Varialift Airships Plc - variable buoyancy airships

Peter Lobner, updated 24 February 2024

1. Introduction

Varialift Airships Plc, headquartered in Stourbridge, West Midlands, UK, was incorporated on 23 March 2007 with the goal of developing all-aluminum, rigid, heavy-lift cargo airships that implemented variable buoyancy control based on patent applications first filed in 2005 by Alan Hadley and subsequently granted in the U.S., Europe and Hong Kong. Alan Hadley is the current Director of Varialift Airships Plc. The firm's website is here: https://www.varialift.com

General arrangement of a Varialift all-aluminum, rigid, variably buoyancy airship. Source: Varialift

Varialift developed designs for two large, modular cargo airships, the 50 metric ton (55 ton) ARH 50 and the 250 ton (275 ton) ARH 250.

In 2010 – 2011, Varialift built and operated a sub-scale test rig that validated the modular design of the variable lift unit from which Varialift airships will be built.

The firm designed and planned to build a sub-scale operational prototype, the ARH-PT, that would further validate the Varialift airship design and also serve to train future pilots and attract investors to fund further airship development and certification work.

After determining that a suitable manufacturing site was not available in the UK, Varialift considered a number of potential sites in France and in 2016 selected a former military facility in Châteaudun, southwest of Paris, which offered the space and basic structures needed for large-scale, modular airship manufacturing.

Development and operation of the manufacturing facility at Châteaudun was the responsibility of a Varialift Plc subsidiary, Varialift Manufacturing France SARL, which was established in November 2016. After site improvements, Phase 1 work focused on setting up the manufacturing line for the ARH-PT. Airship completion was expected by late summer 2019, with flight testing to commence later in that year.

Phase 2 work later would set up the manufacturing line for the full-scale, 50 ton ARH 50 commercial cargo airship. At some later time, manufacturing would be expanded to include the much larger 250 ton ARH 250 commercial cargo airship.

At the March 2019 Aviation Innovations Conference – Cargo Airships in Toronto, Canada, Varialift reported that it has received binding orders for the ARH 50 and ARH 250 airships.

Affected by Brexit, COVID-19, French labor issues and a funding shortage, Varialift stopped work on the ARH-PT in 2021, when the airship about 50% complete. Varialift's lease on the Châteaudun factory site expired in August 2022, and the firm was forced to vacate the site.

Varialift's hope for an agreement with the UK Department of Trade and Industry for substantial additional funds did not materialize. As of February 2024, Varialift has not announced a renewal of the Châteaudun site lease or relocation of its ARH-PT manufacturing activity. The fate of the ARH-PT prototype airship is uncertain.

2. General characteristics of Varialift airships

Varialift has identified the following main features of their airships:

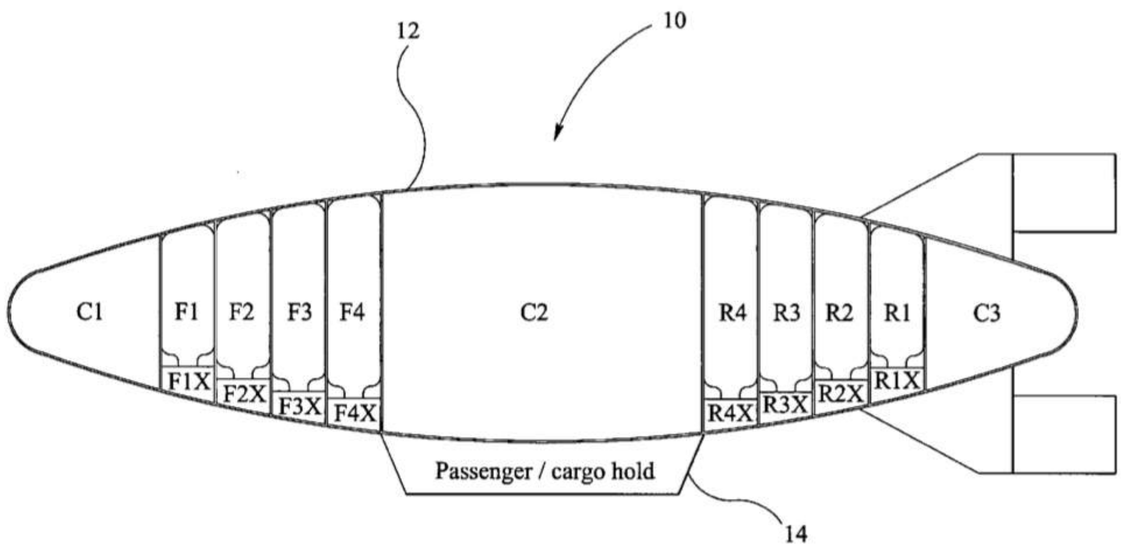
- Rigid aluminum airframe and aluminum-clad aeroshell with the following attributes:
    - Minimum loss of helium
    - Long working life; at least 40 years airframe operating life expected
    - Practical to repair away from base; can be welded with MIG or TIG
    - Insulated to limit heat input to helium cells
    - Well suited for installation of solar cells
    - Can be recycled at end-of-life
- All lift is aerostatic (from the lifting gas), managed by a variable buoyancy control system.
- Designed for modular construction. The airship's hull is built up from many standardized "variable lifting units" that can be manufactured separately and assembled into the complete airship at the factory.
- Capable of vertical takeoff and landing (VTOL) and hovering indefinitely without the need for lift from engines (vectored thrust).
- Capable of operating in strong front and crosswind conditions (up to 50 knots / 92.6 kph), due to the high inertial mass of the airframe supplemented by bow and stern lateral thrusters.
- Capable of operating from any flat space large enough for the airship to land vertically. No airport or runway infrastructure, ground crew or hangar is needed.
- Designed for operation in full IFR (instrument flight rules) conditions, with a full glass cockpit.
- Capable of flying at higher altitudes than conventional and hybrid airships; cruise at 6,096 m (20,000 ft); maximum altitude 9,144 m (30,000 ft).
    - At maximum altitude, solar power generation will be a factor of 2 greater than at sea level.

