LTA Research and Exploration LLC (LTA)

Peter Lobner, updated 24 July 2022

1. Introduction

LTA Research and Exploration (LTA) is an aerospace research and development company building experimental and certified manned and remotely piloted airships. According to their LinkedIn site, “We are developing advanced technologies to dramatically increase the capabilities and lower the cost of 21st century airships. With these next-generation airships, we strive to improve humanitarian aid delivery and reduce carbon emissions, while providing economic opportunity and new jobs to Americans. LTA airships will have the ability to complement — and even speed up — humanitarian disaster response and relief efforts, especially in remote areas that cannot be easily accessed by plane and boat due to limited or destroyed infrastructure. We ultimately aim to create a family of aircraft with zero emissions that, when used for shipping goods and moving people, would substantially reduce the global carbon footprint of aviation.”

LTA was created in 2013 by founding CEO Alan Weston and by Google co-founder Sergey Brin. Dr. Weston was Director of Programs at the NASA Ames Research Center from 2006 to 2013, when NASA was involved in several large airship programs.

LTA is operating in the San Francisco Bay area out of Moffett Field Hangar 2, which is one of three large airship hangars at the 1,000-acre Moffett Field site is Sunnyvale, CA. Other Bay Area LTA facilities are closer to the Googleplex headquarters in Mountain View, CA. LTA also has a research & manufacturing facility in Gardnerville, NV.

LTA currently is leasing space at the Akron Airdock and in nearby facilities in Akron, OH. LTA reports that they have entered into an agreement to purchase the Akron Airdock, pending an approval process, and are increasing their research, development and manufacturing workforce in Akron.

The LTA website is here: https://www.ltaresearch.com

Their LinkedIn site is here: https://www.linkedin.com/company/lta-research/

LTA is building two large, rigid "Pathfinder" airships. The 400-foot (122-meter) Pathfinder 1 airship is being built in Moffett Field Hangar 2. The substantially larger Pathfinder 3 will be built in the Akron Airdock. There is no Pathfinder 2.

This article provides an overview of LTA's airship program and is organized as follows:

- LTA patents
- Airship manufacturing facilities
- Engineering development
- Training and testing airships and flight simulators
- Pathfinder 1 & 3
- The full-size next-generation airship

I am grateful to LTA Research and Exploration for their input for this article.

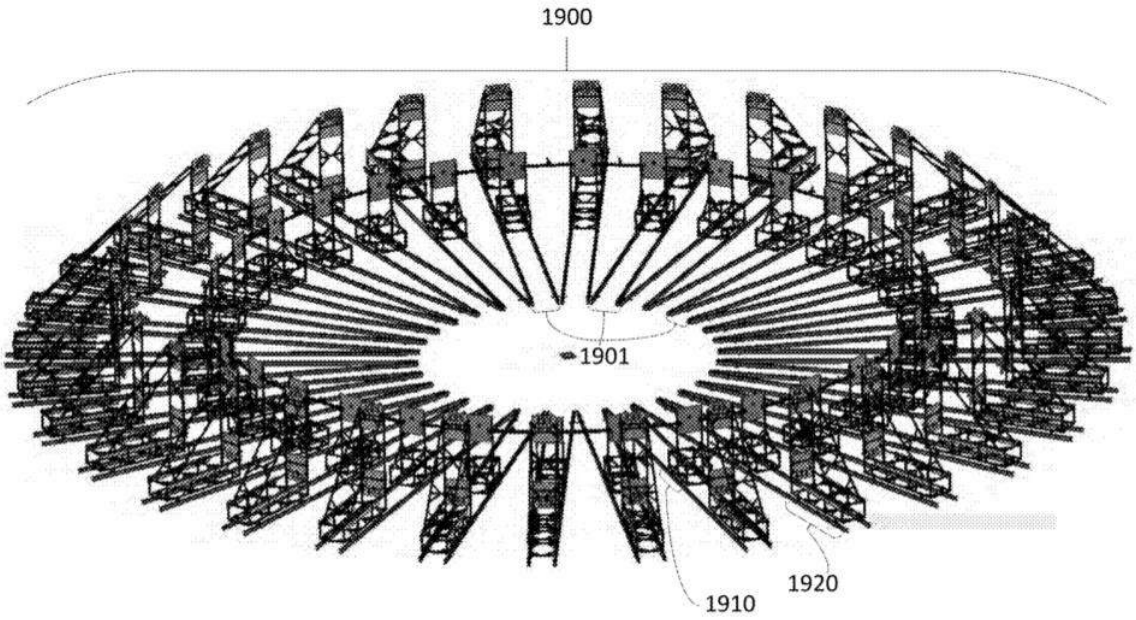
2. LTA Patents

The LTA airships have rigid, geodesic hulls that are designed to be assembled from a catalog of standard parts, many of which are 3D printed parts. The variety of parts used to build the rigid airship are defined in detail in patent US2021/0122453A1, "Methods and Apparatus for Constructing Airships." This patent also describes two types of assembly jigs:

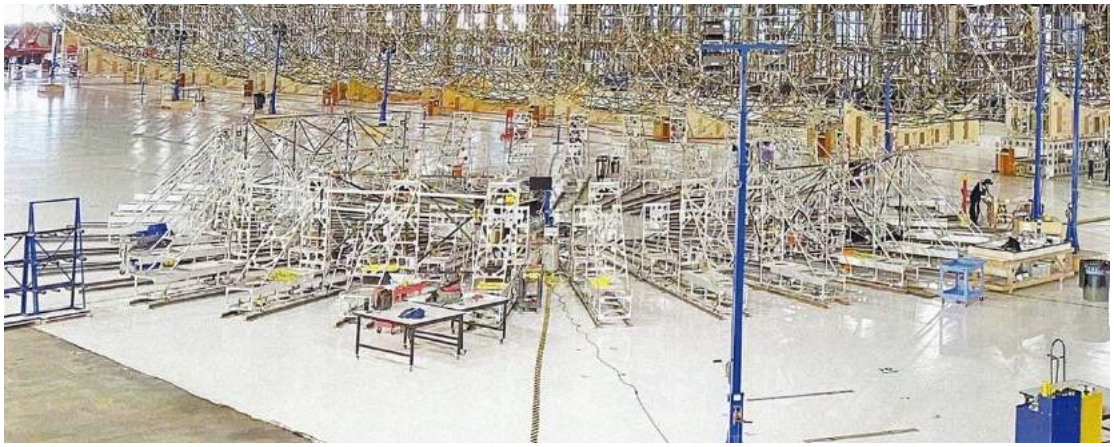
- Universal mainframe jig, used to assemble mainframes
- "Rollercoaster" jigs, used to assemble complete structural modules (hull segments)

Both jigs enable assembly and finishing work to be performed by workers at ground level.

The universal mainframe jig (1900) shown in patent Figure 21A (below) establishes the precise geometry for assembling a mainframe, which is one structural ring of a cylindrical structural module. The jig is installed horizontally on the floor, allowing easy access for workers. A mainframe is assembled in the space between the front carts (1910) and the back carts (1920).



