Airships International – "Home of metalclad airships"

Peter Lobner, 5 November 2023

1. Introduction

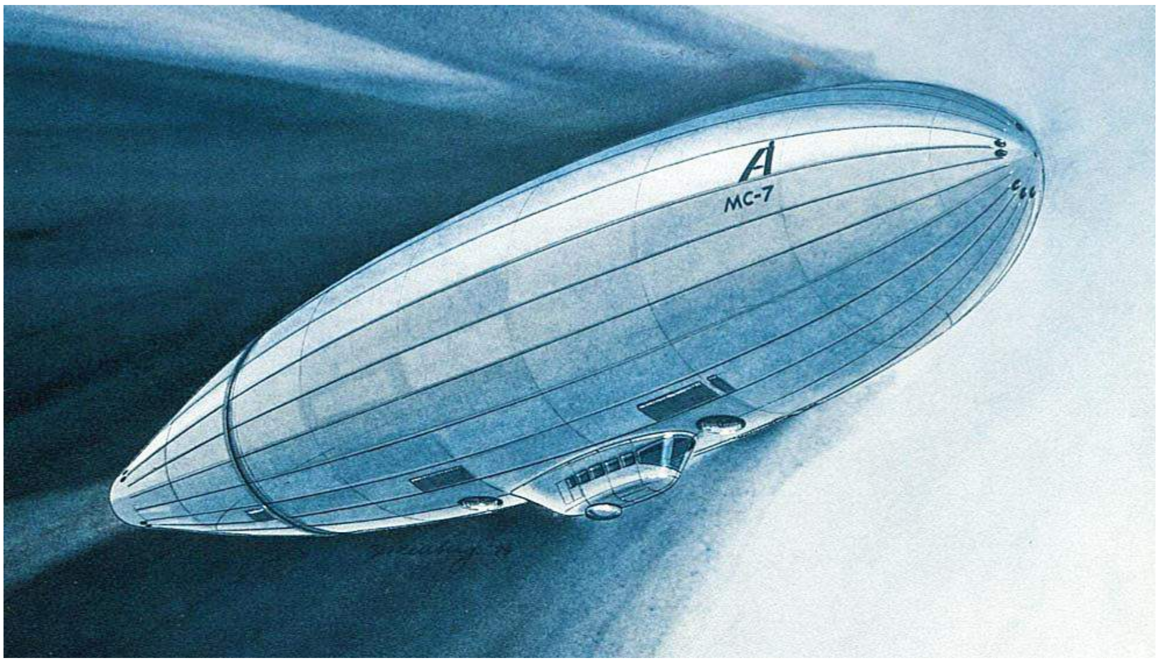
Airships International was founded by Dr. Earl Kiernan and Prof. Vladimir Pavlecka in 1977, near the former US Navy blimp base in Tustin, CA. Their business goal was to commercialize modern metalclad airships derived from the successful ZMC-2 metalclad airship designed by Pavlecka in the late 1920s and flown by the U.S. Navy for 10 years, from 1929 to 1939. The ZMC-2 was a milestone of lighter-than-air (LTA) flight, and remains the only successful metalclad airship in the world.

AI's management team, L to R: Prof. Vladimir Pavlecka (Chief Scientist), Robert Brandt, Dr. Earl Kiernan (President & Chairman of the Board), Al Brandt, John Roda (VP Fabrication & Production) & Richard Pope.

Over the next year, AI representatives visited many airship firms and operators around the world to gather useful experience for their own modern metalclad airship design concepts, the MC-7 and MC-8.

2. Anatomy of AI's basic metalclad airship – the MC-7

Vladimir Pavlecka's first advanced metalclad airship design, designated MC-7, was a novel streamlined, tailless, elliptical vehicle that was propelled by internal turbine engines and was controlled with the aid of bow and stern directional thrusters and midships lifting thrusters. It used helium as the lifting gas and hydrogen as fuel.