- Capable of flying faster than conventional and hybrid airships; 250 - 350 kph (155 – 218 mph), with the higher speeds at higher altitudes.
- Capable of flying long range missions; 11,112 km (6,000 naut. miles) or more with conventional aero engines.
    - Range with solar-electric power system can be longer.
- Very large internal cargo hold; enables roll-on, roll-off (Ro-Ro) cargo handling and economic transport of high-volume / low-weight cargo.
- Able to carry outsized bulky cargo as an underslung external load supported from an internal crane by cables, and deliver the cargo from a hover, without landing.
- Costs 80 to 90% less to purchase and operate than an equivalent cargo aircraft.
- With conventional aero engines, burns 80 to 90% less fuel than an equivalent fixed-wing cargo aircraft.
    - Operating costs rival truck or rail (point-to-point) transportation costs.
- Can implement a solar-electric power system with zero carbon emissions.
    - If an EU aviation carbon tax is implemented, a solar-powered airship may be eligible for aviation carbon credits.

3. Variable buoyancy patent

As described in patent US7568656B2, which was granted in 2009 to Alan Hadley, the airship (10) includes a metal body shell (12), a load-bearing hold for cargo and passengers (14) and the following features related to the variable buoyancy control system:

- C1 - C3 are fixed compartments containing the lighter-than-air gas.
- F1 - F4 are forward variable displacement compartments (lift cells).
- F1X – F4X are forward fixed-volume pressurized receiver cells.
- R1 – R4 and R1X – R4X are the comparable rear compartments.



Source: US7568656B2, Fig. 3

The patent describes operation of the buoyancy control system as follows:

> "A system for controlling lift of an aircraft comprises an inflatable compartment for containing a gas which is lighter than air. A receiver receives and stores the gas in a compressed condition. Means are provided for compressing the gas and transferring it from the inflatable compartment into the receiver thus reducing the lift force on the aircraft."

> “The system ………further comprising a plurality of expansion systems to expand and transfer the gas from one of the receivers into the associated inflatable container thus increasing the lift.”
>
> “The system may further comprise a fixed displacement compartment containing a gas which is lighter than air. This compartment provides a fixed lift to overcome the dead weight of the airship, with the variable displacement compartments being used to vary the lift.”

Other aspects of the patent pertain to the use of diaphragm pumps for efficient helium compression and the design of the aluminum body shell, which must allow air to enter and vent as needed to maintain atmospheric pressure within the shell while the inflatable helium compartments expand or contract.

Other related variable buoyancy patents are:

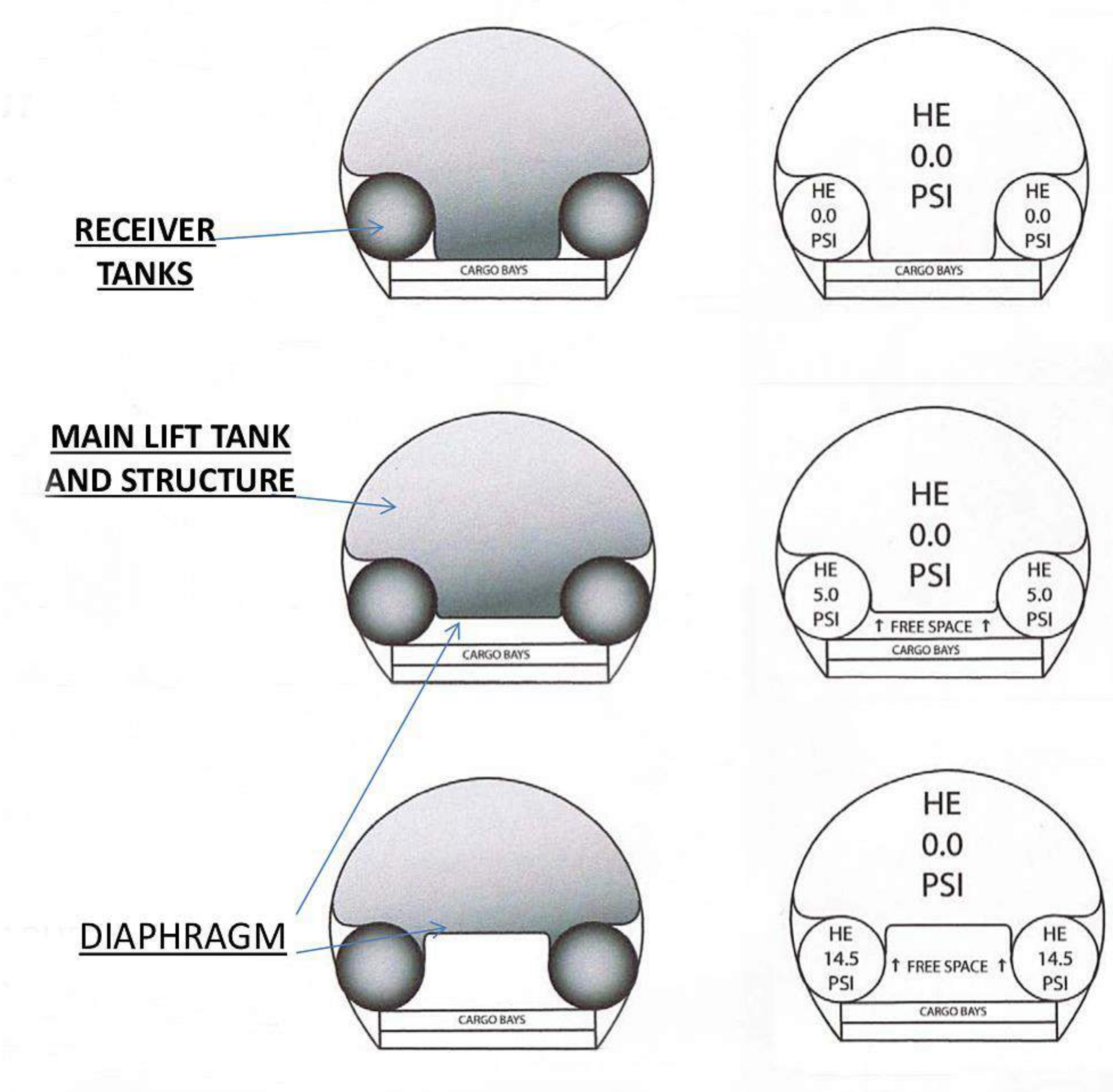
- European Patent No. EP1591356B1
- Hong Kong Patent No. HK 1083614

