Cargolifter airships

Peter Lobner, updated 8 March 2022

1. Introduction

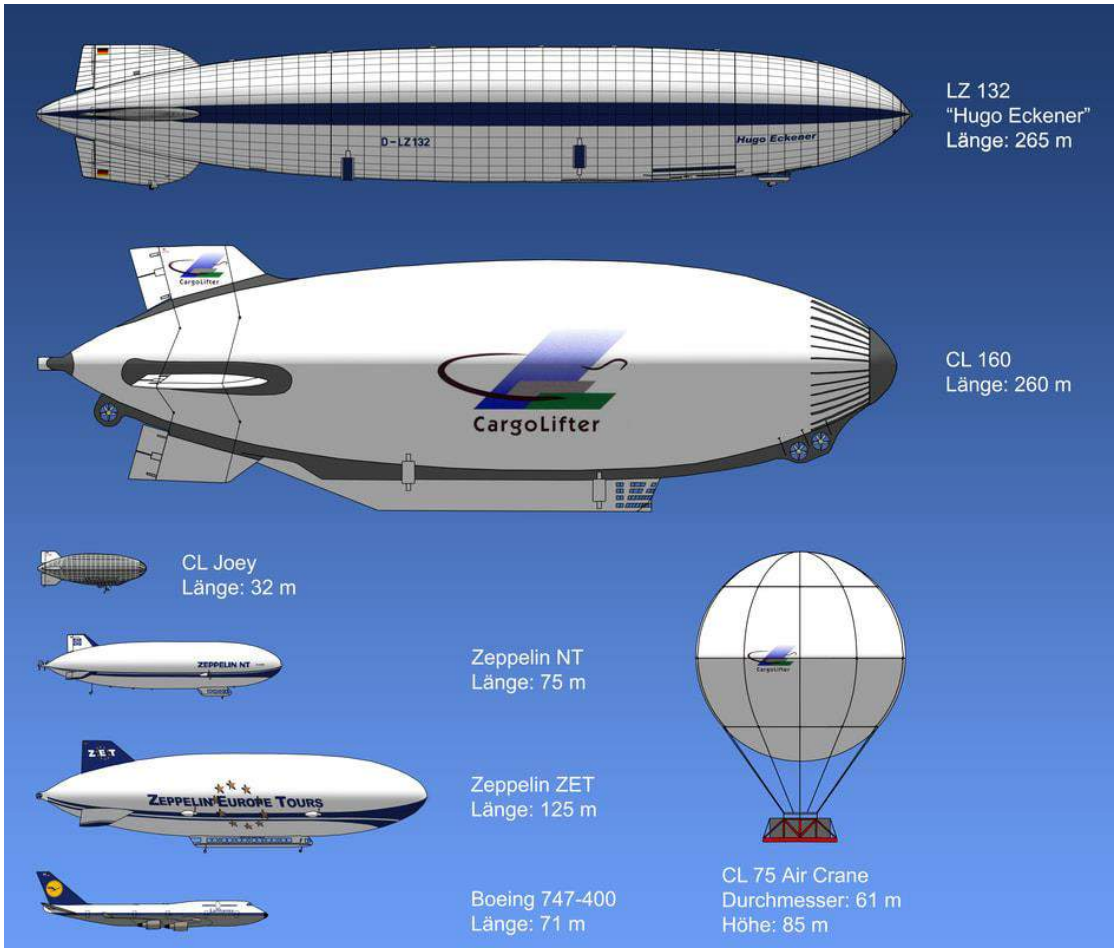
CargoLifter AG was founded in September 1996 in Wiesbaden, Germany, with the objective of offering a logistics service based on the point-to point transportation of heavy and oversized loads using lighter-than-air (LTA) technology in airships of their own design.

An abandoned former Soviet military airbase in Brand-Briesen, south of Berlin, was selected as the site to build their production and operation center, including a giant airship hangar that in 2020 remains the largest freestanding building in the world.

Cargolifter hanger circa 2001. Source: Stefan Kühn via Wikipedia

Three different types of Cargolifter airships were planned: the 1:8 scale manned experimental airship “Joey,” the unmanned CL75 AC “AirCrane” transportation balloon and the CL160 semi-rigid airship.

The CL160 was much larger than the LZ-129 Hindenburg zeppelin built in the 1930s and the similar LZ-132 concept from the 1950s.



Size comparison of CL160 Cargolifter, CL75 AC AirCrane transportation balloon, and CL "Joey" experimental airship with other air vehicles. Source: migenda.weebly.com