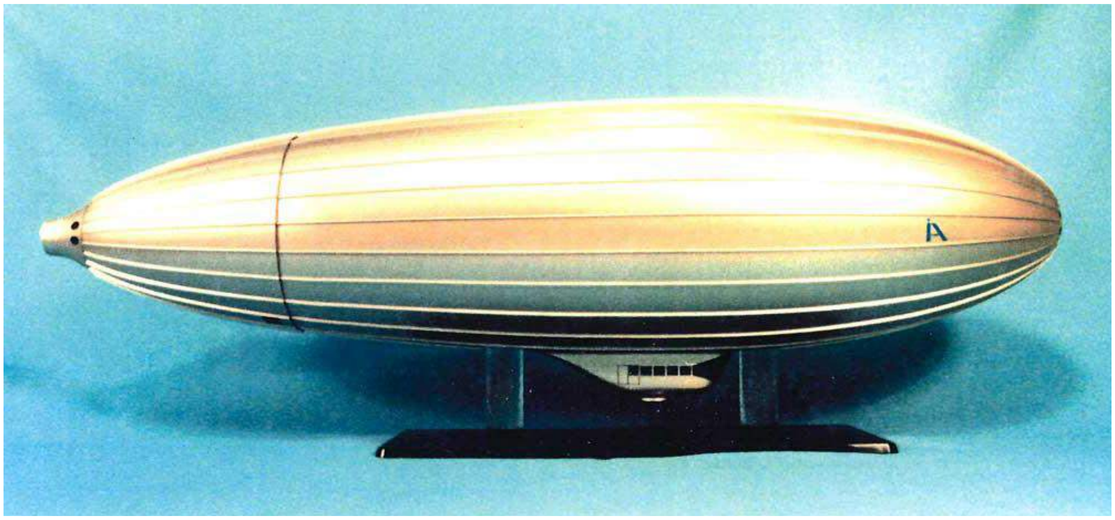


A basic MC-7 can be configured for a wide range of applications. Source: AI company brochure, 1980.

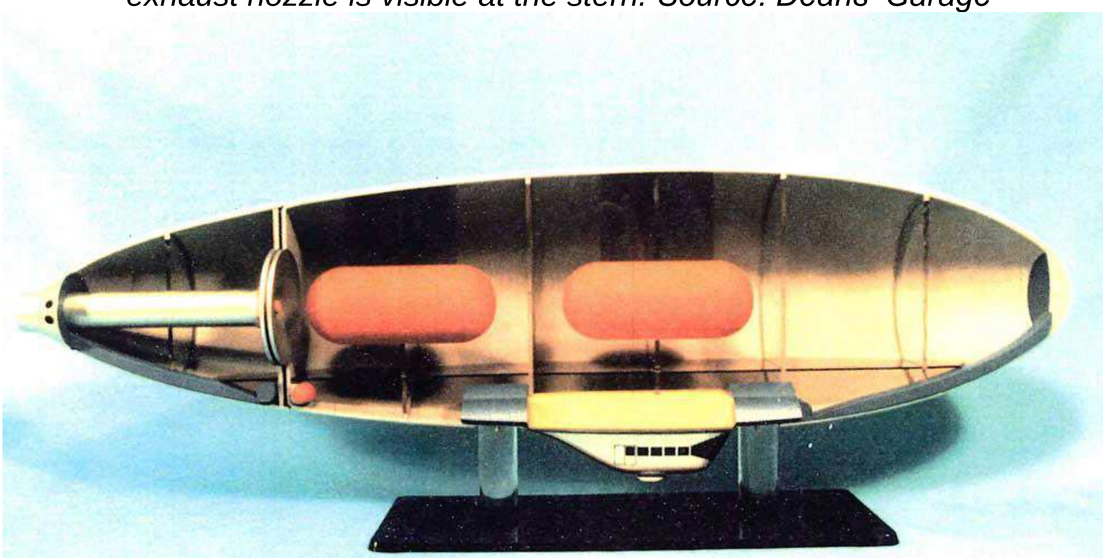
- Modified monocoque metal (aluminum) hull in which all elements of the pressurized hull are loaded in tension and shear.
- Efficient, low-drag hull shape without conventional, drag-producing aerodynamic fins and control surfaces.
- Integral attachment of the load-supporting structures to the pressurized, metalclad hull.
- Automated flight control system.
- Propelled by internal contra-rotating propellers, with an annular air intake around the hull and an exhaust at the tail.
- Pitch and yaw control are accomplished at all speeds with sets of directional thrusters at the nose and tail of the airship.