4. Implementing variable buoyancy control on a Varialift airship

Variable buoyancy control is implemented as follows:

- The variable buoyancy system and associated low-speed control system enable the airship to maintain position and orientation during vertical takeoff and landing (VTOL) and hover. Varialift airships can hover indefinitely in suitable wind conditions.
- Main lift volumes operate at atmospheric pressure. Maximum pressure in the pressurized receiver tanks is 100 kpa (14.5 psig).
- When on the ground, the airship can be made heavier-than-air by compressing some of the helium in the main lift volume and moving it into smaller pressurized receiver tanks. In response to the reduced size of the main lift volume, ambient air enters the aeroshell and maintains atmospheric pressure. With the added mass of the air, the now heavier-than-air airship is stable for loading and unloading without the need for additional ballast control.
- Following loading, the cargo bays are secured, the main lift tank is recharged with helium from the pressurized receiver tanks and some ambient air within the aeroshell is vented to the atmosphere until positive buoyancy is achieved. The now lighter-than-air airship lifts vertically into the air without the need for the engines to generate propulsive lift or forward motion to produce aerodynamic lift.
- Bulky underslung loads (i.e., electricity pylons, wind turbine blades and towers, large power plant components, prefabricated structures) can be picked up and dropped off from precise locations without the airship having to land. The variable buoyancy control system manages changes in mass as cargo is picked up or dropped off.
- The time it takes for the airship to change buoyancy during a load exchange depends on the amount of buoyancy compensation required and the pumping / venting capabilities of the variable buoyancy system.

The arrangement of the main lift tank (the helium volume), the receiver tanks and the ambient air volume are shown in the following diagrams, which also show the expansion of the air volume (labeled "FREE SPACE") as the receiver tanks are pressurized.



Source: Adapted from Varialift / University of Manitoba, Canada

The Varialift airship's VTOL capability depends entirely on helium lift. This is quite different than the short takeoff and landing (STOL) capability of hybrid airships that depend on the combined aerostatic lift from the buoyant lifting gas, propulsive lift from thrust-vectoring engines, and aerodynamic lift from the shaped fuselage once the airship is in forward flight.

When performing a load exchange, the variable buoyancy system must precisely manage helium lift by compressing helium from the main lift tanks or by releasing compressed helium into the main lift tanks. Compression will be the slower process, and will dictate how quickly a neutrally buoyant Varialift airship that has just landed will be able to discharge cargo. In this case, the helium compression system must make the airship heavier-than-air, at least equal to the weight of the cargo to be discharged plus some margin to ensure stability of the airship on the ground. Failure to make the airship heavy enough could result in the airship floating upward or moving in the wind during cargo unloading.

When hovering for an in-flight load exchange, the Varilift airship will be neutrally buoyant throughout the load exchange, with small variations in lift being managed by the airship's station keeping system.

5. The Varialift ground test rig

In 2010 – 2011, Varialift built a ground test rig that was representative of a single variable lift unit of their modular variable buoyancy airship. The rig was built and tested at Halfpenny Green Airport in Wolverhampton, UK. Varialift reported, “The project was completed in November 2011 when the test flight was successfully conducted and the unit lifted off the ground under full control using its variable buoyancy units. The first man to be lifted into the air was Mr. David Bacon.”

During the tests, the maximum operating pressure of the receiver tanks was 100 kpa (14.5 psig). One receiver tank was later tested to determine its burst pressure, which was found to be 311.6 kpa (45.2 psig); providing a wide safety margin. The scale of a receiver tank is apparent in the following Varialift photo.

Receiver tank prior to installation in the test rig. Source: Varialift.

The validated design of the variable lift unit is the basis for the modular units that will be manufactured and assembled to produce an airship hull.

Following is a series of Varialift photos showing the construction of the variable lift unit for the test rig. These photos also provide insights to the actual design of the Varialift airship.

Receiver tank installed in fuselage structure.

Start of the tubular framework for one variable lift unit showing the positions of the two receiver tanks. Source, both photos: Varialift.

Tubular framework and receiver tanks for one variable lift unit.

Installation of aluminum skin on a variable lift unit in progress.
Source, both photos: Varialift.

Aluminum shell complete on one variable lift unit.

Gas envelope installed in one variable lift unit.
Source, both photos: Varialift.

6. The Varialift ARH 50 airship

The first heavy-lift commercial Varialift airship, the ARH 50, is expected to be certified to carry up to 50 metric tons (55 tons; 110,200 lb) of cargo and will be powered by standard aero gas turbine engines. The rigid aluminum exterior offers the potential for adding thin-film solar panels on the hull and batteries to power a distributed electric propulsion system on future versions. There is space for almost 10,000 m^2 (107,600 ft^2) of solar panels on an ARH 50 hull.

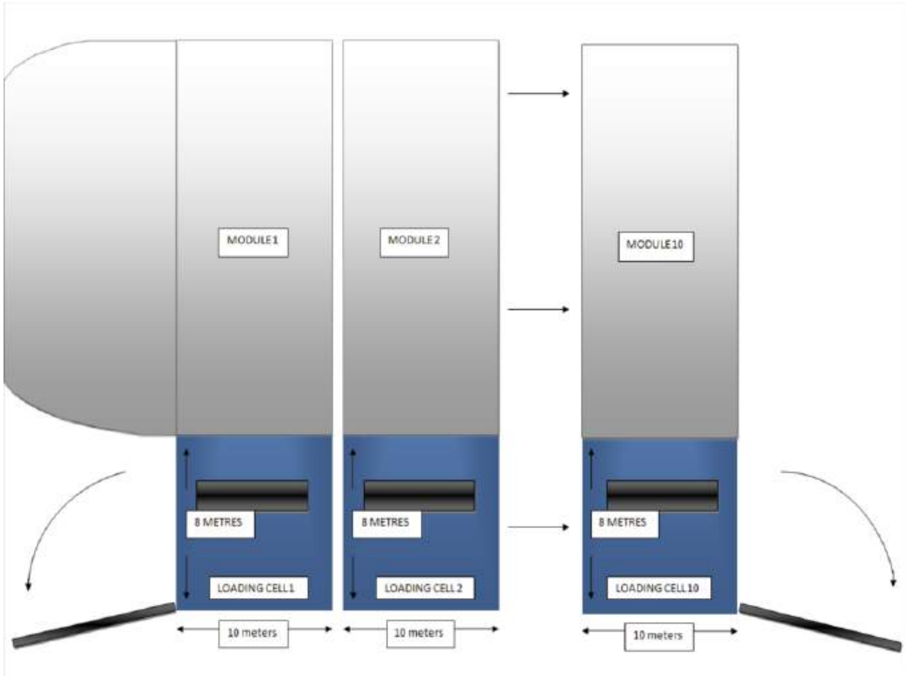
Basic design characteristics of the ARH 50

