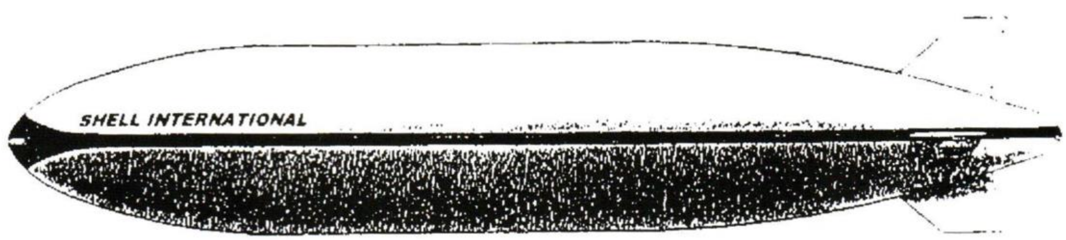
Shell / Aerospace Developments - methane gas transporter

Peter Lobner, updated 8 March 2022

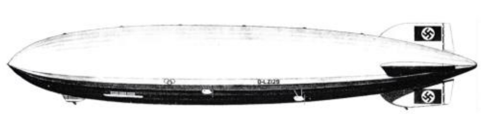
1. Introduction

Shell International Gas Ltd. initiated work in the late 1960s on their concept for a natural gas carrying airship that could compete economically with ocean transportation of liquefied natural gas (LNG), which required specialized cryogenic LNG vessels and costly liquefaction plants in the producing country. The political situation associated with the Middle East gas crisis in the early 1970s reduced investor confidence in building new LNG facilities in that region. This political climate helped raise interest in Shell's methane gas transporter airship concept, which envisioned a fleet of 12 of the giant airships flying between the Middle East and the UK.

The methane gas transporter was an enormous airship, measuring more than twice the length and diameter of the Hindenburg. Even more impressive was the methane gas transporter's gas envelope, which contained almost 14 times the volume of Hindenburg.



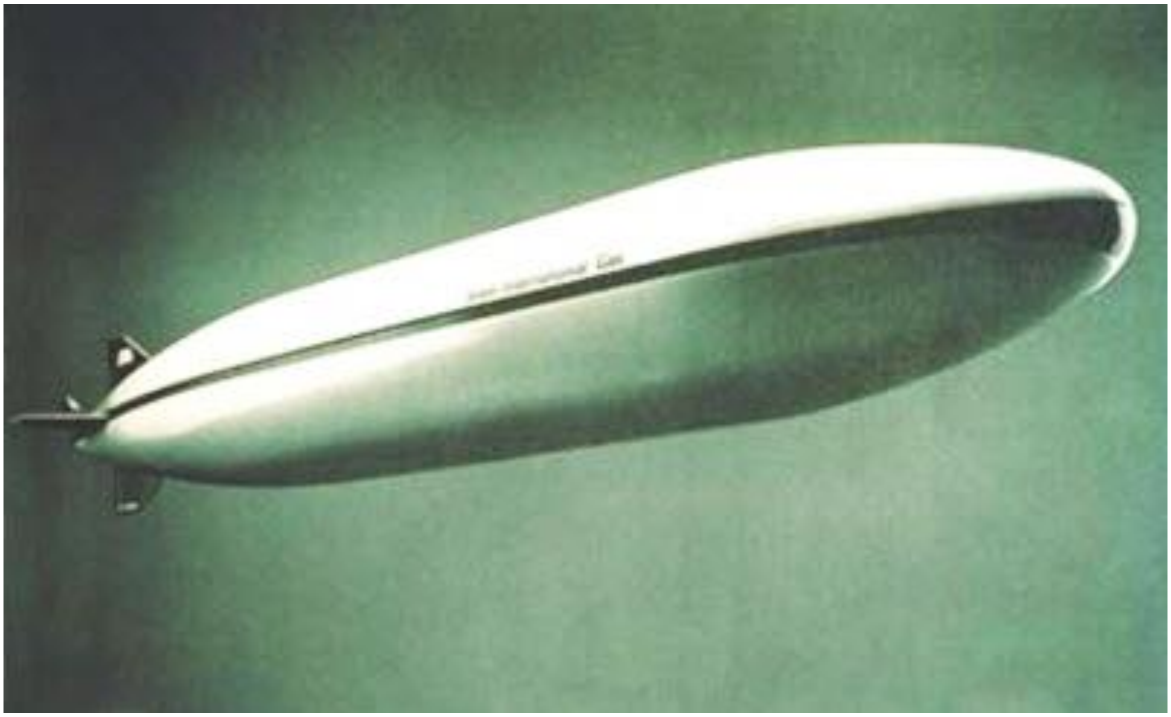
Shell International Gas Ltd. / Aerospace Developments methane gas transporter
Length = 549 meters (1,801 feet), Diameter = 91 meters (299 feet)
Volume: 2,750,000 m³ (97,000,000 ft³)