Isometric view of a universal mainframe jig.
Source: US2021/0122453A1, Fig 21A



A universal mainframe jig on the manufacturing floor in Moffett Field Hangar 2, with the Pathfinder 1 airship under construction in the background.
Source: https://www.ltaresearch.com/

In patent Figure 25, the rollercoaster jig (2310) is shown as a fixed, arched support structure that allows a partially completed carbon fiber mainframe (240) to be precisely positioned vertically and then rotated around its longitudinal axis while finish work is completed by workers at ground level. A stationary tower (2333) may be used to prevent a single mainframe from falling over during construction.

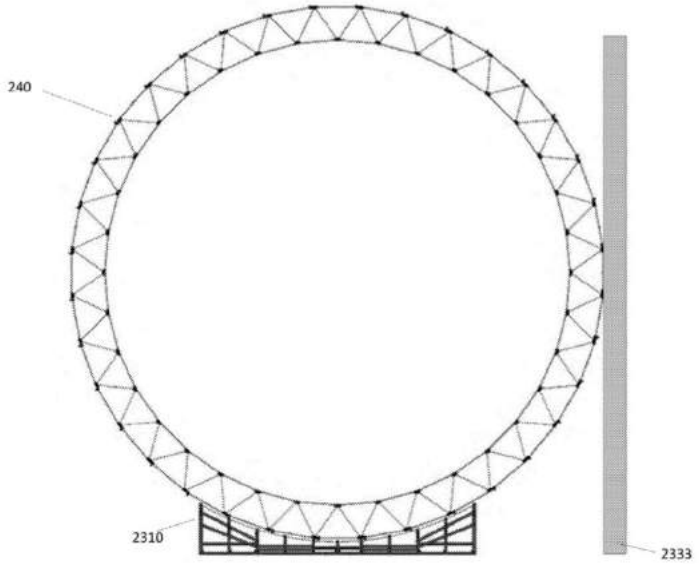


FIG. 25

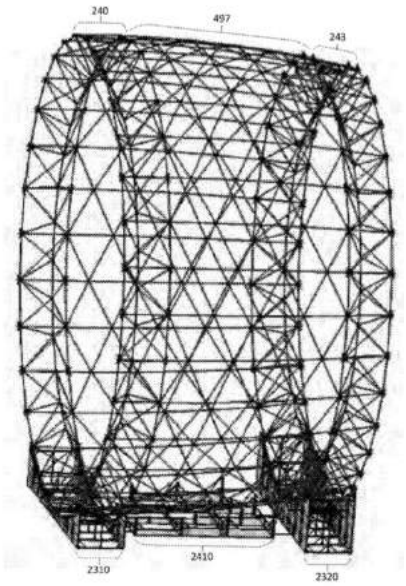


FIG. 27A

Patent Figure 27A shows two rollercoaster jigs (2310 & 2320) supporting two adjacent mainframes (240 & 243) that are rotated in unison while their connecting geodesic structure (497) is completed by workers at ground level, forming a hull segment.

The airship is assembled on a set of rollercoaster jig that are precisely positioned on the manufacturing floor. Patent Figure 1 shows a rigid airship hull comprised of 12 mainframes and 13 hull segments.

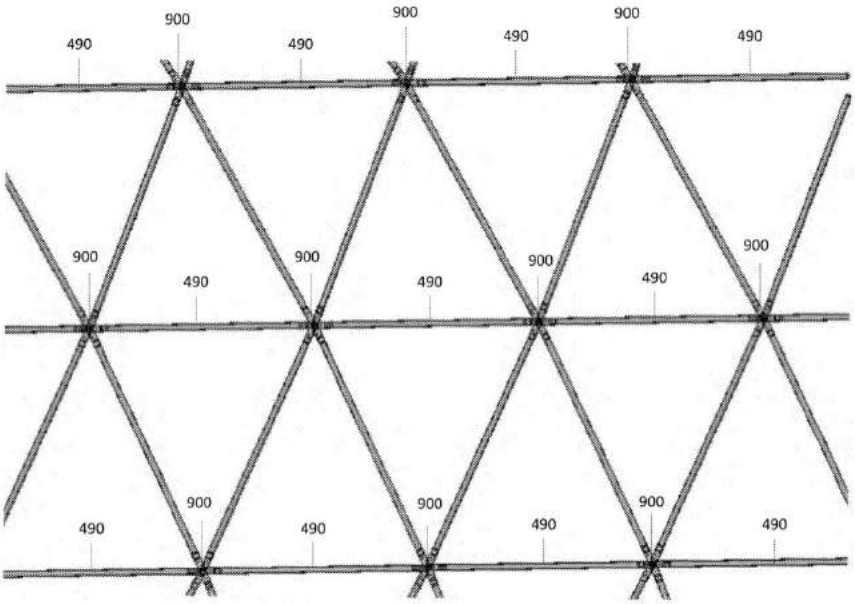
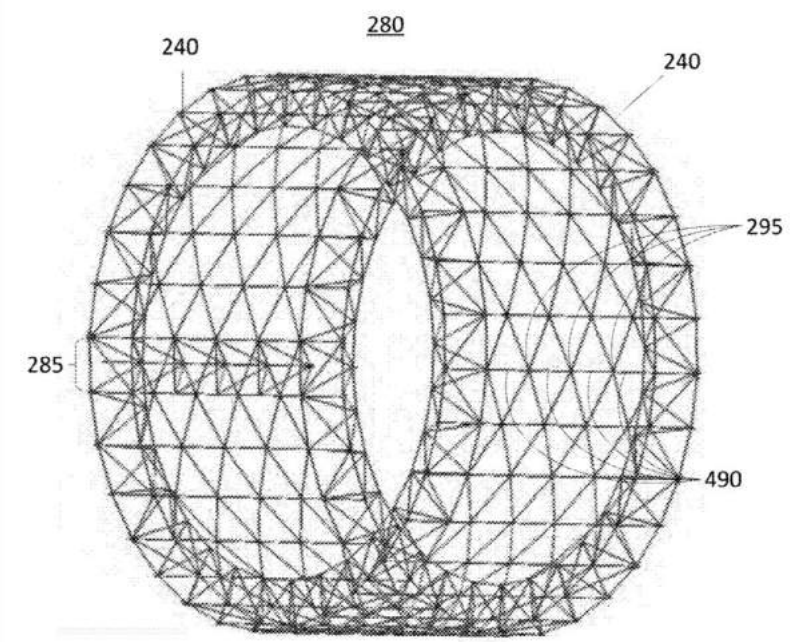


FIG. 5

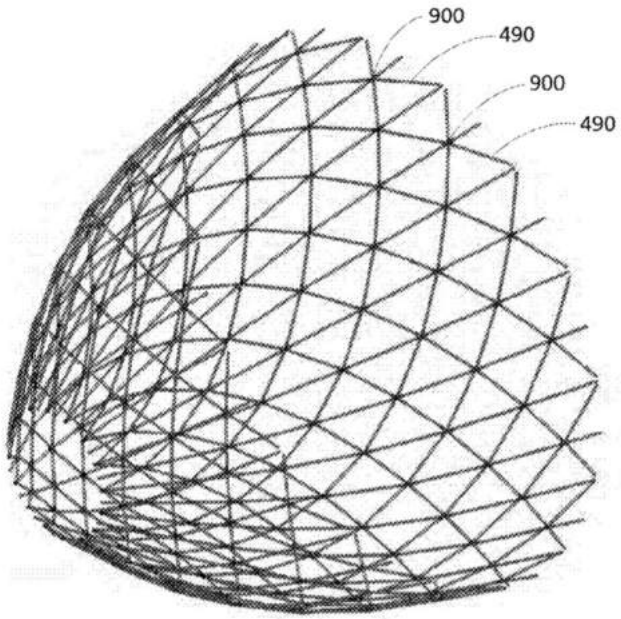
A simple geodesic carbon fiber structure comprised of longitudinal connectors (490) and 6-way geodesic joints (900). Source: US2021/0122453, Figure 5

