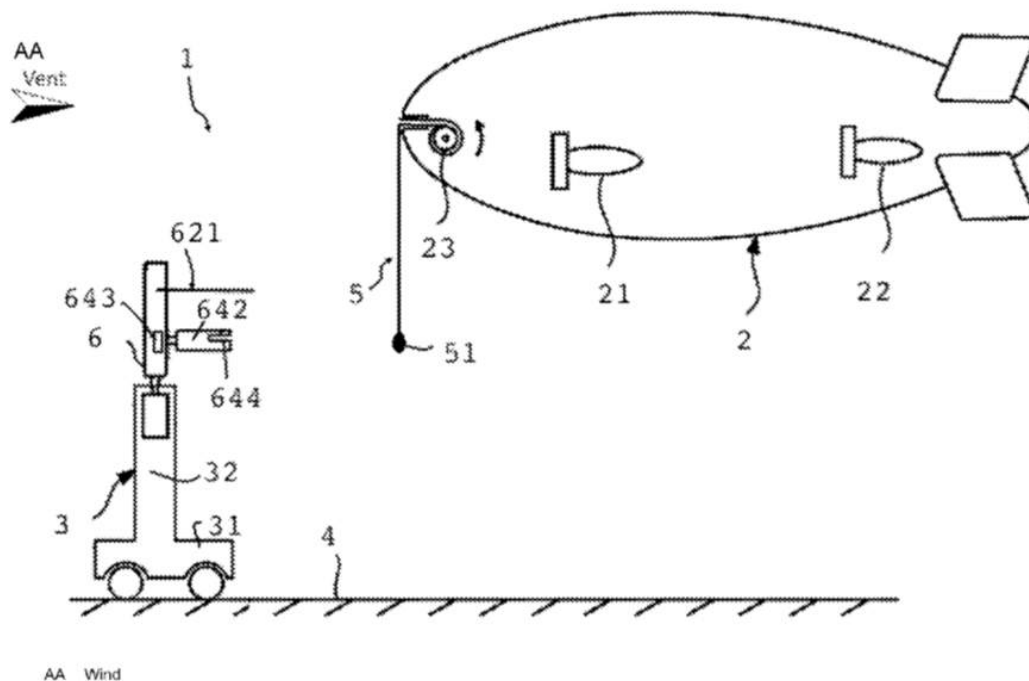
modulating the propulsors, the load is set down and its weight is transferred to the ground, the unloaded lift cables are disconnected and the airship is able to depart. Between steps 114 and 116, the light airship transitions to horizontal flight, with the hull pitched down again to compensate for aerodynamic lift and hold the airship at the desired altitude until the destination is reached. Then the airship lands vertically using aerostatic lift and modulated dynamic lift from the propulsors.

If a maximum load had been delivered in step 114, the airship would have had to take on water ballast to reduce net lift into the range where modulating the propulsors provided the control needed to unload the lift cables and allow the airship to safely disconnect from the load.

System for docking an airship: WO2020128316A1

This patent describes a process of an airship (2) with a deployed weighted tether (5, 51) to approach a mast (6) with a fork-type guiding device (621) and receiver (644) that can capture the tether and winch the airship in to the mast.

[Fig.11]