Parameter	**ARH 50**
Type	Rigid, fixed volume, variable buoyancy
Length	150 meters (492 ft)
Width, hull	52 meters (170 ft), not including flank-mounted propulsors
Weight, empty	175 metric tons (386,000 lb)
Internal cargo hold dimensions	L 100 x W 50 x H 10 m (328 x 164 x 33 ft), forming a single-level roll-on, roll-off cargo deck
Internal cargo volume	50,000 m^3 (1.76 million ft^3)
External cargo	Internal cargo crane can carry an external suspended load (i.e., outsized, bulky cargo)
Cargo weight, max	50 metric tons (55 tons; 110,200 lb)
Crew	2
Propulsion & maneuvering	• 2 x flank-mounted, fixed aero gas turbine engines • 2 x lateral “tunnel” thrusters mounted in the hull, one at the bow and one at the stern
Est. fuel consumption	900 liters/hr (238 gallons/hr) with conventional propulsion / maneuvering system
Aerodynamic controls	• Flank-mounted all-moving horizontal stabilizer • Vertical tail fin with rudder
Speed	• 250 kph (155 mph) @ sea level • 350 kph (218 mph) @ 6,096 meters (20,000 ft)
Altitude, max	9,144 m (30,000 ft)
Range at max payload	11,112 km (6,000 naut. miles)
Landing field dimensions, minimum	200 x 200 m (656 x 656 ft)

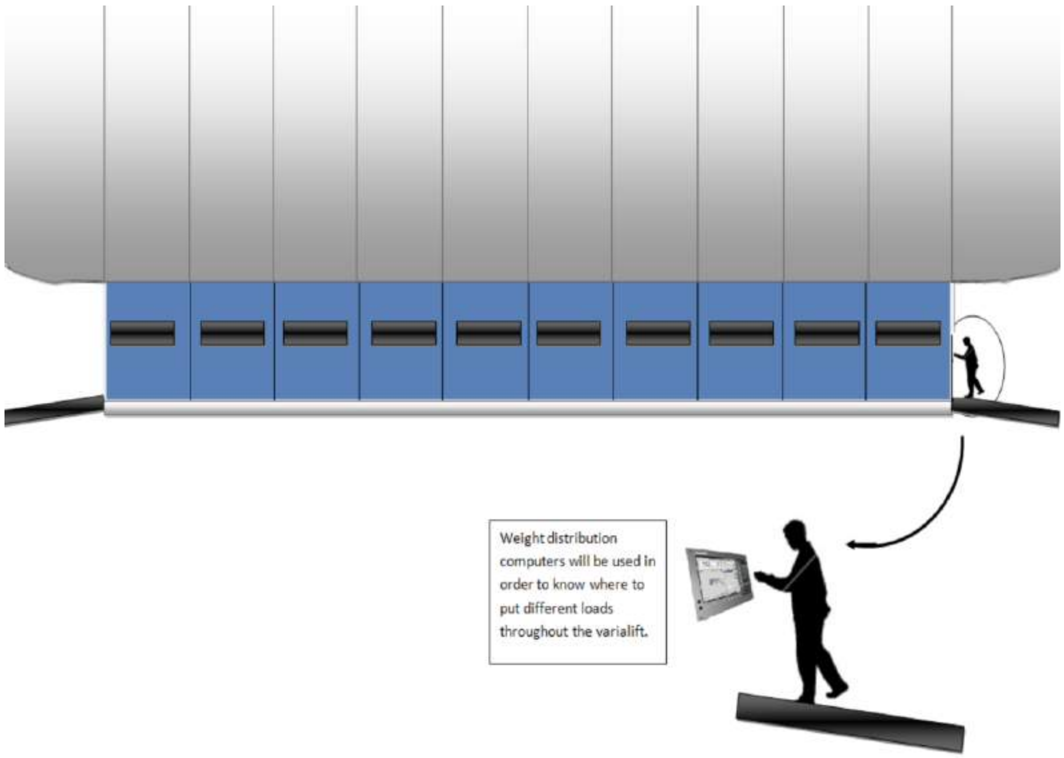
General arrangement of an ARH 50 airship.
The cargo deck is the dark structure attached below the aluminum hull.
Note the dark lateral thruster ports near the nose and tail and
the fixed side-mounted propulsion gas turbine engines.
Source, both graphics: Varialift.

Rendering of an ARH 50 during vertical takeoff.