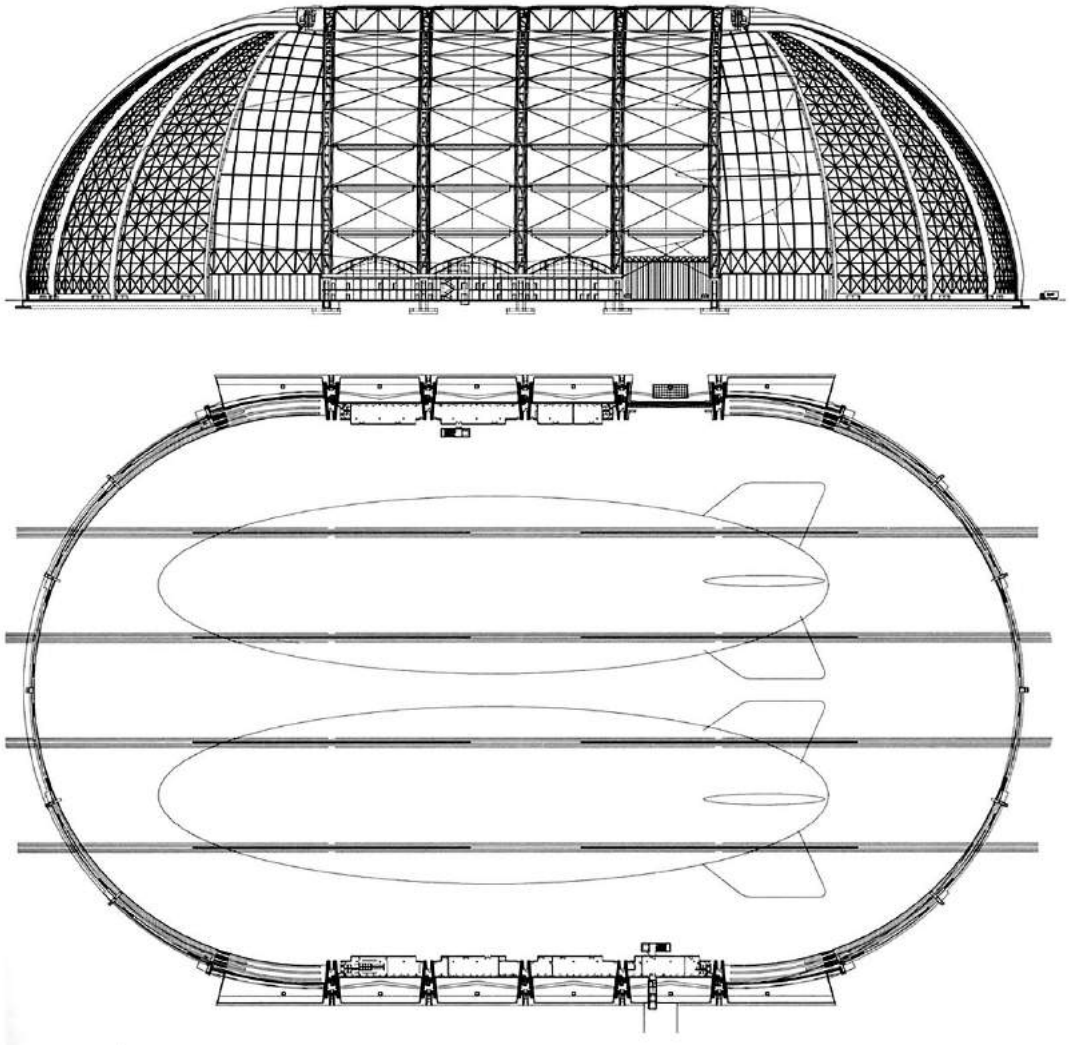
First flight of the CL160 originally was planned to occur in 2003, with series production starting in 2004 / 2005. The first unit, known as P1, was to be used mainly for development risk reduction. The second unit, P2, would have been used to validate lift, control and maneuvering systems in a comprehensive development program.

Cargolifter AG planned to build up to 50 CL160 airships and 10 CL75 AC transportation balloons by 2015 and establish the global infrastructure that could support this fleet of airships. The expected price of the CL160 was about $60 million and the CL75 AC price was about $10 million.

In April 2002, Forbes reported, "…CargoLifter, a would-be manufacturer of heavy-lift dirigibles that so far has lifted $263 million from investors and done precious little else." Cargolifter AG announced insolvency on 2 June 2002. This was after their giant hanger in Brand-Briesen had been completed and the Joey and CL75 AC had flown, but before the first CL160 airship was built. Liquidation proceedings started in July 2002.