Hindenburg
Length = 245 meters (803.8 feet) ,
Diameter = 41.2 m (135.1 feet),
Volume: 200,000 m³ (7,062,000 ft³)

Scale comparison of the Shell methane gas transporter and LZ-129 Hindenburg. Source: Adapted from Morforth, 2007 & Airships.net

Roger Munk and John Wood founded the firm Aerospace Developments (AD) in 1970. The Shell methane gas transporter became their first major project.



Artist's rendering of the Shell / Aerospace Developments methane gas transporter in flight. Source: The Airship Heritage Trust

2. Methane as a lifting gas

Natural gas is a naturally occurring gas mixture, consisting mainly of methane (CH_4) (87 – 98 mole %, typically 94.7% mole %), with small quantities of ethane (typically 4.2 mole %), propane (typically 0.2 mole %) and small quantities of other gases.

The density of air at standard temperature and pressure (STP) is 1.274 kg/m^3. Methane, with a density of 0.716 kg/m^3 at STP, is a lighter-than-air gas that does not leak through the walls of airship lift gas cells as rapidly as the smaller molecules of hydrogen and helium gas. The common airship lift gas, helium, has a density of 0.179 kg/m^3 at STP. The density of bulk natural gas (the mixture of gases) is close to the density of methane.

3. Design and principle of operation of Shell's methane gas transporter

The natural gas cargo functioned as the primary lifting gas on the loaded voyage, with a small amount of helium in separate lift gas cells. Residual positive buoyancy could be balanced with ballast or additional commercial cargo.

During unloading, the collapsible natural gas cells compressed as they were emptied and ambient air filled the interior of the hull. The small amount of helium in the separate lift gas cells, supplemented with hot air from the airships gas-fueled engines, provided adequate buoyancy for the return (empty) trip.

Basic characteristics of the Shell / AD methane gas transporter are summarized below.

- Type: Rigid, metal-skinned monocoque structure, stressed double-skin with a plastic foam honeycomb core
- Length: 549 m (1,801 ft)
- Diameter: 91 m (299 ft)
- Volume: 2,750,000 cubic meters (97,000,000 cu ft), about 90% usable for gaseous cargo, the remaining 10% for a permanent helium volume.
- Lift gas (loaded): Helium + methane
- Lift gas (unloaded): Helium
- Propulsion: Various turboprop and turbofan engines were considered. Vectored thrust arrangements improved maneuverability during takeoff and landing.
- Speed: 170 – 190 kph (106 – 118 mph) cruise speed
- Range & mission duration: A 7,000 km (4,350 miles) flight from the Middle East to the UK would take 37 to 41 hours at cruise speed

4. Patent for transporting natural gas cargo by airship

Patent US3972492A, "Airship for Transporting Gas," was granted on 3 August 1976 to inventor William Milne. This patent is not for the Shell methane gas transporter, but it provides a useful insight to the state-of-the-art for a rigid gas cargo airship at the approximate time when that Shell methane gas transporter was being designed.

The general arrangement of the patented rigid airship (dirigible) is shown in the following diagrams.