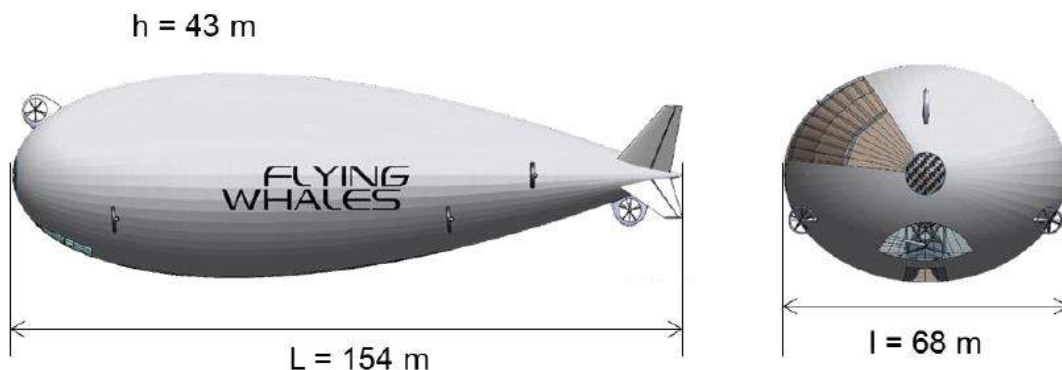


3. Evolution of the LCA60T airship

From 2012 to 2020, the LCA60T airship had a characteristic shape with a broad, elliptical aerobody envelope and twin tails. In December 2020, a new design emerged with a more conventional, cylindrical envelope and a distributed propulsion system. In this section, we'll look at both designs.

Original LCA60T design (circa 2016 - 2020)

The basic configuration and dimensions of the LCA60T airship are shown in the following graphic. This version of the rigid, heavy-lift airship was designed to handle up to 60 metric tons (60,000 kg; 132,277 lb) of cargo that is stowed in a large, ventral cargo hold or suspended externally under the airship.



*LCA60T side and front views.
Source: Flying Whales, pre-2021*

The shape of the airship is established by its rigid structural framework, which also supports the loads of the airships systems, crew compartment and cargo handling features, and provide attachments for carrying the loads from the stabilizing fins and distributed propulsors. The outer hull (the skin) is comprised of multi-layers of specialized fabrics. The helium lift gas is contained in 10 unpressurized cells within the rigid airframe and outer hull. The LCA60T was designed with a maximum airspeed of 100 kph (62 mph), and a maximum operating altitude of 3,000 meters (9,843 feet).