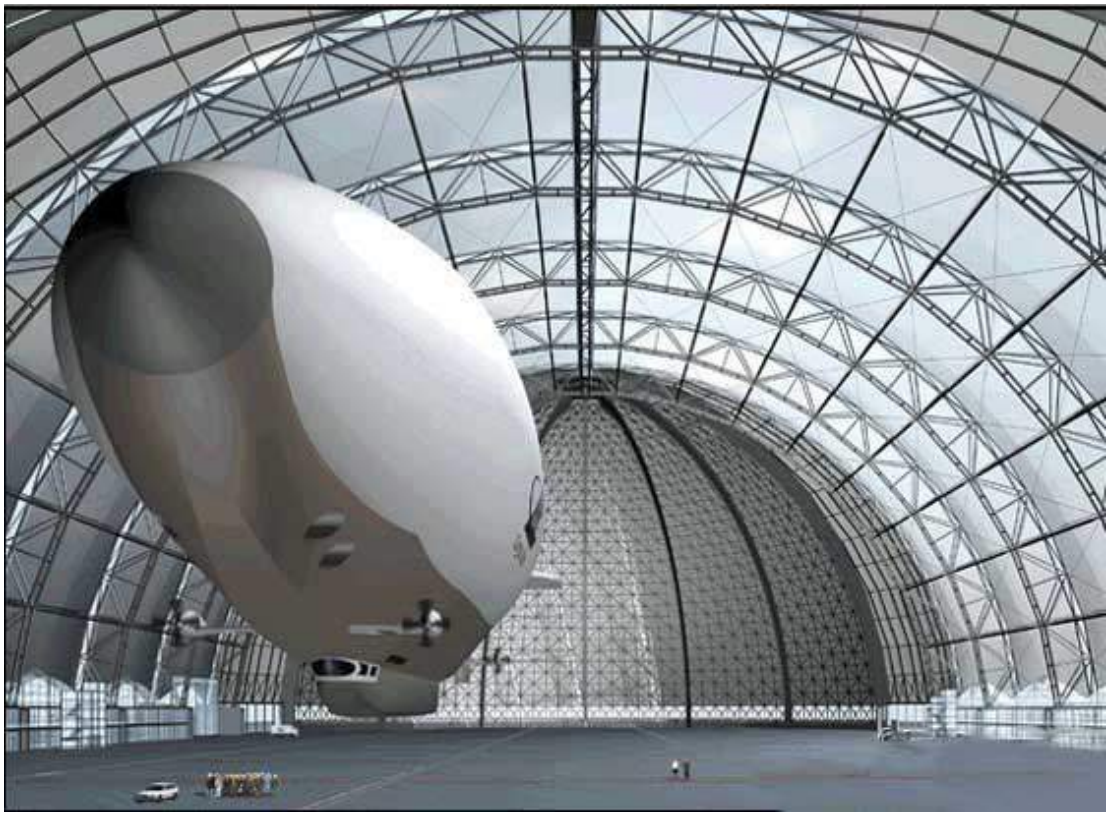
2. The Cargolifter hanger

The massive hanger at Brand-Briesen measures 360 m (1,180 ft) long x 220 m (720 ft) wide x 106 m (348 ft) high and was designed to handle two CL160 airships. It would have been the site for manufacturing the CL75 AC balloons and CL160 airships.

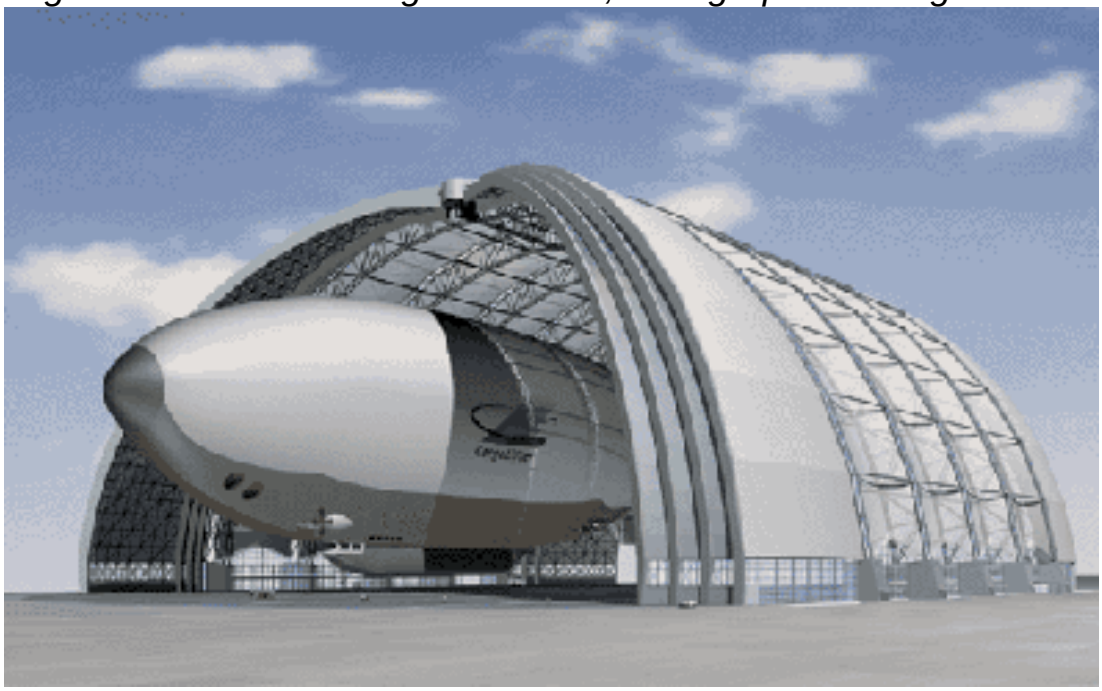


Source: https://www.atlasofplaces.com/architecture/cargolifter/

Most of the hanger construction work was completed by the end of 1999. You can appreciate the scale of the hanger in the following graphics, which shows a single CL160 airship inside the hanger.