FIG. 1

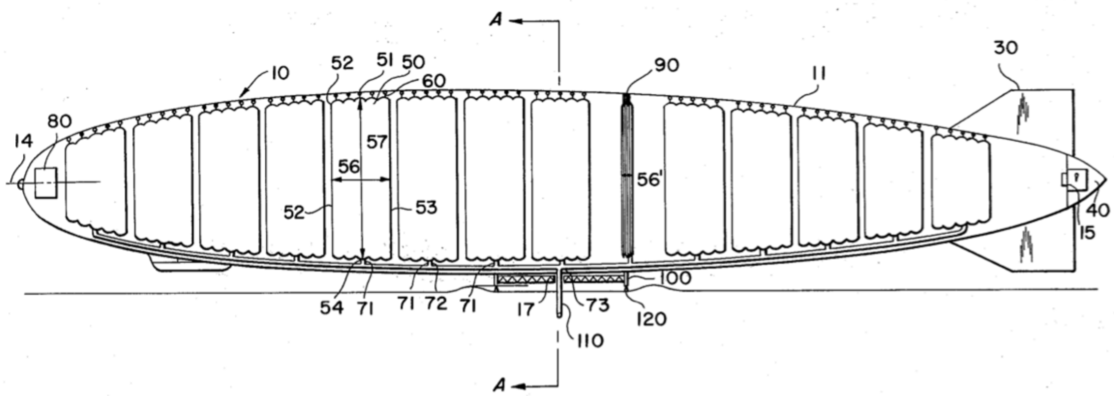


Figure 1 is a cross-sectional view that shows the dirigible (10) docked on a central turntable (100) that is connected to a local natural gas storage facility via a pipeline (110). The outer shell of the rigid envelope (11) defines the aerodynamic shape of the airship and protects the methane cargo storage cells (50) inside. Most of the cylindrical methane cargo storage cells are shown full (56) and one is shown empty and collapsed (56'). These cargo gas cells are aligned longitudinally within the hull and are supported around their periphery by cell hangers (60) connected to the hull. Natural gas is pumped into and out of each storage cell via a branch line (71) that connects to a gas manifold running along the keel of the airship. During cargo loading and unloading, the airship's manifold connects via fittings on the turntable to the pipeline at the ground facility (110). The entire airship rotates on its central turntable to keep the airship pointed into the wind.

When fully loaded with natural gas cargo, the airship is positively buoyant, and may need to be ballasted to achieve the desired buoyancy and trim for flight. On the return trip, the airship will have no natural gas. In this case, buoyancy will be provided by helium, perhaps introduced into some of the empty cargo gas storage cells (50) from a helium reservoir (80).

FIG. 4

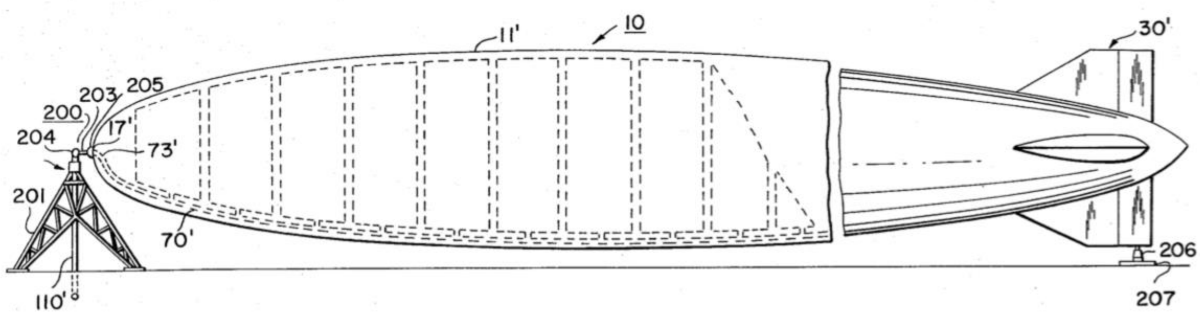


Figure 4 shows an alternate mooring scheme, with the nose of the dirigible (10) moored to a mast (200) that includes the connection between the airship's gas manifold (70) and the pipeline at the ground facility (110). At the tail of the airship, a wheeled support (206) rides in a circular track (207) to keep the nose of the airship pointed into the wind.