*LCA60T front quarter view.
Source: Flying Whales, pre-2021*

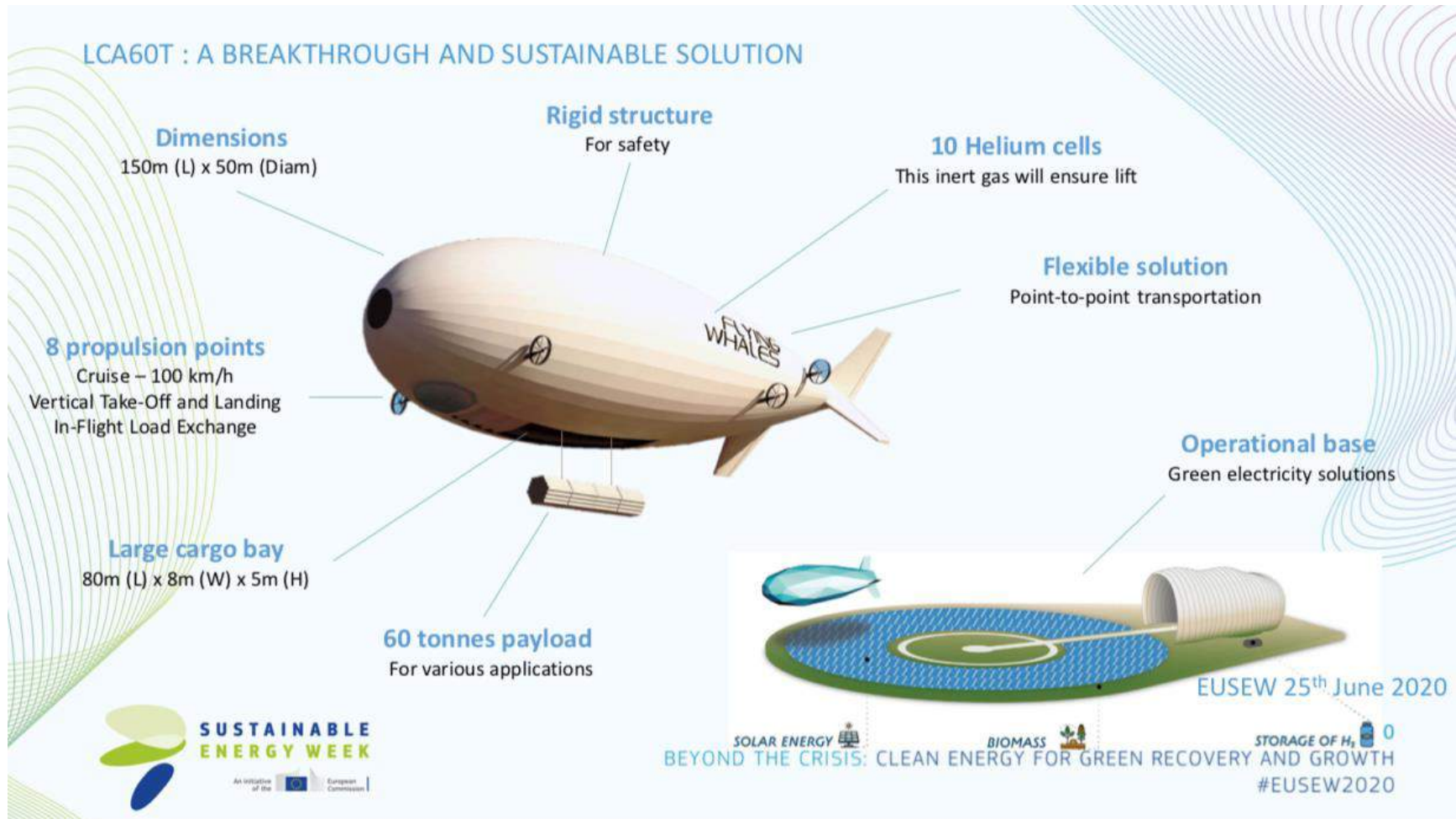


*LCA60T rear quarter view.
Source: Flying Whales, pre-2021*

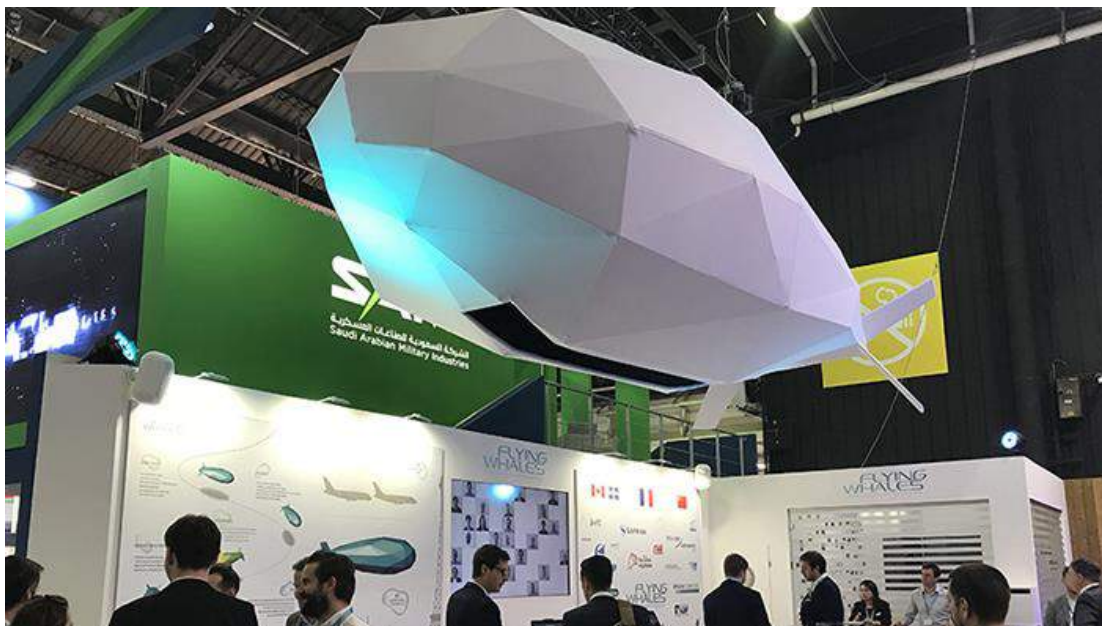
Other basic features of this version of the LCA60T airship include:

- Carbon-fiber composite, rigid lattice airframe structure.
- Distributed hybrid propulsion system:
 - Small diesel generator.
 - Graphene-based ultra-capacitors can be charged and discharged faster than conventional batteries.
 - Seven electrically-powered propulsors.
- Capable of vertical takeoff and landing (VTOL) and hovering.
 - No landing gear. The airship will moor to a mast at a permanent or temporary operating base.
- Cargo can be carried internally in a capacious ventral cargo bay measuring 80 m long x 8 m wide x 5 m high (262.5 x 26 x 16.2 ft).
- Outsized cargo, such as electric transmission pylons, wind turbines, and even entire houses, can be carried externally as sling loads.
- Load exchange can occur while the airship is airborne (hovering). Landing is not required to transfer cargo.
 - Canadian firm REEL COH Inc. is supplying 12 winches that provide the capability to lift or deliver 60 metric tons of cargo.
 - An exchange of water ballast is required during the airborne load exchange.
- The airship also can land at a permanent or temporary land base and discharge or load cargo from its internal cargo bay while on the ground.
 - An exchange of water ballast is required during the load exchange on the ground.
- Maximum range: about 1,000 km (621 miles).
 - In practice, the radius of action is expected to be about 100 km (62 miles).
- Crew of 3, including pilot and loadmaster

In January 2019, Flying Whales completed a test program at an ONERA wind tunnel in Lille, France. The program produced aerodynamic measurements on a 1/150th-scale model of the LCA60T airship to be used in creating a digital model for future simulation of the airship's behavior.

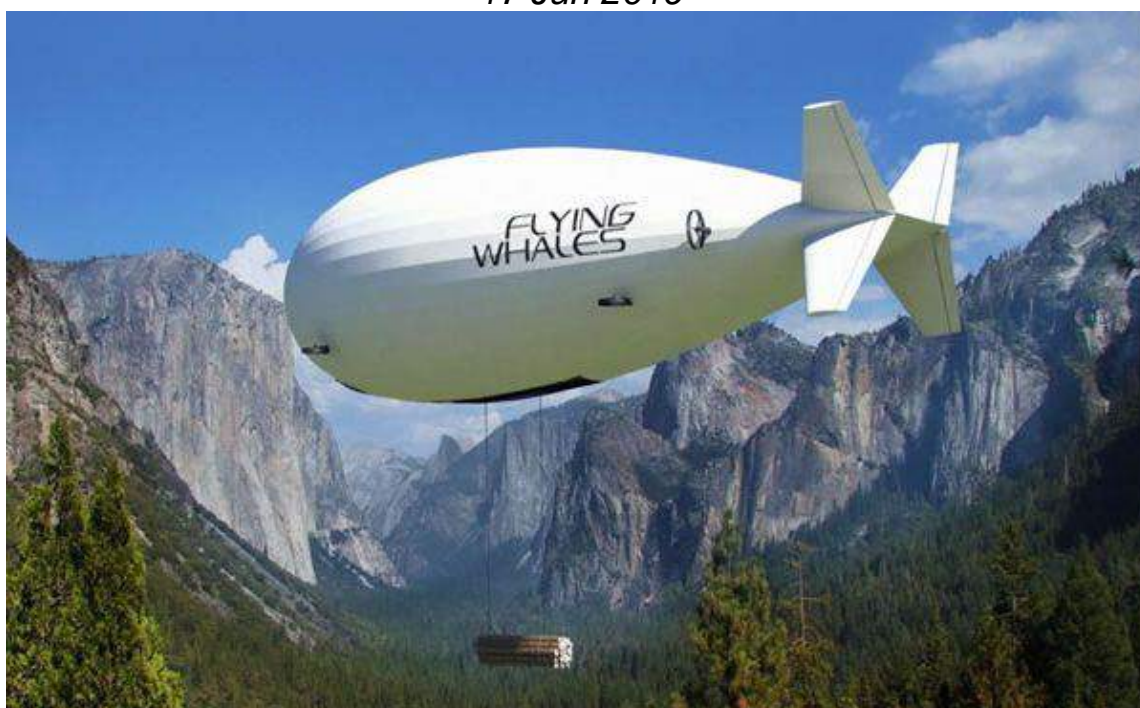


*LCA60T general arrangement, pre-2021 design.
Source: Institute for Infrastructure Environment and Innovation (IMIEU), June 2020*



Polygonal model of the Flying Whales airship (not representative of the smooth surface on the actual airship) showing the long ventral opening for the cargo bay; on display at the Paris Air Show 2019.