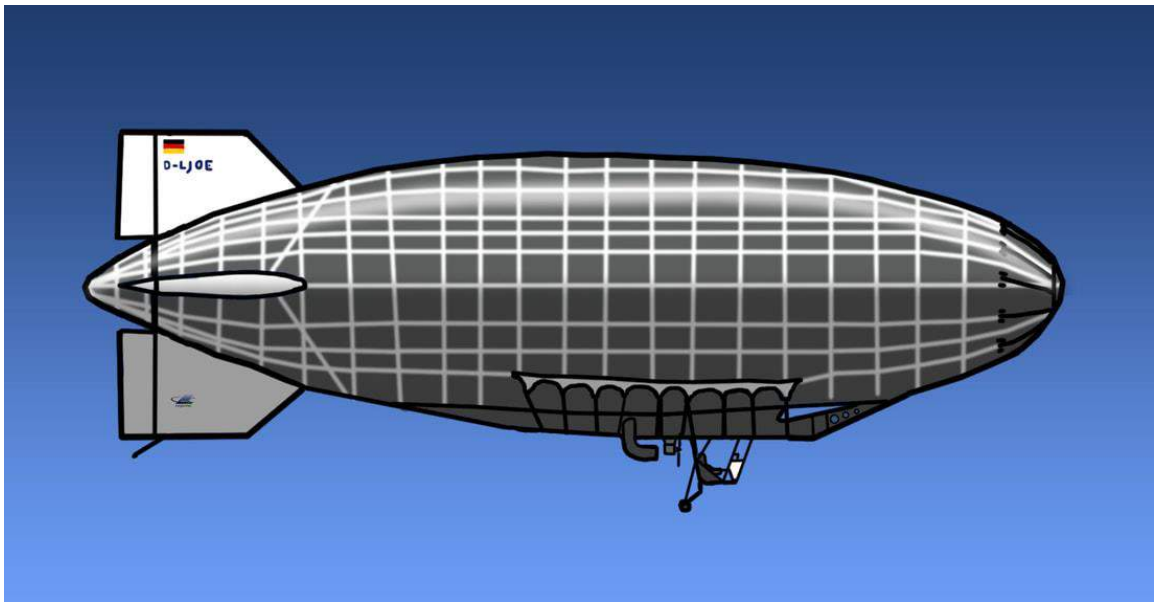


CargoLifter CL160 in hanger. Source, both graphics: CargoLifter AG



3. The Cargolifter "Joey"

"Joey" is a small scale (1:8) experimental airship that is so named because it could fit inside a CL160's cargo bay like a kangaroo baby in its mother's pouch. It is a semi-rigid airship with a rigid keel and a small gondola with side-by-side seating for a pilot and test engineer (or a pilot and more extensive measuring equipment). The airship is 32 m (105 feet) long, 7.9 m (26 feet) in diameter, has a gas volume of 1,050 m^3 (37,080 ft^3) and can carry a payload of 220 kg (485 lb).



Joey profile view. Source: migenda.weebly.com

Development of Joey started in early 1997 at the University of Stuttgart. Joey made its maiden flight on 18 October 1999. Development and construction of Joey helped CargoLifter AG obtain approval in Germany as an aviation development company.

Cargolifter AG used Joey to support the development and validation of the software being used to design and simulate CL160 flight characteristics, to test in-flight airship behavior (i.e., of the helium cells and air cells), and to support development of airship operating processes and procedures. In addition, Joey was used to inspect airship hanger construction from the outside.

The insolvency administrator sold Joey for € 13,000 (about $15,860 at a 2002 exchange rate of 1.22). Today it is in France and is known

as Ziphius 900. You'll find more information (in French) on its current state here: http://www.labfab.fr/portfolio-item/ziphius-900-ballon-dirigeable-pilote/

Joey on a mobile mooring. Source: DPA

Joey in flight. Source: Cargolifter AG

4. The Cargolifter CL75 AC (AirCrane)

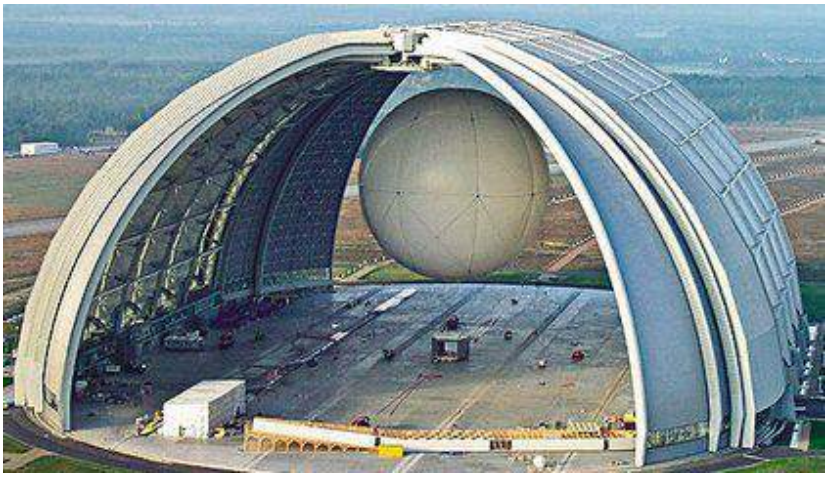
The CL75 AC was marketed as an unpowered, unmanned sky crane with a transport load capability of up to 75 metric tons (75,000 kg, 165,347 lb). The CL75 AC would have been integrated with the CL160 into Cargolifter AG's planned worldwide heavy-lift transportation infrastructure. In operation, the CL75 AC would be towed by a ground vehicle to move heavy cargo from place to place at low altitude. The CL75 AC also was used to validate the tethered in-flight load exchange process to be employed by the CL160.

CL75 AC basic design parameters were:

- Balloon diameter: 61 m (200 ft)
- Height, including cargo load frame: 85 m (279 ft)
- Envelope volume: 110,000 m^3 (3,884,600 ft^3)
- Maximum transport speed (towed): 70 kph (43.5 mph)
- Load frame dimensions: 13 x 6 x 6 m (42.6 x 19.7 x 19.7 ft)

The balloon envelope was developed by ILC Dover and TCOM and manufactured in the US. The load frame was developed and manufactured in the US by AdvanTek International LLC. The complete CL75 AC vehicle was integrated in the Cargolifter AG hanger.

The CL75 AC was severely damaged by high winds in a storm on 10 July 2002. In August 2002, all work on the CL75 AC was halted after Cargolifter AG declared insolvency.



Source: Cargolifter AG

5. Load exchange experiments with CL75 AC heavy-lift aerostat

The load exchange ballasting process for the CL160 was tested from 2000 – 2002 and demonstrated successfully using the CL 75 AC and a specially designed load frame that also carried water ballast when needed. In one outdoor test on 7 May 2002, a 55 metric ton (60.5 ton) German mine-clearing tank was loaded, lifted and discharged from the carriage as water ballast was unloaded and later reloaded in approximately the same time it took to secure the tank in the carriage (several minutes). In this test, the 55 metric tons cargo was exchanged with about 55 cubic meters (1,766 cubic feet, 14,530 US gallons) of water ballast.

Cargo has been loaded. The AC75 is held on the ground by the combined weight of the cargo and ballast water (blue) in the tanks of the load frame.