- Supplementary dynamic lift is provided by lifting thrusters when needed (i.e., when the weight of a large load exceeds the available aerostatic lift).
- Hydrogen fuel

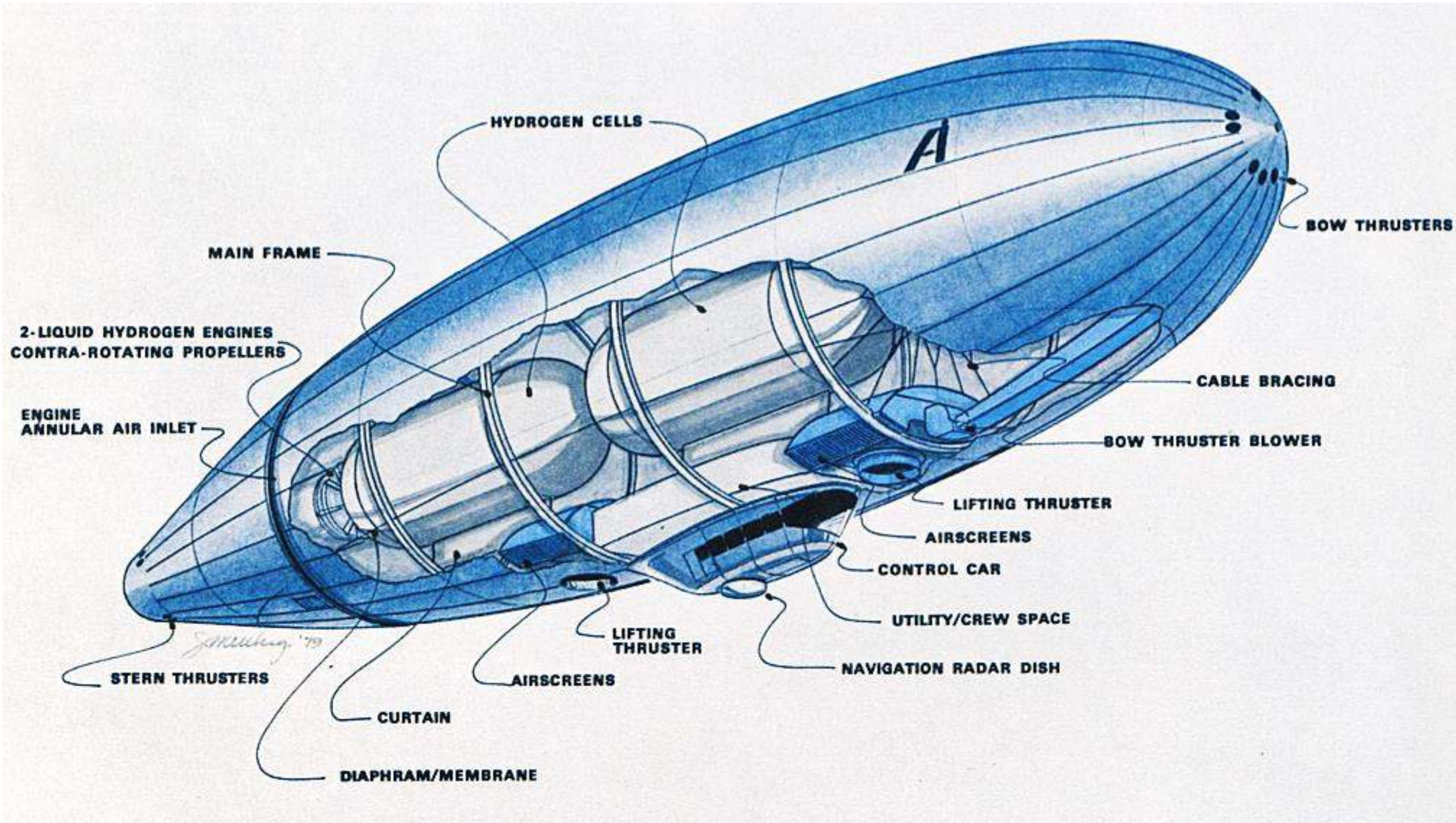
AI created many variants of the basic MC-7 design.