*Source: Joseph Flaig / Institution of Mechanical Engineers,
17 Jun 2019*



LCA60T shown delivering a large item from its internal cargo hold.

Source: Flying Whales, pre-2021



*LCA60T shown delivering a complete housing unit
as an external sling load.*

Source: Flying Whales, pre-2021



LCA60T shown delivering a set of wind turbine blades.

Source: Flying Whales, pre-2021

Current LCA60T design (circa 2021)

In December 2020, Flying Whales released a short video that revealed a substantially different LCA60T with the following features:

- New, longer envelope design: conventional, ellipsoidal, 200 m (656 ft) long, 50 m (164 ft) diameter, 14 helium lift gas cells
- New propulsor type and arrangement: 7 distributed propulsor arrays, each with 4 or 6 small propulsors (32 total)
- New aerodynamic fins: cruciform tail plus small canards

You can watch this short (3:04 minutes) Flying Whales video here:

<https://www.youtube.com/watch?v=vTVGHurbtRU>



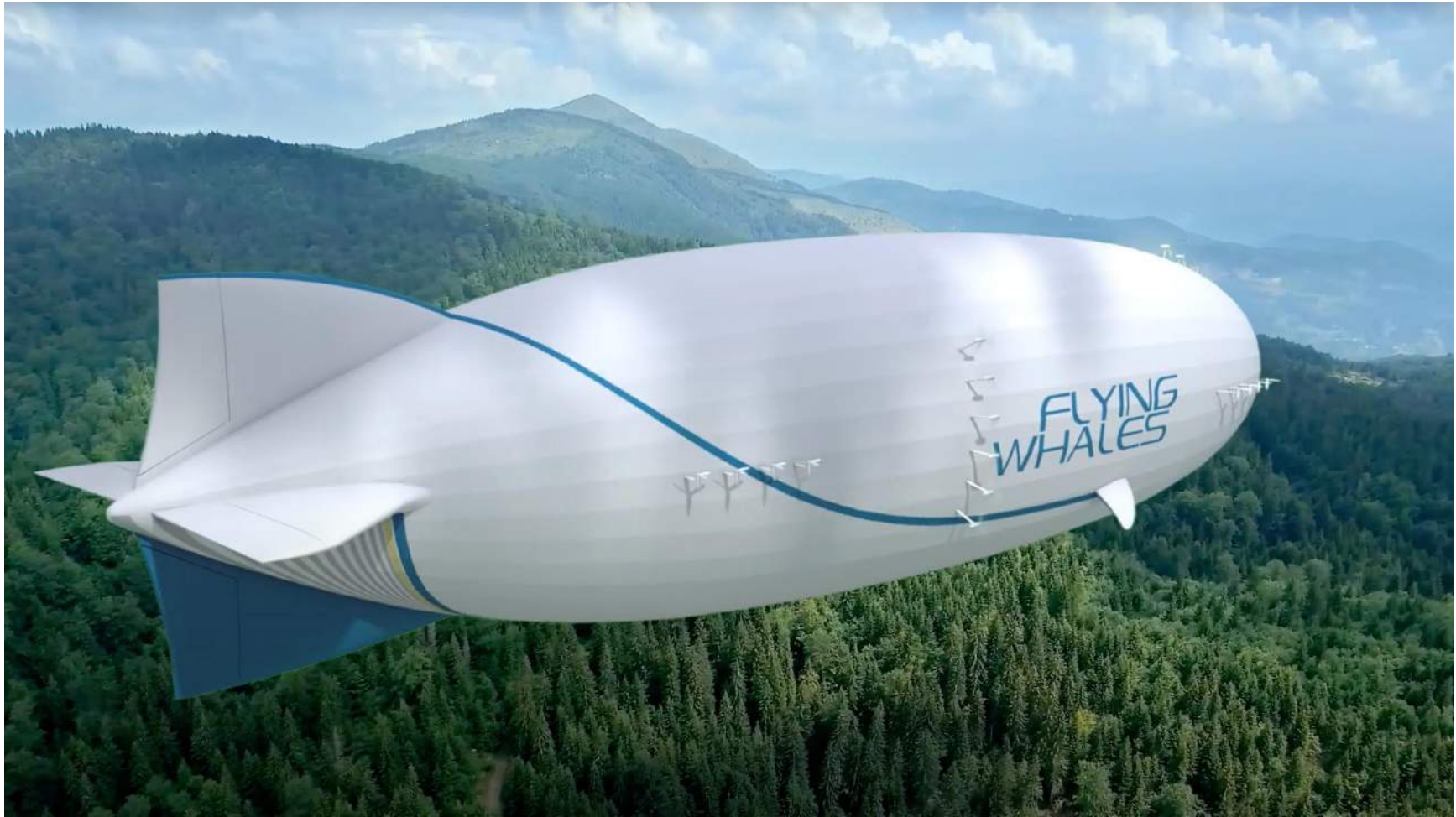
LCA60T airship circa 2021 with a conventional hull shape and distributed propulsion. Four different propulsor arrays are visible in this rendering (bow top, bow side, mid-ship side, and stern side).