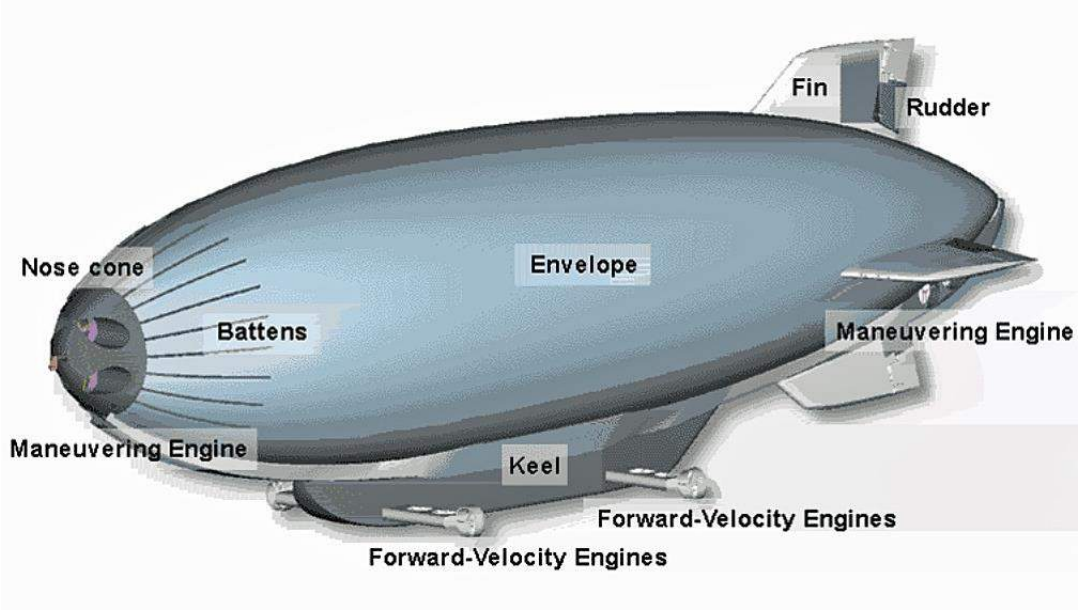
Pumping the ballast water from the load frame to the tanker trucks makes the balloon system lighter-than-air and it lifts off with the cargo, controlled by its tether.

At the destination, the CL75 AC is hauled down. Ballast water is pumped back into the load frame upon landing, stabilizing the balloon system safely on the ground. The cargo now can be removed from the load frame. The balloon system remains held on the ground by the weight of the ballast water.

You can watch a short video of this load exchange test and a simple animation of the water ballast transfer process at the following link. The three graphics above are screenshots from this video.
https://www.youtube.com/watch?v=lralh-LwcJQ

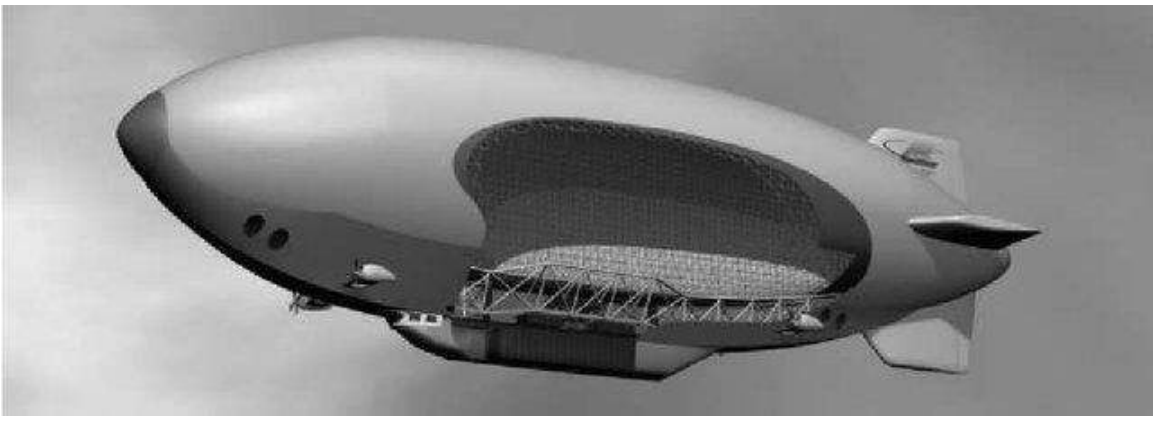
6. The Cargolifter CL160 airship

The CL160 was a very large, conventional, semi-rigid airship with a rigid structural keel coupled to a pressurized gas envelope that supports the full weight of the airship. The neutrally-buoyant airship can hover without the use of propulsive lift from its engines and can perform a vertical takeoff and landing (VTOL). The general arrangement of the CL160 is shown in the following diagram.

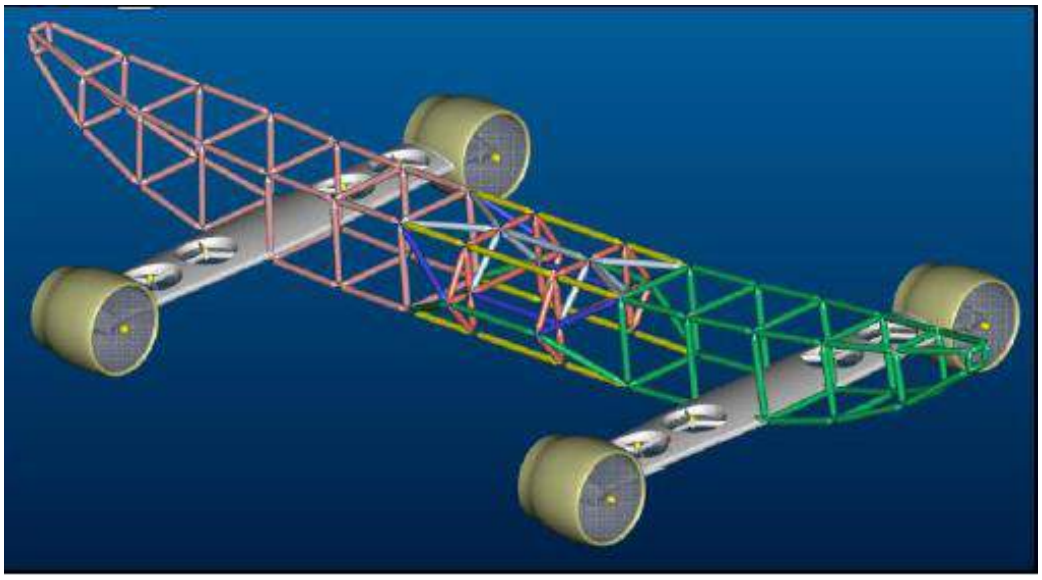


Source: Cargolifter AG

The long structural keel under the envelope carries most of the heavy structural loads. The keel is shown in the following diagrams.