An actual hull segment showing the scale of the carbon fiber longitudinal connectors and 6-way geodesic joints. Source: https://www.ltaresearch.com/



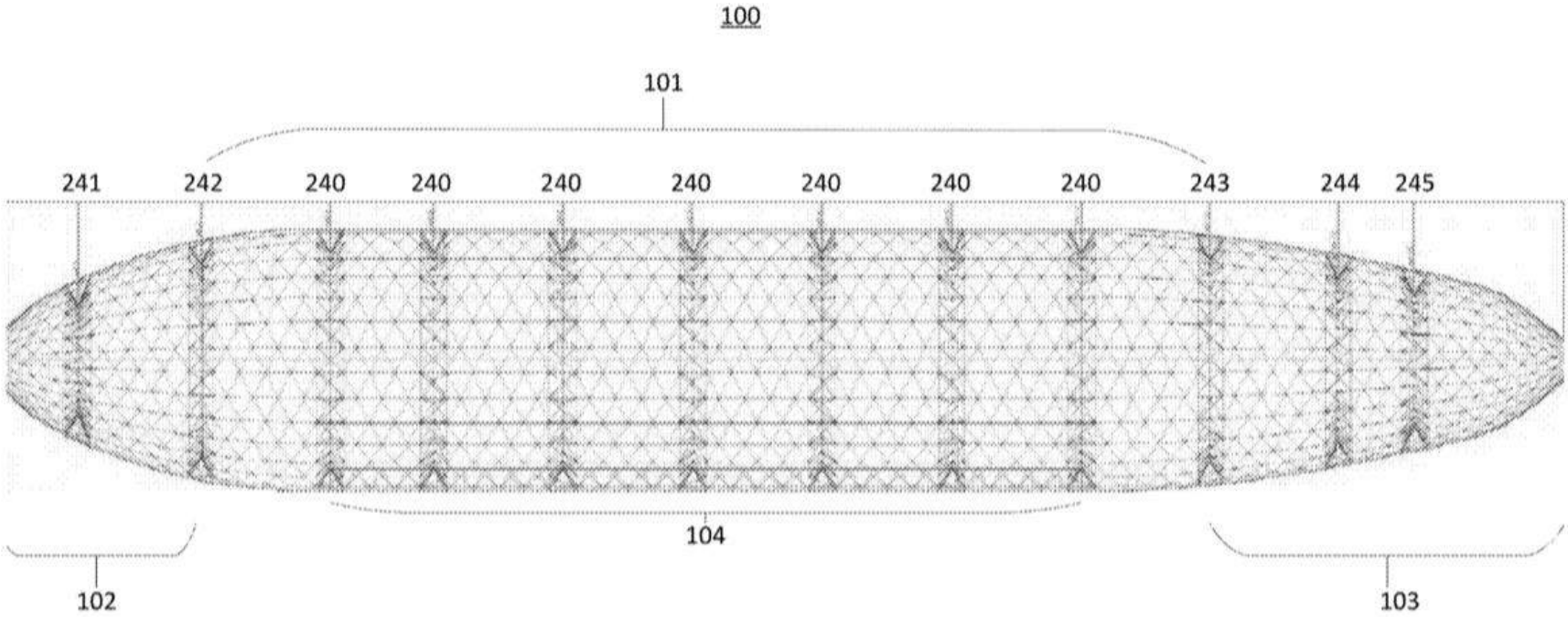
A representative geodesic carbon fiber hull segment (280) with two mainframes (240) forming the ends of the segment, and a geodesic structure (295) joining the mainframes. A "gangway" (285) is a lateral passageway between the mainframes. When installed, the hull segment is rotated so the gangway is on the bottom centerline.
Source: US2021/0122453A1, Figure 2C

Hull segments have been joined to form an airship hull.
Source: https://www.ltaresearch.com/



Sharply tapered, geodesic, carbon fiber structures for the bow and stern sections of the hull are comprised of longitudinal connectors (490) and 6-way geodesic joints (900).
Source: US2021/0122453, Figure 3C

A complex, heavily reinforced, curved geodesic structure.
Source: https://www.ltaresearch.com/



The complete geodesic carbon fiber airship hull in patent Figure 1 is comprised of 12 mainframes (240 to 245) that form the main hull section (101), the bow section (102) and the stern section (103). A gangway (104) provides access along the bottom centerline of the main hull section.
Source: US2021/0122453A1, Figure 1

3. Airship manufacturing facilities

LTA has access to the largest collection of airship manufacturing facilities in the world, with three hangars at Moffett Field in Sunnyvale, CA, and their largest hangar, the Akron Airdock, in Ohio. These extraordinary facilities were built between 1929 and 1943.

Moffett Field, Sunnyvale, CA

In a $1.16 billion, 60-year lease deal signed with NASA In 2014, Google formally took over the 1,000-acre Moffett Field site in Sunnyvale, CA in March 2015. At the time, Google announced that it "plans to repurpose its three airship hangars as laboratories for developing robots, rovers, drones, Internet-carrying balloons and other cutting-edge technology. The company will also manage the airfield's two runways…"

Moffett Field Hangar One, circa 2009. Source: Wikipedia

Hangar One is a giant steel frame structure built in 1933. It measures 1,133 feet (345 m) long, 308 feet (94 m) wide and 198 feet (60 m) high at the peak of the arched roof. Originally, the hangar was clad in galvanized steel panels, which were removed a decade ago when the site was being remediated for toxic materials. The clam-shell doors were designed to reduce turbulence when an airship was moved in or out on a windy day.

Moffett Field Hangar One with exterior panels removed, circa 2012
Source: Wikipedia

Moffett Field Hangars Two and Three.
Source: LTA via Smithsonian Air & Space magazine (October 2021)

Hangars Two and Three are identical wood frame structures built in 1943, when there was a steel shortage during WW II. They measure 1,075 ft (328 m) long, 297 ft (91 m) wide and 171 ft (52 m) high at the peak of the arched roof. Their interior height is about 160 feet (48.8 m). Two concrete and wood post-and-lintel structures support the 121 ft (37 m) high, multi-track, rolling doors at either end. LTA's Pathfinder 1 airship is being built in Hangar Two.