Source: Flying Whales, 2021

In another significant change, Flying Whales announced in 2020 their goal to implement, as soon as practical, a fully electric power system using hydrogen fuel cells carried on the airship. This development is being done in collaboration with Air Liquide.



LCA60T general arrangement. Source: Flying Whales, 2021



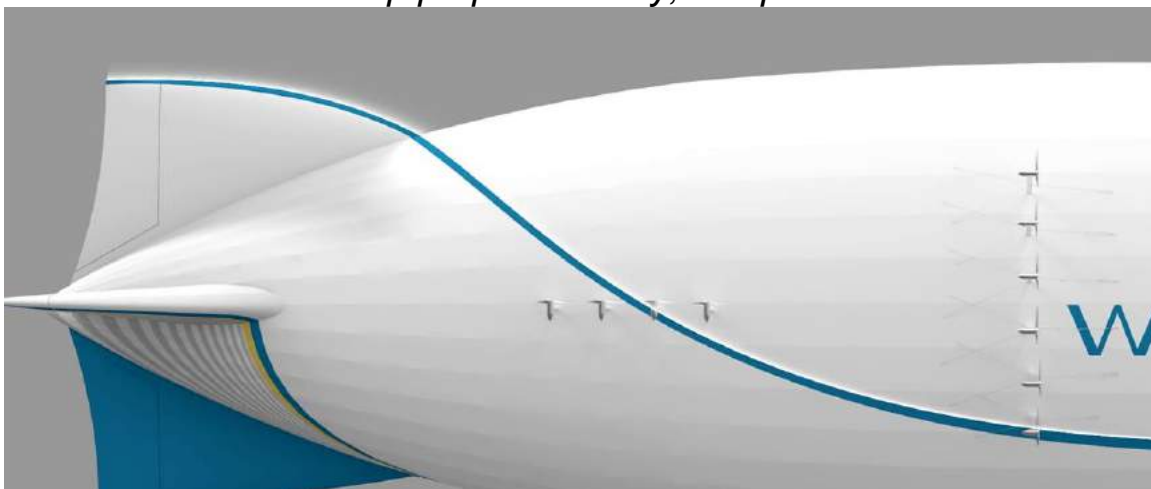
*Rendering of LCA60T in flight, stern quarter view.
Source: Screenshot from Flying Whales 27 Dec 2020 video*



Bow and mid-ship propulsor arrays, side view



Mid-ship propulsor array, oblique view



Stern and mid-ship propulsor arrays, side view
Source, three graphics: Flying Whales, 2021



LCA60T delivering emergency supplies from its internal cargo bay. Ballast exchange would be required. Source: Flying Whales, 2021.



LCA60T exchanging cargo with an offshore ship. Ballast exchange would be required. Source: Flying Whales, 2021



*LCA60T carrying a large external load.
Source: Flying Whales*

After this major redesign, the maiden flight of the LCA60T prototype has slipped from 2021 to perhaps 2024, with certification and commercial service entry in 2026, or later.

4. Business case and competition

Flying Whales has said the LCA60T's current direct competitors are the few very large cargo helicopters presently in service:

- The Russian Mil Mi-26: 20 metric tons (20,000 kg, 44,092 lb) cargo capacity; latest model, the Mi-26M, can lift 25 metric tons (25,000 kg, 55,116 lb)
- The US Sikorsky / Erickson S-64 Skycrane: 9 metric tons (9,072 kg, 20,000 lb) cargo capacity

Flying Whales reported that the Russian helicopter had a daily operating cost of about US \$1 million, whereas the LCA60T is

expected to be more than 20 times cheaper, which equates to a daily operating cost of about \$50,000.