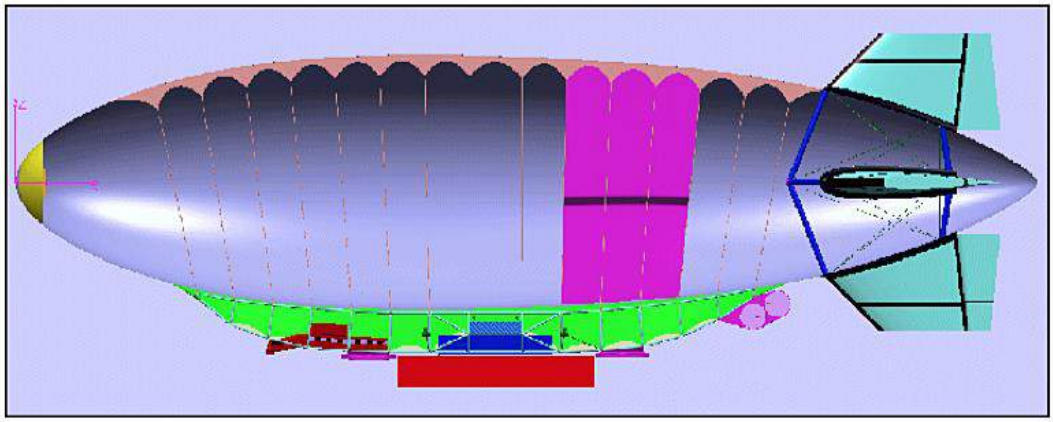


CL160 cutaway drawing showing the keel structure.
Source: Carl Schweizerhof / Wilhelm Rust, "Finite element load limit analysis of thin-walled structures….." July 2002



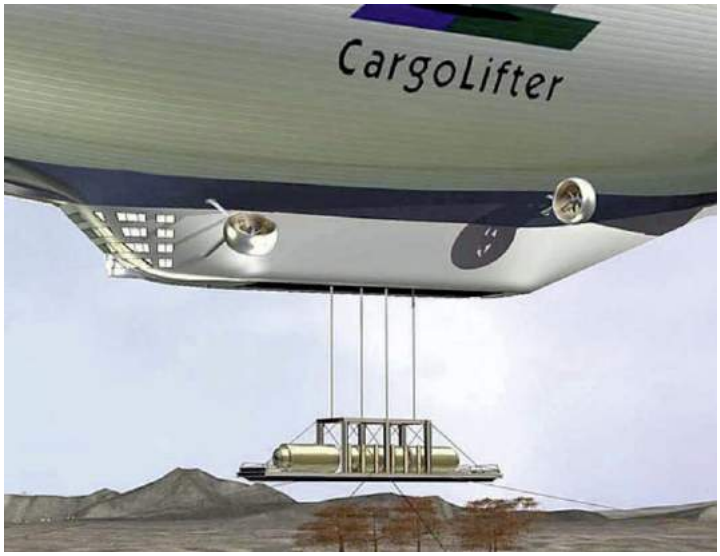
CAD rendering of the CL160 keel structure.
Source: NASA Ames Research Center, June 2016

The lift gas (helium) is in a single gas cell. The use of multiple lift gas cells was rejected due to the added complexity without a corresponding increase in safety. The weight of the loads concentrated in the keel, including up to 160 metric tons (352,000 lb) of cargo, is transferred into the upper surface of the envelope by means of traditional catenary curtains, as shown in the following diagram. Also shown in this diagram is the internal wire-braced frame structure that carries fin forces and distributes those forces into the pre-tensioned (pressurized) envelope. Each fin had a cord of 42 m (137.8 ft) and a span of 21 m (68.9 ft).



CL160 keel structure (green), catenary curtain (rose & magenta), and fin support frame (blue).
Source: NASA Ames Research Center, June 2016

The CL160 was designed for conducting airborne, tethered load exchanges. The airship does not land to pick up or drop off cargo.



Instead, cargo carried in the internal cargo bay, is lowered to the ground on a load frame from a hover altitude of about 100 m (328 ft). A water ballast exchange occurs before the tether can be released and the load frame can be hoisted back to the airship.

Source: Cargolifter AG

The conceptual design was frozen in November 1998. In February 2002, the Preliminary Design Review (PDR) was completed, confirming the technical feasibility of the project and leading to the next stage in its development, the Detailed Design phase. In May 2002, CL160 development was halted due to financial problems.