The Akron Airdock, Akron, OH

The giant steel frame Akron Airdock (formerly the Goodyear Airdock) was built in 1929. It measures 1,175 feet (358 m) long, 325 feet (99 m) wide and 211 feet (64.3 m) high. The Airdock is the facility where several other large rigid airships were built in the 1930s, including the *USS Akron* and *USS Macon.*

The Akron Airdock. Source: Akron Beacon Journal

The Development Finance Authority of Summit County, OH, has owned the Akron Airdock since 2006, with Lockheed Martin leasing the Airdock since then and using it to develop airship and other technologies. Lockheed Martin has sub-leased the Airdock to LTA.

In March 2021, the Development Finance Authority authorized selling the Airdock for an undisclosed sum subject to approval by the Environmental Protection Agency (EPA) on matters related to toxic material immobilization and remediation. As noted previously, LTA reports that they have entered into an agreement to purchase the Akron Airdock, pending completion of the EPA approval process. As of March 2022, the Airdock sale has not closed and no closing date has been set. The sale price won't be disclosed until the property is sold.

In March 2021, the Akron Beacon Journal reported that LTA planned to build large, rigid airships in the Airdock and had posted several local job openings. LTA has been collaborating since 2017 with the University of Akron's College of Engineering and Polymer Science to develop design and prototyping skills, and to build sub-scale, electric-powered models to demonstrate airship manufacturing technologies and support the development of control systems for large airships. Sub-scale models have flown inside the Airdock.

LTA reported in June 2022 that test sections for the Pathfinder 3 airship were being built in the Airdock to refine the manufacturing process. Work on building Pathfinder 3 is expected to start in the second half of 2022, with completion in about two years.

Interior view of the Akron Air Dock with a test section of the Pathfinder 3 (right, background).
Source: Jeff St. Clair / WKSU (May 2022)

4. Engineering development

Fly-by-wire digital flight control system

The digital flight control system combines control inputs from the pilot (via joystick controllers) with flight and equipment sensor feedback to coordinate the operation of the many electric motor-driven, thrust-vectoring propulsors and the aerodynamic control fins. The Pathfinder 1 flight control system has been tested on sub-scale models and on modified commercial blimps owned or leased by LTA.

Outer skin material

LTA reports that, “Our team in Gardnerville, Nevada, researched and tested many cover options for Pathfinder 1. None performed as well as Tedlar® material, which is lightweight, strong, non-flammable, UV-resistant, and blocks visible light.”

Electric propulsion modules

LTA collaborated with electric aircraft pioneer Pipistrel to develop the electric motor-driven, thrust-vectoring propulsors for Pathfinder 1. LTA reports that “the motors rotate from +180º to -180º for effective directional control.”

Hydrogen fuel cells

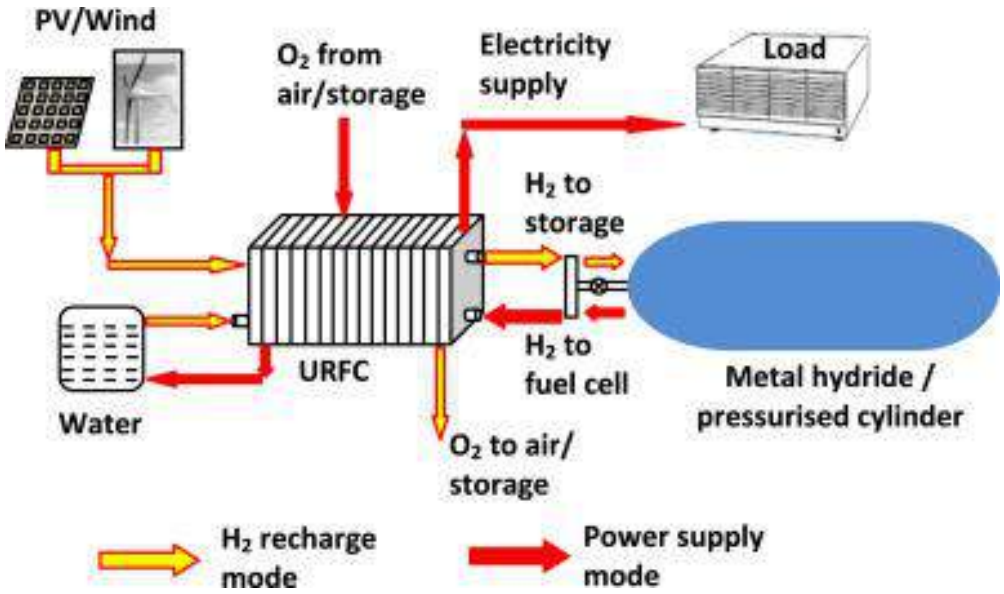
The Pathfinder 1 is expected to have a hybrid solar photovoltaic (PV) electric power system with batteries and diesel generators. There has been speculation that LTA is actively developing hydrogen fuel cell systems for use in later Pathfinder airships and the Next Generation Airship. Details of LTA’s hydrogen fuel cell program are unknown. However, to put such a program in context, we’ll take a brief look at the 2022 state-of-the-art of pressurized, gaseous hydrogen-electric powertrain development for aviation applications.

An advanced all-electric airship designed for 24/7 operation likely will have a hybrid electric power system in which a solar photovoltaic (PV) system generates electric power for operation and “recharging” a regenerative fuel cell (RFC) during daylight hours, and the RFC

generates electric power for operation at night. Diesel engines may be part of the hybrid electric power system for use as backup power sources and/or to supply additional electric power when needed.

As an energy storage device, an electrolyzer (the “regenerative” part of the RFC system) uses electrical energy to split water into hydrogen and oxygen. The hydrogen is stored in pressurized tanks for use during the next cycle of energy generation. The oxygen may be stored or vented to the atmosphere. As a generator, stored hydrogen and oxygen (from a storage tank or the ambient atmosphere) are combined in the fuel cell to produce electrical energy and water. One kilogram (2.2 lb) of hydrogen combining with oxygen produces nine kilograms (19.8 lb) of water, which is reused in the next regenerative cycle to again produce pressurized hydrogen and oxygen gas.

Authors Biddyut Paul and John Andrews reported in 2016 on design considerations for a unitized regenerative fuel cell (URFC), which is a single cell that can function both as a fuel cell and electrolyzer. They noted that “URFCs have mass and volume savings compared to conventional hydrogen systems employing a separate electrolyzer and fuel cell.” Such savings may be particularly attractive for airship applications. Following is a process-flow diagram for a UFRC.



Source: B. Paul & J. Andrews (2016), https://doi.org/10.1016/j.rser.2017.05.112

In a February 2021 article, Mark Harris, writing for TechCrunch, reported that "…the largest (non-regenerative) hydrogen fuel cell to fly to date is a 0.25-megawatt system (250 kilowatts / 340 shp) in ZeroAvia's small passenger plane last September (2020)."

A year later, in February 2022, Graham Warwick, writing for Aviation Week & Space Technology reported: "ZeroAvia is preparing to fly a 19-seat Dornier 228 with a 600 kW (816 shp, non-regenerative) hydrogen-electric powertrain, aiming for market entry in 2024. The startup also is developing a 2 – 5 megawatt (2,719 – 6,798 shp) system and has agreements to retrofit 50-seat regional jets and 80-seat turboprops."

Clearly, the state-of-the-art is rapidly developing for pressurized, gaseous hydrogen-electric powertrains for aviation applications. It will be interesting to see when such powertrains are introduced on LTA airships.