Flying Whales told Lloyd's Loading List that it is one of a handful of 'serious' cargo airship projects in the world, including one in the UK (Hybrid Air Vehicles / Airlander), two in the US (likely Lockheed Martin LMH1 and Aeros Aeroscraft), one in Russia (likely RosAeroSystems / ATLANT, which was acquired in 2018 by the Israeli firm Atlas LTA Advanced Technology, Ltd.), and one in Canada (likely Millennium Airship / SkyFreighter).

5. Manufacturing plans

In an interview with French newspaper Sud-Ouest, Flying Whales' CEO, Sébastien Bougon, stated that the company had chosen the Bordeaux region of France as the location of its first manufacturing plant, which will serve the European market. Representing an investment of € 90 million, the factory is scheduled to enter service in 2021 and have a production capacity of up to a dozen airships annually starting in 2022.

In early March 2019, AVIC Research Institute announced the formation of a joint venture between Flying Whales and China Aviation Industry General Aircraft Co., Ltd. (AVIC) to develop large-capacity airships targeting the global market. A factory for the airships will be built in the central Chinese city of Jingmen.

Sébastien Bougon estimated likely sales at € 5 billion over 10 years from a fleet of 150 airships built in factories in France and China. After the Canadian firm LTA Aerostructures (LTAA) failed to build its airship manufacturing center in Mirabel, Quebec, Canada, the Quebec government implemented a new plan to develop an airship industry in the Montreal area in collaboration with Flying Whales. In June 2019, Quebec's Economy Minister announced at the Paris Air Show that Quebec was in the process of buying a minority stake in Flying Whales and expected to construct a production facility in the Montreal area within five years (by 2024).

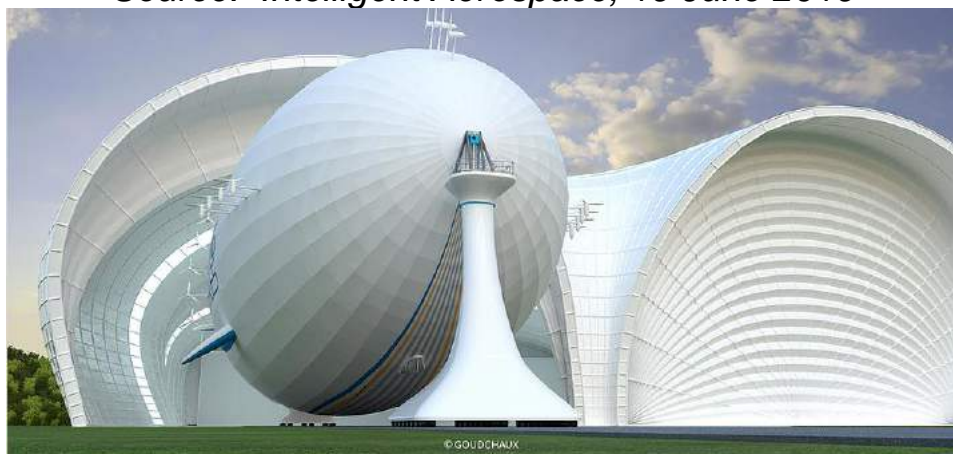
6. Airship operational infrastructure plans

The Airdock

Flying Whales and French firm Groupe ADF signed an exclusive industrial and financial partnership at the 2019 Paris Air Show. The partnership provides for the construction of an airship interface system known as an “Airdock”. This is a 30 meter (98 foot) tall mobile superstructure that is designed to dock an arriving LCA60T airship, undock a departing airship, maintain a parked airship in the correct position, and control the airship during ground maneuvers while it is being moved between a storage hangar and a launch pad.



*General configuration of the Group ADF Airdock.
Source: Intelligent Aerospace, 19 June 2019*



*Airdock configuration mid-2021.
Source: Goudchaux via Flying Whales*

Hangar and airship cradle

An LCA60T does not have landing gear. When it needs to be brought into a hangar, it will be secured on a self-propelled cradle with a mooring point and driven into a hangar.