FIG. 2

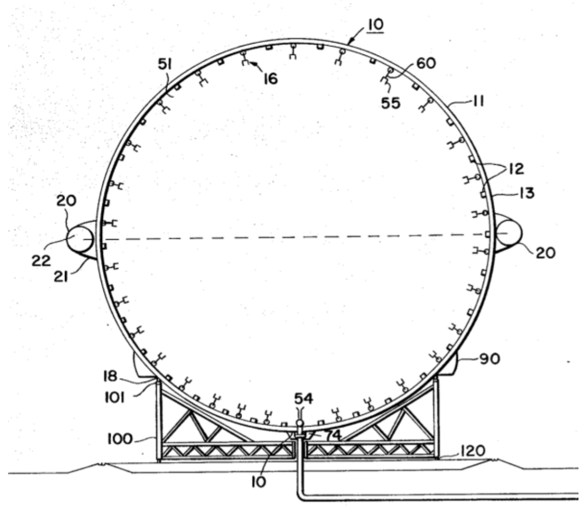


Figure 2 is a transverse section through the hull of the airship (10) docked on a central turntable (100). Two representative propulsion engine (20) are mounted to the hull. The peripheral cargo gas cell hangers (60) are shown connected to the hull.

5. Conceptual design phase ends

Well known British scientist, engineer and inventor Barnes Wallis was involved in the Shell methane gas transporter project in its early stages. In 1970, Shell engaged a new team from Aerospace Developments (AD), which was led by John Wood and Roger Munk.

In his book, “An Introduction to the Airship,” E. Mowforth reported,

> “Ground handling would clearly be a major issue, and systems for operating from a revolving platform or from water were being examined……..Some form of buoyancy compensation for the weight of fuel consumed at these high speeds would also be required….Unfortunately, the project was terminated before a detailed study of the concept could be crystallised…."

Two smaller-scale test prototypes were planned. However, no airship was built to validate Shell’s methane gas transporter concept.

Shell cancelled the project in 1974 as part of a general cutback in long-term research and development expenditures. Subsequent work by the AD team showed that Shell’s methane gas transporter concept was impractical.

6. For additional information

- E. Mowforth, “An Introduction to the Airship,” The Airship Association, Ltd., Third edition, pp. 101 – 102, ISBN: 0-9528578-6-3, September, 2007
- “Aerospace Developments AD 500 - The first of the new era,” (there’s introductory text on the Shell methane gas carrier airship), The Airship Heritage Trust, 2020: https://www.airshipsonline.com/airships/AD%20500/index.html
- “Airship Industries,” in the article “Aerospace Developments, 1970–79,” Wikipedia: https://en.wikipedia.org/wiki/Airship_Industries
- M. Sonstegaard, “Airships for transporting highly volatile commodities,” Proceedings of the Interagency Workshop on Lighter than Air Vehicles, NASA-CR-137800, pp. 551 - 562,

Doc ID 19760007973, 1 January 1975: https://ntrs.nasa.gov/citations/19760007973

- "Concept: Natural Gas Delivery Via a NG-Powered Airship," Green Car Congress, 14 May 2006: https://www.greencarcongress.com/2006/05/concept_natural.html

Patents

- Patent US3844507A, "Process for the transportation of impellent gases, for example natural gas, and apparatus for carrying out the process," inventor: Hermann Ernst Robert Papst, filed 19 March 1973, granted 29 October 1974: https://patents.google.com/patent/US3844507A/en
- Patent US3972492A, "Airship for transporting gas," inventor William Milne, filed 29 January 1975, granted 3 August 1976: https://patents.google.com/patent/US3972492A/en

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    - Kiev OKBV – Aerostatic fuel transportation system (SATT)
    - Novosibirsk OKB – natural gas carrier
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