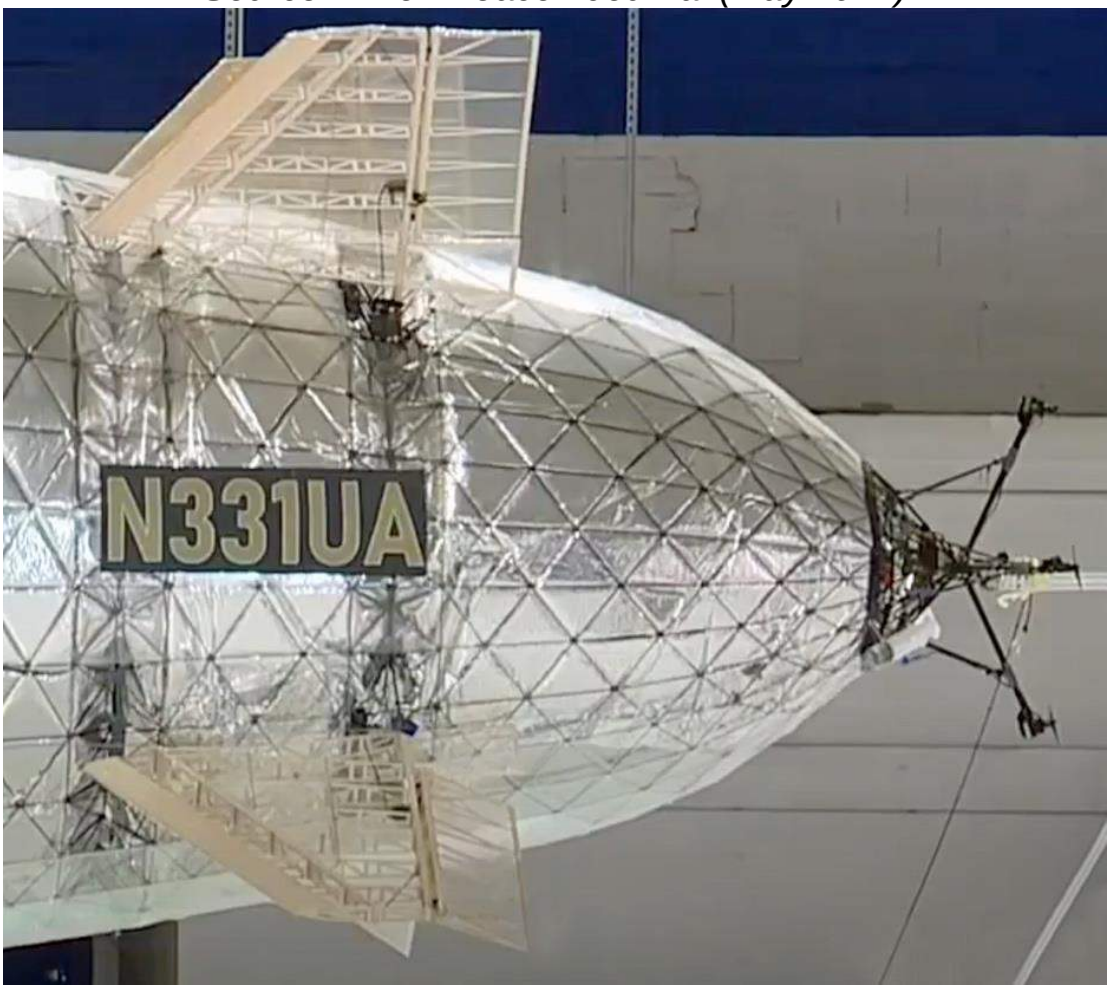
5. Training and testing airships and flight simulator

LTA has been flying subscale airship models to help validate design features and flight control systems. In addition, LTA is flying two commercial blimps near their headquarters at Moffett Field, CA.

Subscale airship models

One example is a 50-ft (15-m) long, lithium-ion battery powered, 12-engine "baby airship" that has been used primarily as a testbed for the Pathfinder 1 flight control system. The general layout of this subscale model closely resembles the Pathfinder 1.

Subscale airship moored in its cradle in the Akron Airdock.
Source: Akron Beacon Journal (May 2022)



Stern details, including X-tail & four stern thrust-vectoring propellers.
Source: Screenshot, News 5 Cleveland, 5 video (May 2022)

Bow view of a subscale airship in the Akron Airdock.
Source: LTA via BBC (July 2022)

Thrust-vectoring flank propeller details.
Source: Screenshot, News 5 Cleveland, 5 video (May 2022)