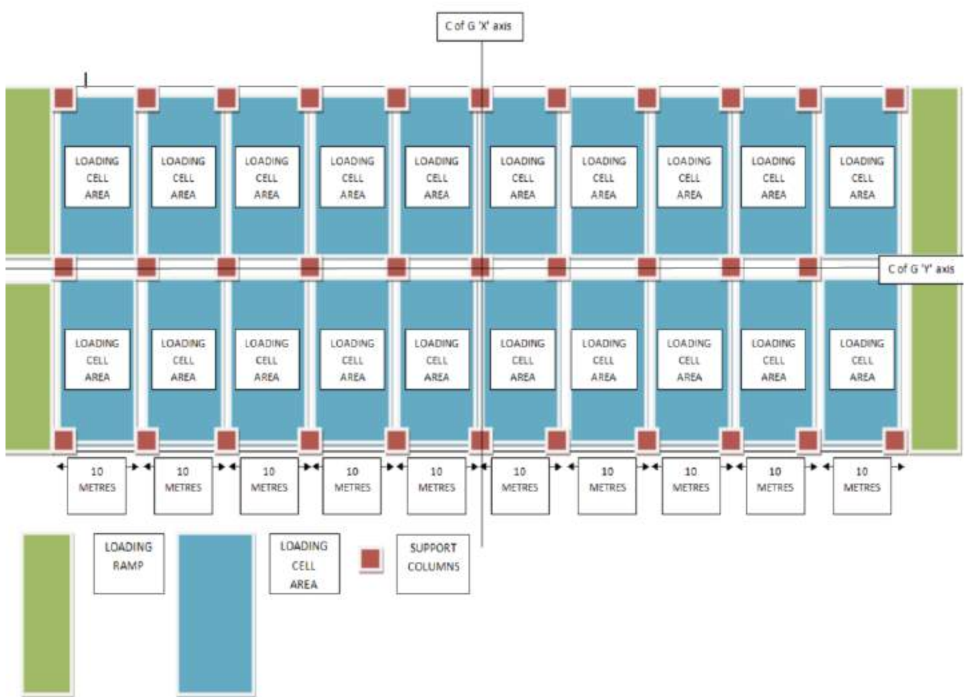
Varialift airships are designed for modular construction, with the ARH50 comprised of 10 standard lift cell modules plus separate nose and tail modules.



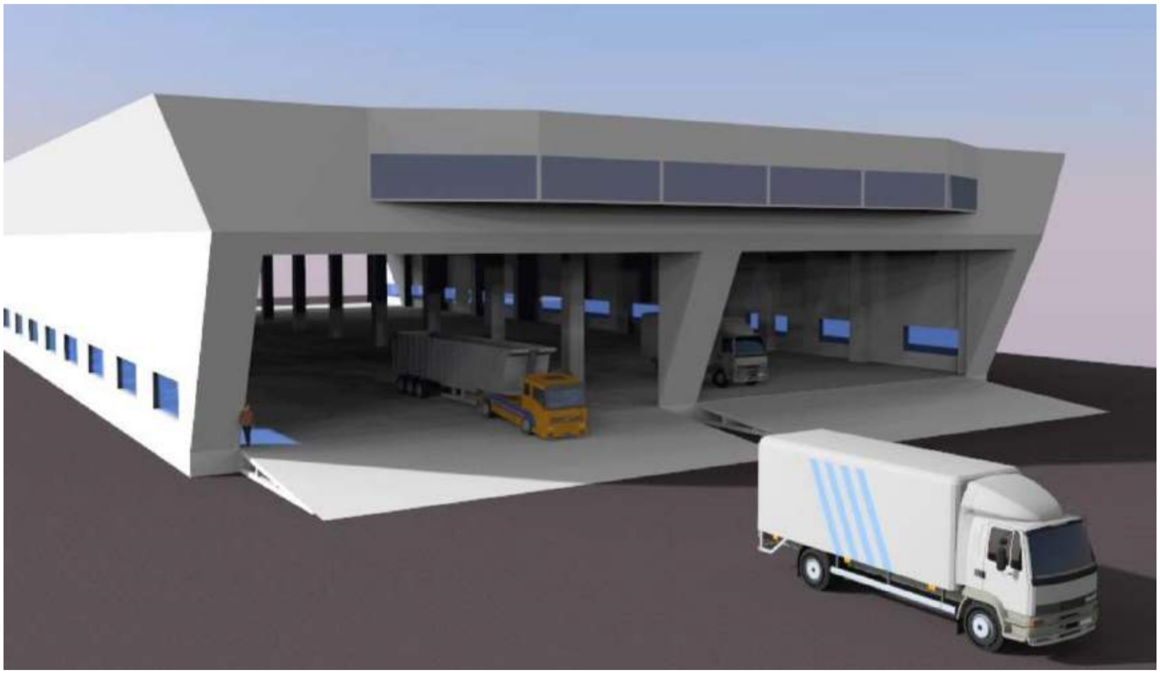
Basic modular design concept for the ARH 50.
(Note: Loading cell height should be 10 meters)
Source, both graphics: Varialift



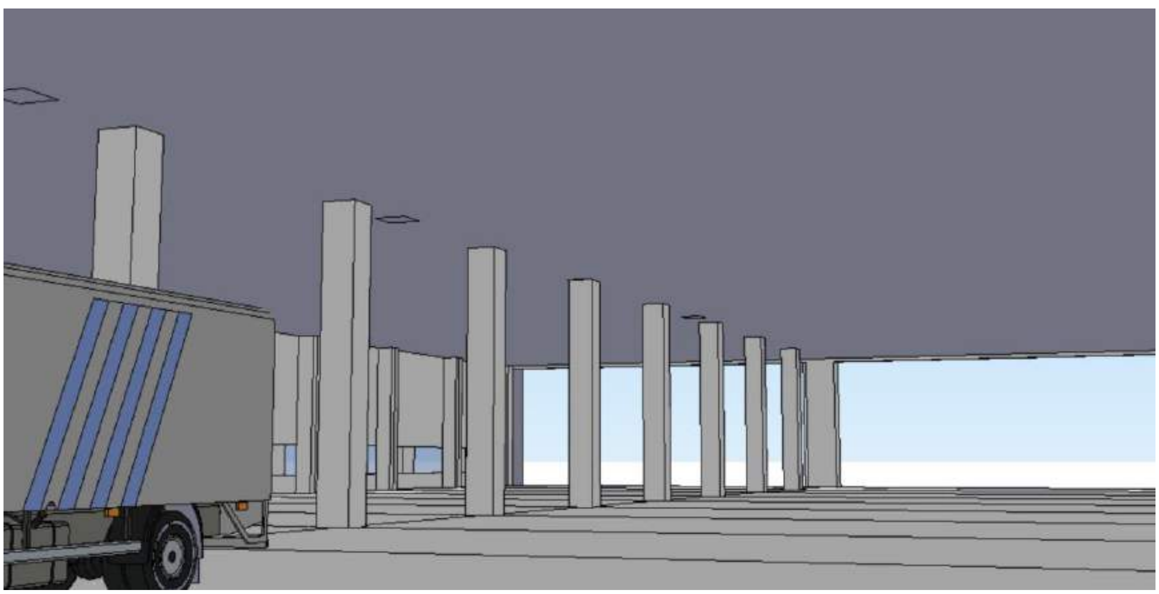
An ARH 50 assembled from 10 standard modules, each comprised of a variable lifting unit (above) and a loading cell (cargo bay section, below)