MC-7 model, exterior arrangement. The annular air inlet for the internal contra-rotating propellers is the vertical stripe (left of center). The main propulsion exhaust nozzle is visible at the stern. Source: Deans' Garage



MC-7, interior arrangement. The two orange tanks store cryogenic liquid hydrogen fuel for the propulsion turbines. Helium lifting gas is in the surrounding space within the metal hull. The main frames (ribs) within the metal skin are visible. The lifting thrusters are located immediately forward and aft of the gondola (grey panels, where the model support legs attach).
Source: Deans' Garage



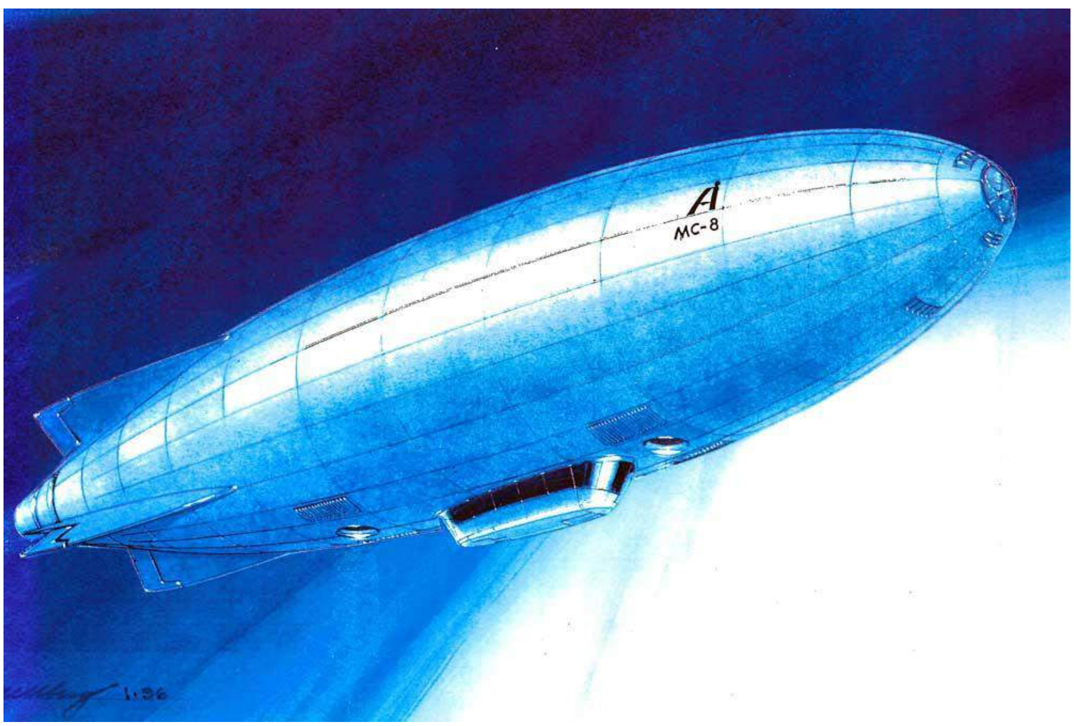
MC-7 cutaway drawing. Source: Graphic by John Melberg via Airships International (197