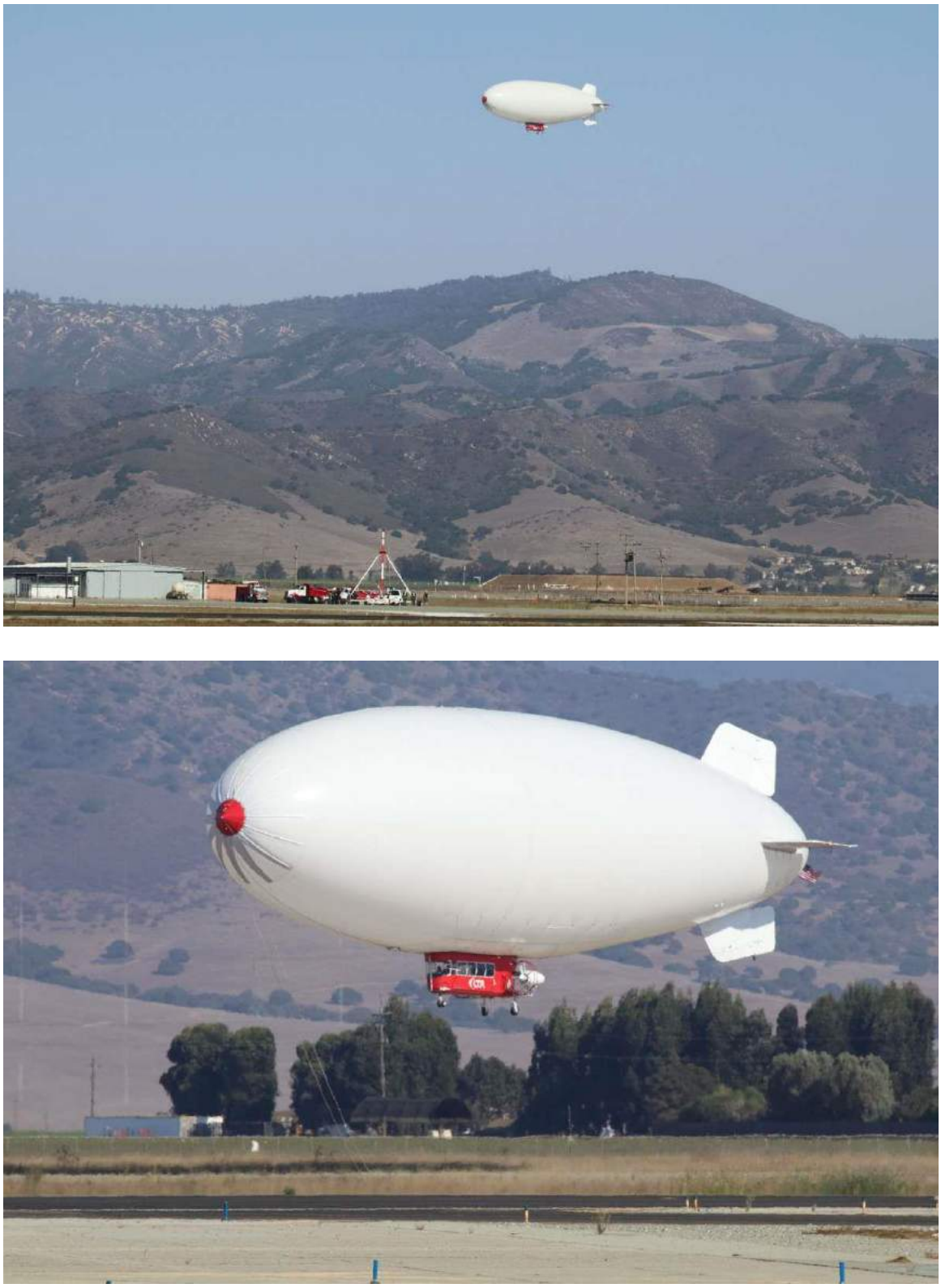
American Blimp Corp. A-60R

LTA became the registered owner of American Blimp Corp. (ABC) A-60R, tail number N615LG, on 1 September 2020 and has been flying this blimp in the San Francisco Bay Area. This blimp operated for many years as a MetLife advertising blimp.

LTA's A-60R flying in January 2020. IEEE Spectrum

American Blimp Corp. A-170G

ABC originally manufactured the non-rigid MZ-3A blimp for the Navy in 2006. After the Navy retired the blimp in 2014, ABC purchased it back in 2017. Now with civilian registration N157LG and known as the A-170G, this blimp made its first civilian flight in June 2021. Later in 2021, ABC leased the A-170G to LTA, where it is being used for airship systems development and training.



A-170G with LTA logo at the Salinas Municipal Airport on 3 October 2021. Source, both photos: Alan Wilson via SFGate (5 Oct 2021)

Flight simulator

LTA has developed and is operating an airship flight simulator in Akron, in a building near the Airdock.

Source: Screenshot from LTA video

Andrea Deyling, airship pilot and head of pilot training at LTA in the flight simulator. Source: Mike Cardew / Akron Beacon Journal (May 2022)

6. Pathfinder 1 airship

The Pathfinder 1 is being built in Hangar Two at Moffett Field and, as of mid-2022, was in an advanced stage of construction.

General design characteristics of the Pathfinder 1

Parameter	**Pathfinder 1**
Airship type	Rigid • Carbon composite and titanium geodesic spaceframe hull • Multi-layer Tedlar® fabric outer skin
Length	400 feet (121.9 m)
Diameter	Estimated at about 67 ft (20.4 m), scaled from LTA 3D model
Hull aspect ratio	6.0 (calculated)
Lifting gas	Helium
Total lift	28 tons (56,000 lb / 25,401 kg)
Lifting gas volume	Estimated at about 806,940 ft^3 (22,850 m^3), at sea level, based on LTA cited total lift
Payload	Estimated at about 20% of total lift: 5 to 6 tons (10,000 – 12,000 lb / 4,536 – 5,443 kg)
Propulsion / maneuvering system	12 electric motor-driven, thrust vectoring propellers: • Eight electric motors arranged longitudinally along the flanks of the airship • Four motors in an array at the tail
Aerodynamic control surfaces	X-tail with fixed fins and ruddervator control surfaces, which combine the functions of both a rudder and an elevator.
Power system	Hybrid solar photovoltaic (PV) / battery electric power system • Diesel generators for backup & peak power
Accommodations	Conventional gondola carrying up to 14 people: • Two crew positions in the cockpit • Up to 12 passengers

LTA reported that the hull is comprised of 13 mainframes, each weighing 600 pounds (272 kg) in the main (cylindrical) hull section and less in the smaller diameter bow and stern hull sections. The hull is reinforced where the spaceframe connects to the gondola, landing gear and the tail motors. A small gangway running the length of the keel, providing crew access to the interior rigid frame.

The German firm ZLT Zeppelin Luftschifftechnik GmbH (builders of the Zeppelin NT) manufactured the gondola, landing gear and fins for Pathfinder 1. The tandem landing gear was adapted from the Zeppelin NT design, with stronger dampers and wheels to handle the heavier loads that will be encountered on Pathfinder 1.

FAA records show that the Pathfinder 1 was assigned N-number N125LT on 22 May 2020. The FAA registry information for Pathfinder 1 is available here: https://registry.faa.gov/aircraftinquiry/Search/NNumberResult?NNumberTxt=125LT

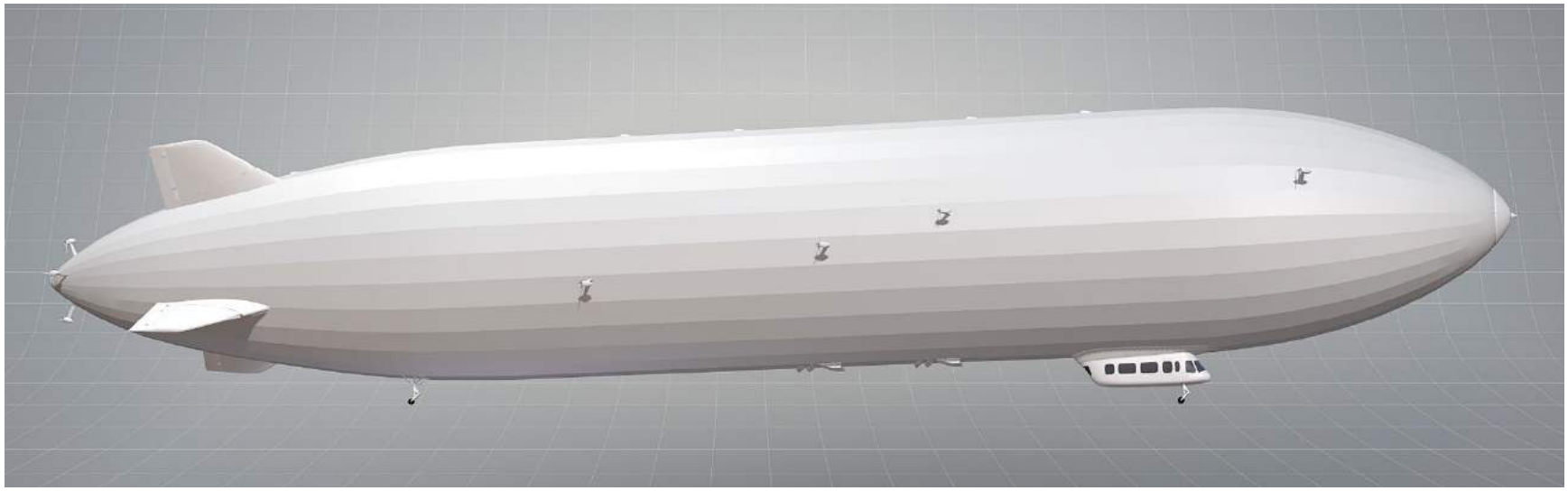
The Pathfinder 1 is expected to make its first flight in 2022. When the airship is fully outfitted, Pathfinder 1 will conduct flight tests near its base at Moffett Field before relocating to its future home at the Airdock in Akron, OH.