Overhead view of the 100 m (328 ft) long ARH 50 cargo bay.
Source, both graphics: Varialift



ARH 50 single-level, roll-on, roll-off (Ro-Ro) cargo deck is 50 m (164 ft) wide.
Source: 3D model by Ross McAleenan via Varialift



Interior view of the ARH 50 cargo bay showing support column locations.
Source: Varialift

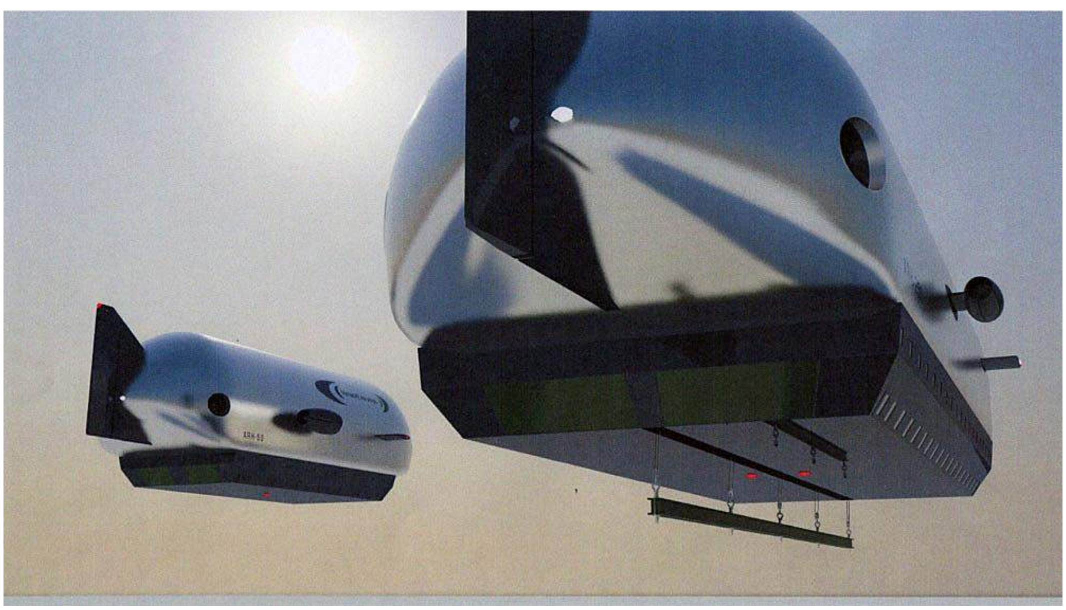
In 2019, ARH 50 roll out was expected in 2021, with a 24-month certification process before commercial deliveries began. By 2021, that schedule had slipped by several years and was dependent on significant new funding and successful performance and type certification of the ARH-PT pilot training airship (the prototype).

7. The Varialift ARH 250 airship

Varialift also is developing the design for the much larger ARH 250 airship, which will share the same basic design as the ARH 50, but on a much larger scale.

Basic design characteristics of the ARH 250

Parameter	**ARH 250**
Type	Rigid, fixed volume, variable buoyancy
Length	300 meters (984 ft)
Width, hull	110 meters (361 ft), not including flank-mounted propulsors
Weight, empty	175 metric tons (386,000 lb)
Internal cargo hold dimensions	L 250 x W 100 x H 20 meters (820 x 328 x 66 ft), forming a two-level roll-on, roll-off cargo deck
Internal cargo volume	500,000 m^3 (17.6 million ft^3)
External cargo	Internal cargo crane can carry an external suspended load (i.e., outsized, bulky cargo)
Cargo weight, max	250 metric tons (275 tons, 551,000 lb)
Crew	3
Propulsion & maneuvering	• 2 x flank-mounted, fixed aero gas turbine engines • 2 x lateral “tunnel” thrusters mounted in the hull, one at the bow and one at the stern
Est. fuel consumption	2,500 liters/hr (gallons/hr) with conventional propulsion / maneuvering system
Aerodynamic controls	• Flank-mounted all-moving horizontal stabilizer • Vertical tail fin with rudder
Speed	• 250 kph (155 mph) @ sea level • 350 kph (218 mph) @ 6,096 meters (20,000 ft)
Altitude, max	9,144 m (30,000 ft)
Range at max payload	14,816 km (8,000 naut. miles)
Landing field dimensions, minimum	400 x 400 m (1,312 x 1,312 ft)



Scale comparisons of the ARH 50 and the much larger ARH 250.
Source, three graphics: Varialift

ARH 250 airship hovering and handling heavy external cargo at a remote site.
Source: Varialift

ARH 250 airship transporting a heavy external load.
Source: Screenshot from Varialift video.

8. Beyond the ARH 50 and ARH 250

Varialift claims that much larger airships, with payloads up to 3,000 metric tons (3,300 tons; 6.6 million lb), can be developed based on the same design and technology as the ARH 50 and ARH 250.

Varialift's also was pursuing opportunities to deploy its variable buoyancy airship technology for use in static and maneuverable airborne communication platforms (pseudo-satellites) that operate at high altitudes [19,812 to 22,860 meters (65 to 75,000 feet)] on long-duration missions. One possible application was for an ARH 50 derivative without the large cargo hold to serve as a node in a 5G wireless telecommunications network. This airship would be capable of carrying about four metric tons (4.4 tons, 8,818 pounds) on long-duration, high-altitude missions.