3. Anatomy of AI's metalclad airship – the MC-8

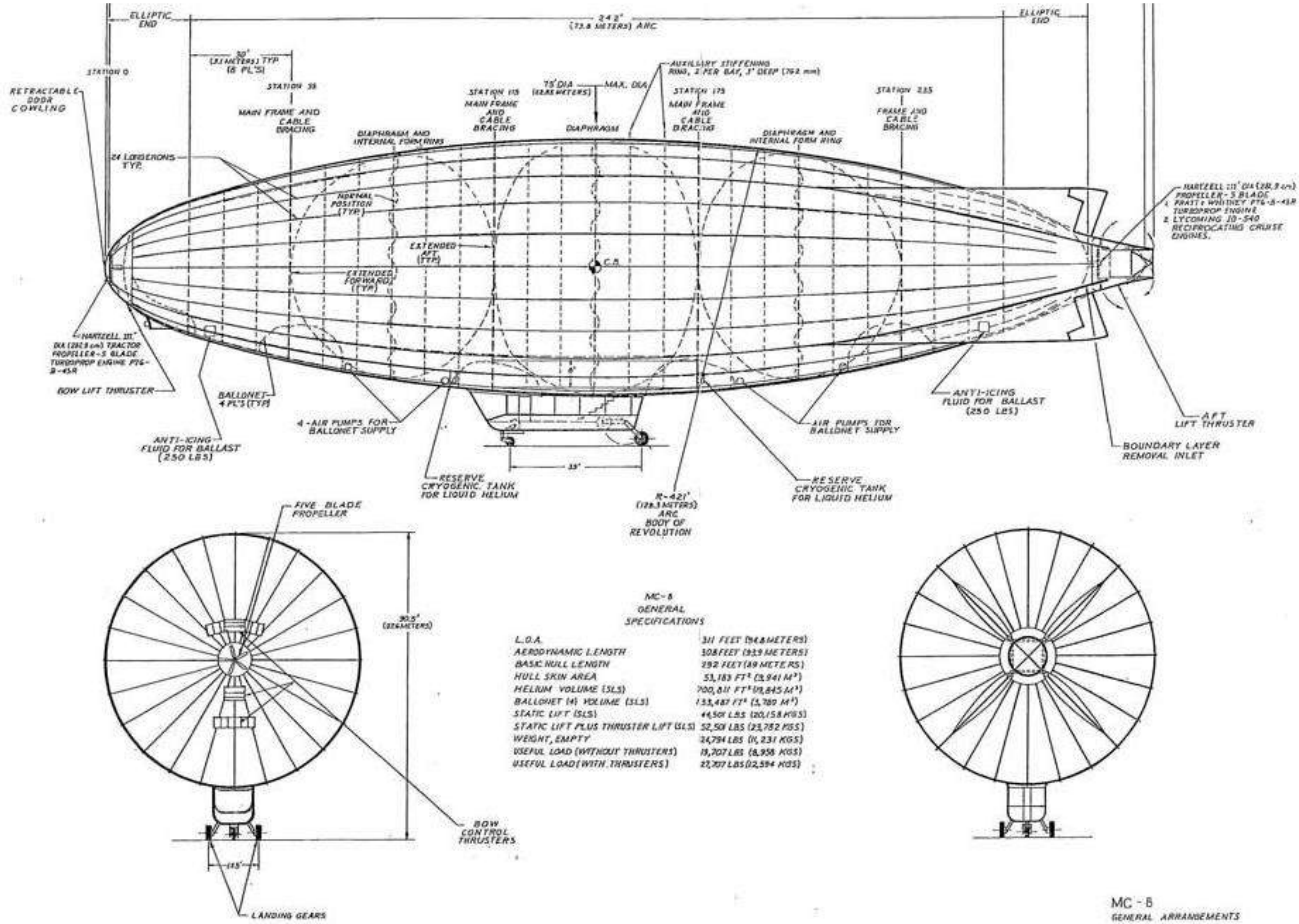
Vladimir Pavlecka's second advanced metalclad airship design, designated MC-8, also was a streamlined elliptical vehicle that used directional control and lift thrusters. However, it had many significantly different design features:

- Propelled by a 3-bladed Hartzell propeller inside the tail duct, driven by a Pratt & Whitney PT6 turboprop engine and/or two Lycoming 10-340 reciprocating cruise engines.
- Directional control in flight is provided by aerodynamic control surfaces on the X-configured tail fins.
- A stern lift thruster is located under the tail duct.
- Bow directional and lift thrusters are supplied with high pressure air from a nose mounted, internal, 5-bladed Hartzell tractor propeller driven by a Pratt & Whitney PT6 turboprop engine.
- A boundary layer removal duct just aft of the tail fins reduces turbulence and drag.

No variants of the basic MC-8 design have been identified.



MC-8. Source: John Melberg via Deans' Garage



MC-8 three-view drawing. Source: John Melberg via Deans' Garage

4. AI patents for metalclad airships

Nearly 50 years after he designed the metalclad hull of the US Navy's successful ZMC-2 airship in the 1920s, Vladimir Pavlecka developed several patents for key technologies that were incorporated in AI's metalclad airship designs in the late 1970s and 1980s. John Roda, also a member of the original ZMC-2 team, patented a novel process that AI would have used to assemble their metalclad airships.