Basic design parameters for the CL160 were:

- Length: 260 m (853 ft)
- Diameter: 65 m (213 ft)
- Overall height: 82 m (269 ft)
- Gas envelope volume: 550,000 m^3 (19,423,067 ft^3)
- Payload: 160 metric tons (176 tons, 352,000 lb)
- Payload bay volume: 3,200 m^3 (113,000 ft^3)
- Load frame dimensions: 50 x 8 x 8 m (164 x 26.2 x 26.2 ft)
- Propulsion and control: 8 x GE CT7-8L turboshaft engines (2,500 – 3,000 shp class), 4 x for propulsion, 4 x for control
- Speed: 90 kph / 56 mph (cruise), 125 kph / 77.7 mph (max)
- Range: up to 10,000 km (6,214 miles)
- Maximum altitude (pressure altitude): 2,000 m (6,562 ft)

7. Executing a load exchange from a hovering CL160 airship

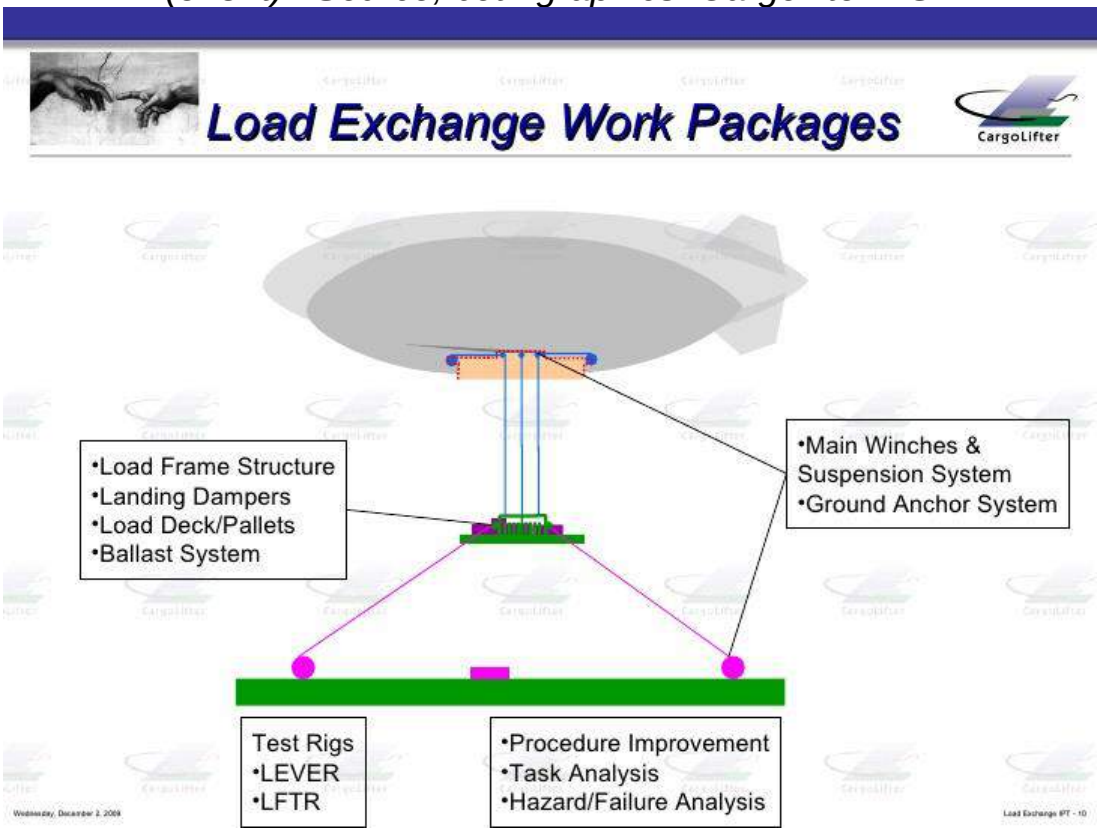
Among the challenges in making an in-flight load exchange from a hovering airship are station keeping over the destination, and managing the balance between lift and mass while massive cargo items are being added to, or removed from, the airship. As described on the Aviation Technology website (https://www.aerospace-technology.com/projects/cargolifter/) the CL160 would perform an in-flight delivery of cargo as follows

> "The airship's load exchange procedure makes use of a new, specially developed technology, allowing it to load and unload without landing. The airship hovers at about 100 m above the ground and a special loading frame, which is fixed during flight to the keel of the airship, is then rigged with four cable winches to the ground, a procedure which is to assure that the airship's lifting gear stays exactly above the desired position. Ballast water is then pumped into tanks on the frame and the payload can be unloaded. The anchor lines are released and the frame is pulled back into the payload bay of the airship."

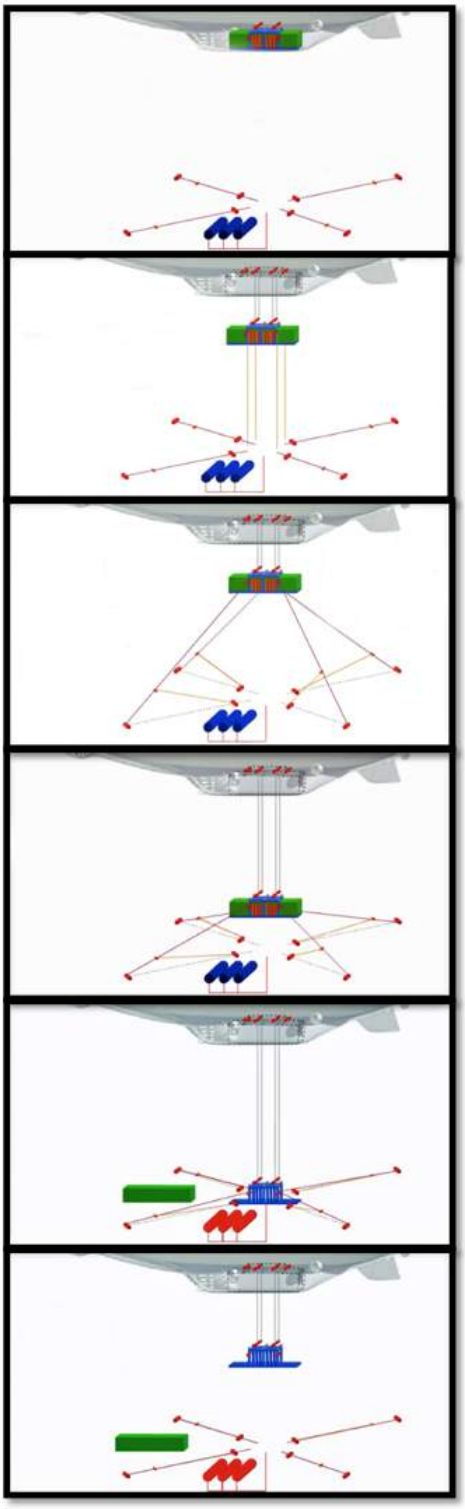
When the CL160 receives new cargo during a load exchange transaction, the weight of water ballast on the load frame needs to be reduced by the same amount as the weight of the new cargo.
A load exchange can be conducted in steady wind up to 10 m/s (22.3 mph) or +/- 5 m/s (11 mph) gusts, comparable to operating limits for a modern construction crane.