9. The Varialift ARH-PT prototype and the Châteaudun factory

The prototype airship

This ARH-PT is a subscale version of Varialift's larger cargo airships, With a hull width of 25 meters (82 ft), it is small in comparison to an ARH 50, which has a 52 meter (170 ft) wide hull. The ARH-PT is capable of carrying a 4 metric ton (4.4 ton, 8,800 lb) payload.

The roles of the ARH-PT are to validate the Varialift airship design, train future pilots and attract investors to fund further airship development and certification work. Varialift planned to manufacture several ARH-PT airships to meet the needs for pilot training around the world.

While Varialift didn't plan to manufacture a large number of ARH-PT airships, several potential customers have expressed interest in a commercial cargo version of this airship.

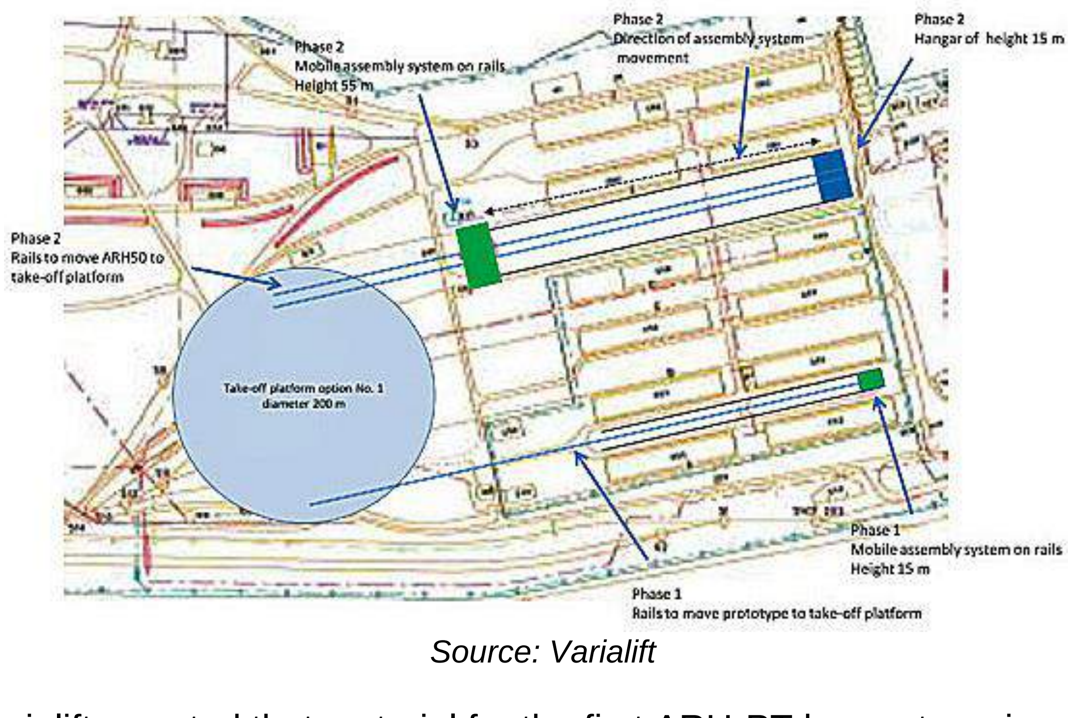
The French factory site

From 2012 - 2016 Varialift management held discussions on potential factory sites with representatives from a number of localities in France that were hopeful of attracting investment. Agreement was finally reached in 2016 with the Prefecture of Eure et Loir, the town of Châteaudun and the French Ministry of Defense for use of a 50 ha (123.5 acre) former army equipment establishment (ETAMAT) site at La Chapelle-du- Drow, which offered the space and basic structures needed for large-scale, modular airship manufacturing.

Varialift Plc established its French subsidiary, Varialift Manufacturing France SARL, in November 2016 with Varialift Business Development Director Ernesto Soria serving as Operations Supervisor at the Châteaudun site. Recruitment of designers and manufacturing line employees commenced. Long-term development plans projected a need for up to 2,000 employees at the site after series production of the large commercial airships had started.

A plan for the Châteaudun factory shows that, in Phase 1, an assembly line for the ARH-PT prototype airship would be set up along with a 200 m (656 ft) diameter takeoff and landing area. In Phase 2, a larger assembly line would be set up for the ARH 50 airships.

Varialift factory plan at ETAMAT Chateaudun Phases 1 and 2



Source: Varialift

Varialift reported that material for the first ARH-PT began to arrive at the Châteaudun factory in March 2017. At that time, completion of the first ARH-PT was expected by late summer 2019, with flight testing to commence later in that year. This schedule proved to be optimistic.

In the May / June 2017 timeframe, work started on manufacturing components for the first airship module, including the semicircular curved arches that form the top of the module and the frame structure for the cargo bay along the bottom of the module.

Wooden "jig" on which the semicircular hull frames are built. The frames measure 40 m (131 ft) along the curve; 25 m (82 ft) in diameter.
Source: Varialift (circa mid-2017)

Considerable site work was done in July to December 2017, setting foundations on which the ARH-PT structure would be assembled. In addition, work began on assembling complex frames for the airship.

Manufacturing fuselage frames.
Source: Varialift (circa 2nd half 2017)

In early 2018, site work focused on building assembly carousels that enabled helium receiver tanks and semicircular hull frames to be welded or riveting from a single location, while the work piece is rotated on the carousel.

In the July to December 2018 timeframe, aluminum plate material for the helium receiver tanks arrived, the first manufacturing jigs were set up, and tank manufacturing commenced. The jigs for making the helium receiver tank ends also were set up and production of first domes began. In addition, a dust-free manufacturing hangar for helium cells was set up and the initial cells produced were tested and passed acceptance tests.

Helium receiver tank segment and end dome manufacturing was underway.
Source, both photos: Varialift (circa 2nd half of 2018)

Helium gas cells manufactured & tested.
Source: Varialift (circa 2nd half of 2018)

By June 2019, Varialift reported: "Assembly towers made of containers have been customized and prepared for the assembly of the module canopies and helium tanks. The overhead crane of height 30 meters (98.4 ft) and span 27 meters (88.6 ft) was tested, assembled and placed on its rails. The assembly of the cargo bays has begun."