*Two views of an LCA60T on its cradle entering a hangar.
Source: Screenshots from Flying Whales 27 Dec 2020 video.*



*An LCA60T on its cradle in a hangar.
Source: Screenshot from Flying Whales 27 Dec 2020 video.*

International airship bases

ADP Ingénierie, a division of the French firm Groupe ADP, which is an international airport operator, signed a Memorandum of Understanding with Flying Whales at the 2019 Paris Air Show to develop a long-term partnership for the design of up to 150 airship bases worldwide. Initial bases are likely to be in France, China, and Quebec, Canada. The goal is “to enable the low-cost, point-to-point transport of heavy and bulky loads by airship.” Groupe ADP plans to acquire an equity stake in Flying Whales.

Airship leasing

The company plans to develop an "ownership operator" segment of its business that will allow clients to use the airships for short-term projects instead of having to purchase an entire unit just for one mission.

7. For more information

- “Flying Whales and Skeleton Technologies partner to develop next generation of large capacity airships,” Skeleton technologies, 4 July 2016:
<https://www.skeletontech.com/news/flying-whales-and-skeleton-technologies-partner-to-develop-next-generation-of-large-capacity-airships>
- Frédéric Tomesco, “Flying Whales poised to lift off in Montreal thanks to Quebec investment,” Montreal Gazette, 18 June 2019: <https://montrealgazette.com/business/flying-whales-poised-to-lift-off-in-montreal-thanks-to-quebec-investment>
- Brian Dunn, “Quebec defends \$30 million Flying Whales investment” SkiesMag, 18 February 2020:
<https://skiesmag.com/news/quebec-defends-30-million-flying-whales-investment/>
- “Flying Whales - A new take on the airship,” Air Liquide, 29 July 2020: <https://www.airliquide.com/magazine/energy-transition/flying-whales-new-take-airship>
- Brittany Chang, “French company Flying Whales is creating an airship that can pick up and drop cargo without landing — see how,” Business Insider, 6 September 2020:
<https://www.businessinsider.com/flying-whales-lca60t-airship-can-move-cargo-without-landing-2020-9>
- Phillipe Morin, “Giant airship project, touted as solution to remote shipping, 'on track' says company,” CBC, 4 April 2021:
<https://www.cbc.ca/news/canada/north/flying-whales-schedule-1.5973192>

Patents

- US10494076B2, “Lighter-than-air aircraft and deballasting method implemented in said lighter-than-air aircraft,” filed 11 August 2015, granted 3 December 2019:
<https://patents.google.com/patent/US10494076B2/en?q=us10494076>
- US2018/0157261A1, “Aircraft and method of stabilizing an aircraft,” filed 12 May 2016, published 7 June 2018:

<https://patents.google.com/patent/US20180157261A1/en?q=US15%2f575508>

- US2020/0283170A1, “Hybrid airship and related assembly and/or maintenance method,” filed 13 November 2017, published 10 September 2020:
<https://patents.google.com/patent/US20200283170A1/en?q=US20200283170>
- US 2020/0361589A1, “A method for transporting a payload to a target location and related hybrid airship,” filed 13 November 2013, published 19 November 2020:
<https://patents.google.com/patent/US20200361589A1/en?q=US+2020%2f0361589>
- WO 2018/099870 A1, “System and Method for Docking an Aerostat, and Aerostat and Receiving Structure Equipped for Such Purpose,” filed 27 November 2017, published 7 June 2018: <https://patents.google.com/patent/DE10121854C1/fr>
- WO2020128316A1, “System and method for improved securing of an aerostat to a receiving structure,” filed 18 December 2019, published 25 June 2020:
<https://patents.google.com/patent/WO2020128316A1/en>

Video

- “Gironde: Flying Whales dévoile le design de son LCA60T,” (3:04 minutes), Flying Whales, 27 December 2020:
<https://www.youtube.com/watch?v=vTVGHurbtRU>

Other *Modern Airships* articles

- *Modern Airships - Part 1*: <https://lynceans.org/all-posts/modern-airships-part-1/>
- *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/>