You can view a short Cargolifter AG video showing the load exchange process here: https://zukunft-in-brand.de/lta/lta-technik-gesellschaft/2006/cl-160.html

Load exchange in progress from a CL160 hovering at about 100m (328 ft). Source, both graphics: Cargolifter AG



An in-flight load exchange is illustrated in the following graphics. The sequence-of-events graphic was created with screenshots from the above video. A 160 metric tons cargo requires the exchange of 160 cubic meters (5,138 cubic feet, 42,269 US gallons) of water ballast.



The CL160 arrives above the delivery site with cargo . The ground anchor system and ballast water on the ground are ready.

The CL160 lowers its load frame with the cargo and empty ballast tanks. Haul-down cables are dropped to the ground.

The CL160 haul-down cables are secured to the ground anchor system. The CL160 is now tethered to the ground via the load frame.

The load frame is hauled down to the ground while the tethered CL160 hovers above.

The load frame is ballasted from the ground storage tanks with water equivalent in weight to the cargo. Then the cargo is removed.

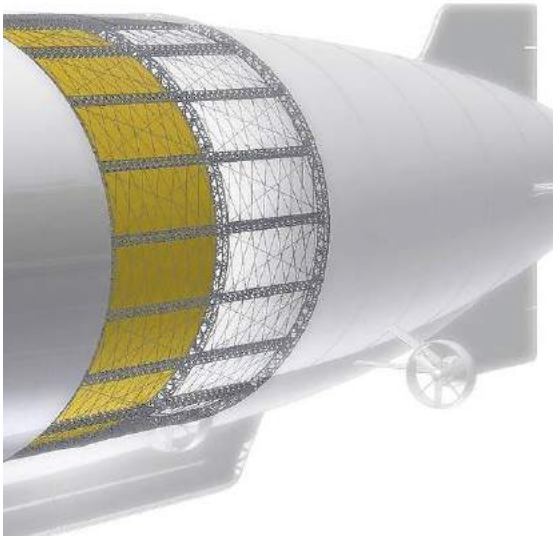
The ballasted load frame is released from the ground anchor system and is lifted back up into the CL160. The airship can depart the site.

8. Cargolifter Epilogue

Almost two decades after the demise of Cargolifter AG, the CL160 business venture remains as an important milestone in the development of the technology and the business case for modern heavy cargo airships.

The successor firm, CL CargoLifter GmbH & Co. KGaA, was founded in Berlin in 2005. This new entity owns the patents of the former Cargolifter AG and seeks to sell lighter-than-air technology, services and products. They advertise that, "Based on proven and certified components of the AirTruck product range, CargoLifter can develop and build a full-fledged airship. Suited for extremely over-sized loads of more than 60 meters and payloads of more than 80 tons, with a flexible load bay for various industrial components. As a rigid airship, it would follow the proven design of the Hindenburg." Their rigid aerostructure design is shown in the following diagram.

You'll find more information on the CargoLifter website here: https://www.cargolifter.com/en/company/



Current rigid aerostructure design.
Source: CL CargoLifter GmbH & Co. KGaA

The giant hanger in Brand-Briesen is still in use today, not for aviation, but as the world's largest indoor tropical rainforest and water theme park named Tropical Islands Resort. Here's the link: https://www.tropical-islands.de/en/tropical-world/

9. For more information

- Ingolf Schafer, “Structural Design Aspects of the Cargolifter CL160,” AIAA-99-3910, American Institute of Aeronautics & Astronautics, 1999: https://arc.aiaa.org/doi/pdf/10.2514/6.1999-3910
- Kevin Bonsor, “How Cargolifter's Airship Will Work,” HowStuffWorks: https://science.howstuffworks.com/transport/flight/future/cargolifter.htm
- “CargoLifter CL160,” Aerospace Technology: https://www.aerospace-technology.com/projects/cargolifter/
- “CargoLifter CL160,” GlobalSecurity.org: https://www.globalsecurity.org/military/systems/aircraft/cargolifter.htm
- “All hangar, no airship,” Forbes, 28 April 2002: https://www.forbes.com/global/2002/0429/034.html?sh=67ae273185df
- “Deutsche Zeppeline und Zeppelinprojekte nach 1945” (German Zeppelins and Zeppelin Projects Since 1945), migenda.weebly.com: https://migenda.weebly.com/deutsche-zeppeline-und-zeppelinprojekte-nach-1945.html
- “SIAT GmbH CargoLifter 1997–1999” (a detailed description of the Cargolifter hanger), 425AR, August 2018: https://www.atlasofplaces.com/architecture/cargolifter/

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Airfloat HL
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - Flying Whales
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/