4.1 CA1168644A, "Metal-clad airship hull construction," filed 22 June 1979

This patent describes the basic structural elements of an elongated, ellipsoidal, metalclad airship:

- Integral, continuous**, transverse circular framing rings** located internal to, and secured to, the metal shell at predetermined intervals along the longitudinal axis of the airship. Each framing ring is a separate, continuous structure with a triangular cross-section having corrugated shear webs interconnecting the apexes of the triangle.
  - The diameter of the framing rings varies according to its longitudinal position along the hull.
  - There are primary and secondary transverse circular framing rings, with two secondary framing rings equally spaced between each pair of primary framing rings.
- **Longitudinal framing members** (longerons) located external to, and secured to, the metal shell and spaced at regular intervals around the perimeter of the airship. Each longeron is a separate, continuous structure with a triangular cross-section, extending the length of the airship, from the nose to the tail, and having corrugated shear webs interconnecting the apexes of the triangle.
- The **metal shell** is the low-leakage, pressure-retaining structure that contains the lifting gas. The thickness of this ellipsoidal shell is greatest at the top of the hull at the point of maximum diameter and diminishes longitudinally toward the front and rear of the airship, and perimetrally from the top to the bottom of the airship. The transverse circular framing rings are inside, and

attached to, the metal shell, and the longitudinal framing members are outside, and attached to, the metal shell.

- A **keel corridor** extends longitudinally along the bottom of the hull, inside the metal shell.
- A **top corridor** extends longitudinally along the top of the hull, inside the metal shell.

4.2 US4208027, "Gradation of skin thickness on metal-clad airship hulls," filed 9 August 1978

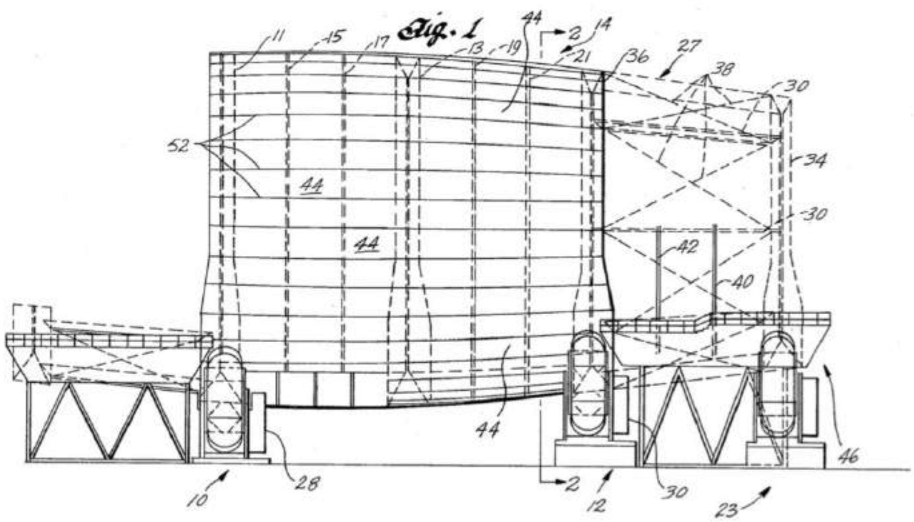
This patent describe methods for assembling the external skin of a metal-clad airship using sections of hull plating with varying thicknesses. The thickest hull plating is at the top centerline of the hull at the point of maximum diameter. Plating thickness diminishes around a circular transverse section, reaching a minimum at the bottom centerline of the airship.

The hull plating is attached to internal transverse circular framing rings and longitudinal framing members (longerons) that are individually continuous from nose to tail and triangular in cross-section. The transverse frames and longitudinal framing members have corrugated shear webs in each side surface of the triangle.