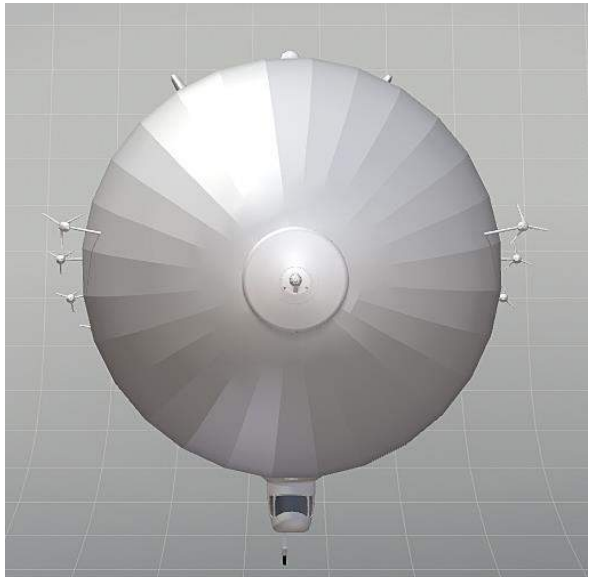
400 foot (121.9 m) long Pathfinder 1 under construction in 2021 in Moffett Field Hangar 2. Note the mainframe jig in the foreground and the several tan-colored "rollercoaster" jigs under the mainframes in the geodesic hull. Source: LTA via Smithsonian Air & Space magazine (October 2021)

Pathfinder 1 side view, in Moffett Field Hangar 2 in mid-2022.
Source: LTA, screenshot from website video (July 2022)

Pathfinder 1 bow quarter view, in Moffett Field Hangar 2 in mid-2022.
Source: LTA, screenshot from website video (July 2022)

Pathfinder 1 stern view, in Moffett Field Hangar 2 in mid-2022.
Source: LTA via BBC (July 2022)

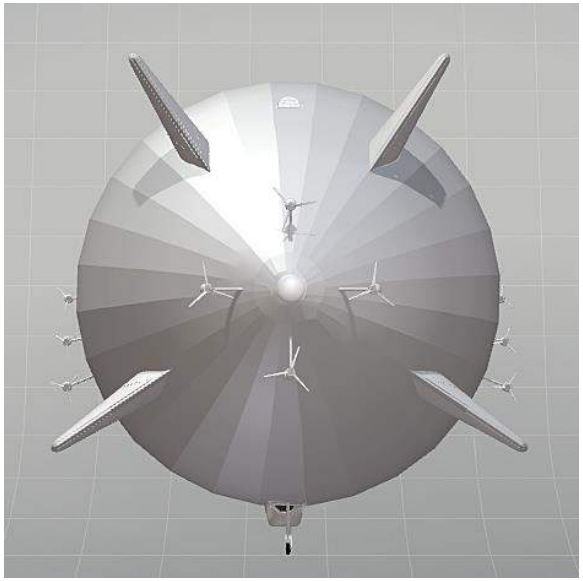


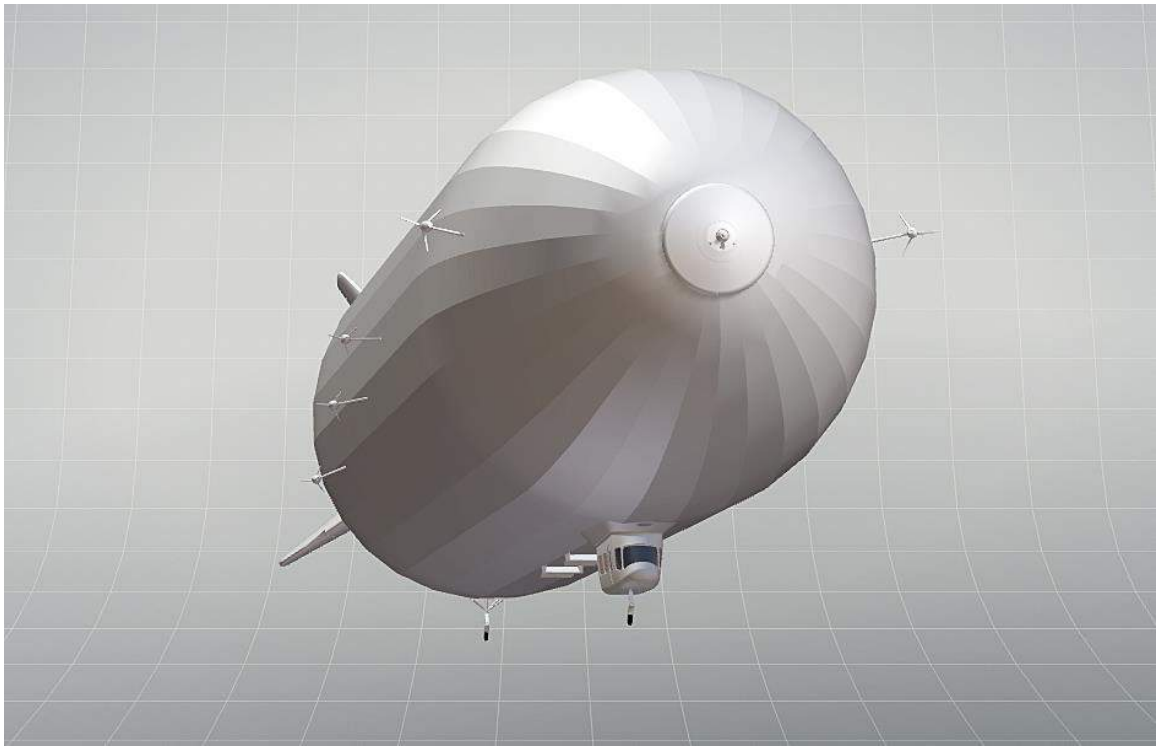


LTA 3-D model side, bow & stern views of the Pathfinder 1 airship. Note the placements of:

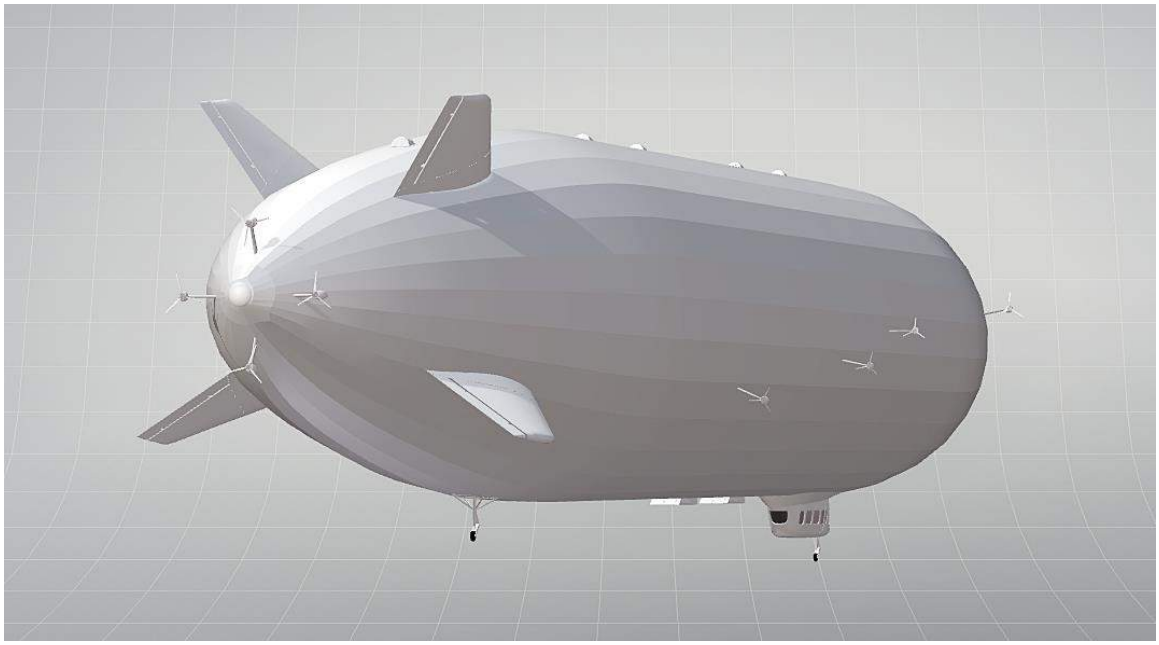
- *Eight (8) flank-mounted propellers and four (4) stern-mounted propellers,*
- *Fore and aft centerline landing gear, and*
- *X-tail upper fin dihedral & lower fin anhedral angles*

Source: LTA screenshots





LTA 3-D model bow quarter view of the Pathfinder 1 airship.



LTA 3-D model stern quarter view of the Pathfinder 1 airship.
Source, both images: LTA screenshots

Pathfinder 1 tail electric motor layout.
Source: Source: Screenshot, LTA video

Pathfinder 1 gondola, manufactured by ZLT Zeppelin Luftschifftechnik GmbH. Source: Screenshot, LTA video

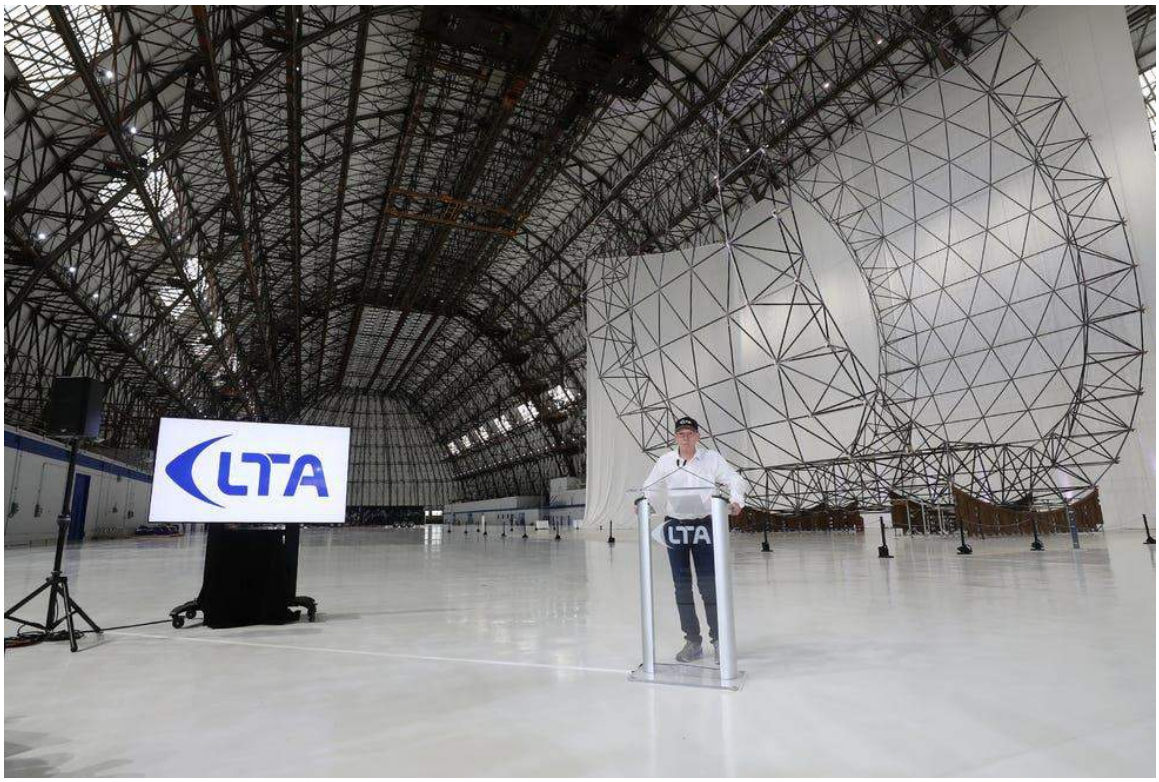
7. Pathfinder 3 airship

LTA reported in May 2022 that test sections for the Pathfinder 3 airship were being built in the Airdock. In addition, LTA reported the following design parameters.

General design characteristics of the Pathfinder 3

Parameter	**Pathfinder 3**
Length	About 600 ft (183 m)
Diameter	About 100 ft (30.5 m)
Hull aspect ratio	6 (calculated)
Lifting gas	Helium
Total lift	About 100 tons (200,000 lb / 90,719 kg)
Lifting gas volume	Estimated at about 2,882,347 ft^3 (81,619 m^3), at sea level, based on LTA cited total lift
Payload	About 20 tons (40,000 lb / 18,144 kg), about 20% of total lift
Range	About 10,000 miles (16,093 km) using electric-only power sources
Power system	• Initially, hybrid solar PV / battery electric power system, likely with diesel generator backup (similar to Pathfinder 1) • Long-term goal is to implement a hybrid solar PV / regenerative hydrogen fuel cell power system, possibly with diesel generator backup
Endurance	About two weeks

Work on building Pathfinder 3 is expected to start during the second half of 2022, with completion within two years.



LTA's CEO Alan Weston standing in front of a 100-foot (30.5-m) tall mainframe test section on rollercoaster jigs in the Akron Airdock. Source: Mike Cardew / Akron Beacon Journal (May 2022)

8. Next-Generation Airship

LTA's Next-Generation Airship will be built in the Akron Airdock. It will be larger than Pathfinder 3 and too large to be built at Moffett Field.

The Next-Generation Airship will benefit from lessons learned in building and flying the Pathfinders 1 and 3 airships. While LTA has not provided confirmation, the Next-Generation Airship is expected to have a hybrid solar PV / hydrogen fuel cell electric power system, probably with diesel generators for backup power. The airship is expected to have long range to enable intercontinental deployments on various missions, including humanitarian missions.

When LTA's Next-Generation Airship has received its type certificate and is operational, it will be an important milestone in achieving LTA's goal of substantially reducing the global carbon footprint of aviation.

9. For more information

LTA

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