Assembly towers and new gantry crane.
Source: Varialift (circa mid-2019)

New gantry crane installed and construction started on the cargo bay for the first ARH-PT airship. Note that the first five modules of the cargo bay have been completed and are sitting on their assembly foundations. Source: Varialift (circa mid-2019)

Varialift posted no further progress reports on their website after June 2019.

Subsequent progress is reported in [a series of annual reports and financial statements filed by Varialift Plc with the UK government](). The actual filing dates of these reports typically are one year after the period covered in the report. Some events in these reports are out of sync with the reporting period (i.e., some events in 2022 are discussed in reports for the period ending 29 December 2021). I've tried to reconcile such discrepancies in the following chronological summary of events from 2020 to 2024.

In their "Full Accounts" report for the period from 1 January 2020 to 29 December 2020," Varialift Plc reported:

- Manufacturing and material handling problems were resolved by building a large gantry crane to lift and position airship sections.
- "The COVID-19 pandemic caused a large delay in the production of the pilot airship in 2020. Government support for

the subsidiary has been obtained for short term working and a loan of 80,000 Euros to help the subsidiary through lockdown restrictions imposed by the French authorities."

- "Brexit has brought challenges with regards to the work force, however these have been overcome by using a mixture of local workforce and agency workers."
- The ARH-PT airship was 33% complete and was expected to be finished in 2022. The French subsidiary required additional funding from Varialift Plc to complete the ARH-PT.

In 2021, Varialift announced a crowdfunding campaign that apparently did little to improve their financial condition.

In their "Full Accounts" report for the period from 1 January 2020 to 29 December 2021," Varialift provided the following update:

- "The subsidiary continues to have been adversely affected by the continuing outbreak of COVID-19, which has resulted in the suspension of the building of the pilot airship."
- "Renewing the lease or purchasing the site in France is an ongoing development and creates a high risk on the future of the subsidiary."

In mid-2022, the Prefecture of Eure et Loir announced that it would not renew the occupancy agreement for the Châteaudun factory site it had granted in 2016 and asked Varialift to leave when the agreement expired on 6 August 2022.

Varialift made the decision to transfer all of their machinery offsite to protect assets, leaving behind various site improvements, including the large gantry crane. The sub-prefect of Châteaudun, Hervé Demai, reported to the Times.News, "The company didn't recover much, and the big gantry they had built is still there…..The Ministry of the Armed Forces has asked the prefecture to work on a proposal (for alternate uses for the site)."

Varialift's hope for an agreement with the UK Department of Trade and Industry for substantial additional funds did not materialize.

In their “Full Accounts” report for the period from 1 January to 29 December 2022, Varialift did not discuss that their French subsidiary had vacated the Châteaudun factory site after their lease expired. Neither did they address the whereabout of the partially-completed ARH-PT or any of their machinery removed from the factory site prior to lease expiration.

Instead, Varialift reiterated that renewing the Châteaudun factory site lease or purchasing the property was an “ongoing development and created a high risk on the future of the subsidiary.” The ARH-PT was reported to be 50% complete and could be completed in 12 months (by December 2023, with appropriate funding).

Varialift has not yet filed its required annual report with the UK government for the year ending 29 December 2023.

As of February 2024, Varialift has not announced a renewal of the Châteaudun site lease or relocation of its ARH-PT manufacturing activity. The fate of the ARH-PT prototype airship is uncertain.

10. For more information

- Varialift Airships PLC, Company number 06180690, filing history with UK government Companies House from 23 March 2007 to 22 December 2003: https://find-and-update.company-information.service.gov.uk/company/06180690/filing-history
- “Varialift Patent Granted and Proof of Concept Demonstration,” Airshipworld Blog, 7 January 2009: http://airshipworld.blogspot.com/2009/01/varialift-patent-granted-and-proof-of.html
- Alan Handley, “Varilift Airships,” presentation at Airships to the Arctic VI Conference, Seattle, 2011: https://isopolar.com/wp-content/uploads/2013/04/Alan-Handley-presentation-Varialift_A_New_Horizon.pdf
- Donna Lu, “A solar-powered airship is being built to transport cargo more greenly,” New Scientist, 2 October 2019: https://www.newscientist.com/article/2218360-a-solar-powered-airship-is-being-built-to-transport-cargo-more-greenly/

- "In Châteaudun, end of the game for the Varialift airships," Time.News, 12 September 2022: https://time.news/in-chateaudun-end-of-the-game-for-the-varialift-airships/
- "End of a British airship dream - in France," International Transport Journal, 16 September 2022: https://www.transportjournal.com/en/home/news/artikeldetail/end-of-a-british-airship-dream-in-france.html

Patents

- US7568656B2, "System for controlling the lift of aircraft," Inventor: Alan R. Hadley, Filed 26 April 2005, Granted 4 August 2009: https://patents.google.com/patent/US7568656B2/en
- EP1591356 (B1), "System for controlling the lift of an aircraft, "Inventor: Alan Roy Hadley, Filed 27 April 2005, Published 24 December 2008: https://patents.google.com/patent/EP1591356B1/en
- HK1083614A1 (Hong Kong), "System for controlling the lift of an aircraft," Inventor: Alan R. Hadley, Filed 27 March 2006, Published 7 July 2006: https://patents.google.com/patent/HK1083614A1/en

Videos

- "Varialift in French Television December 2016," (2:05 minutes): https://www.facebook.com/100057253309559/videos/varialift-in-french-television-december-2016/1017328101705672/
- "The Varialift Airship - Sir David King at the Arctic Circle Assembly," (1:31 minutes), Arctic Circle Assembly, 9 November 2018: https://www.youtube.com/watch?v=HNAzkAuXsJg

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Aeros - Dragon Dream prototype variable buoyancy rigid airships
    - Aeros – Aeroscraft variable buoyancy rigid airships

    - Walden Aerospace / LTAS – T-90 & T-280 variable buoyancy rigid airships
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - Atlas LTA Advanced Technology – ATLANT variable buoyancy rigid airships
    - Euro Airship – 10T, 50T & 400T variable buoyancy rigid airships
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/