4.3 US4259776A, "Method of assembly of airship hull," filed 9 August 1978

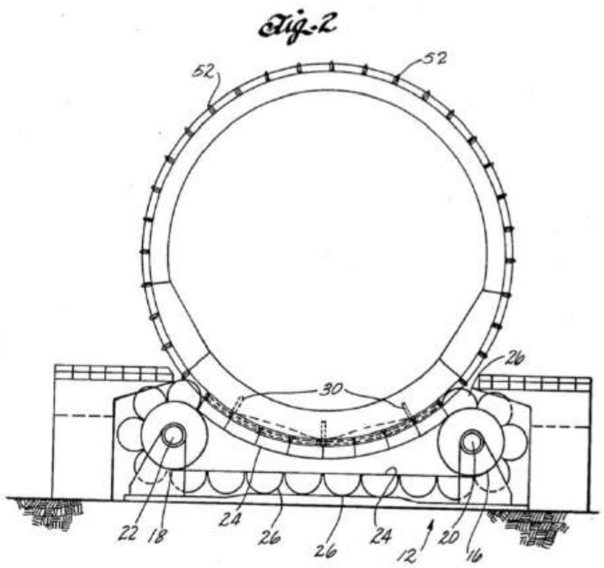
In 1978, John Roda patented a method for assembling the hull of a rigid, metalclad airship using rotating cradles with ground-level and low-level work platforms. As described in detail in the patent, these work platforms are designed to provide the highest degree of accessibility, convenience, and safety for the personnel involved. Rotating cradles hold the entire hull during assembly and move the work site into position at a work platform, thereby eliminating the need for scaffolding around the hull.

Roda's basic process is very similar to the manufacturing process adopted by LTA Research and Exploration 40 years later to construct their Pathfinder 1 and 3 rigid airships in the 2020s.



Legend: The hull (14) is comprised of principal frames (11, 13), secondary frames (15, 17, 19 & 21), longitudinal girders (longerons, 52) and skin panels (gores, 44), which are formed on a stretch press to a predetermined compound curvature and are attached to frames, longerons, and each other. The hull is shown resting on rotating cradles (12, 14) that permit construction work to be performed safely from low-level work platforms.

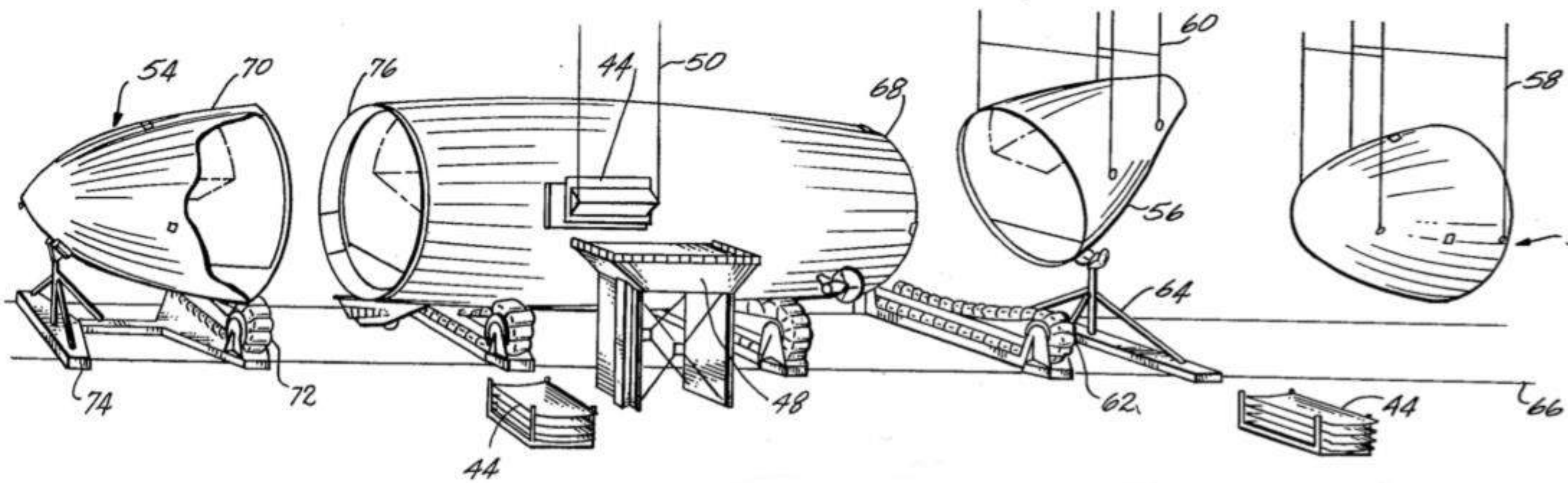
Side elevation view of a hull under construction showing supporting rotating cradles and assembly platforms. Source: US4259776, Fig. 1



Legend: *Rotary cradle (12) supports motor-driven rotating cylinders (16, 18) that drive a loose-fitting belt (24) that is adjusted to the diameter of the hull, which sits on fabric cushions (26).*

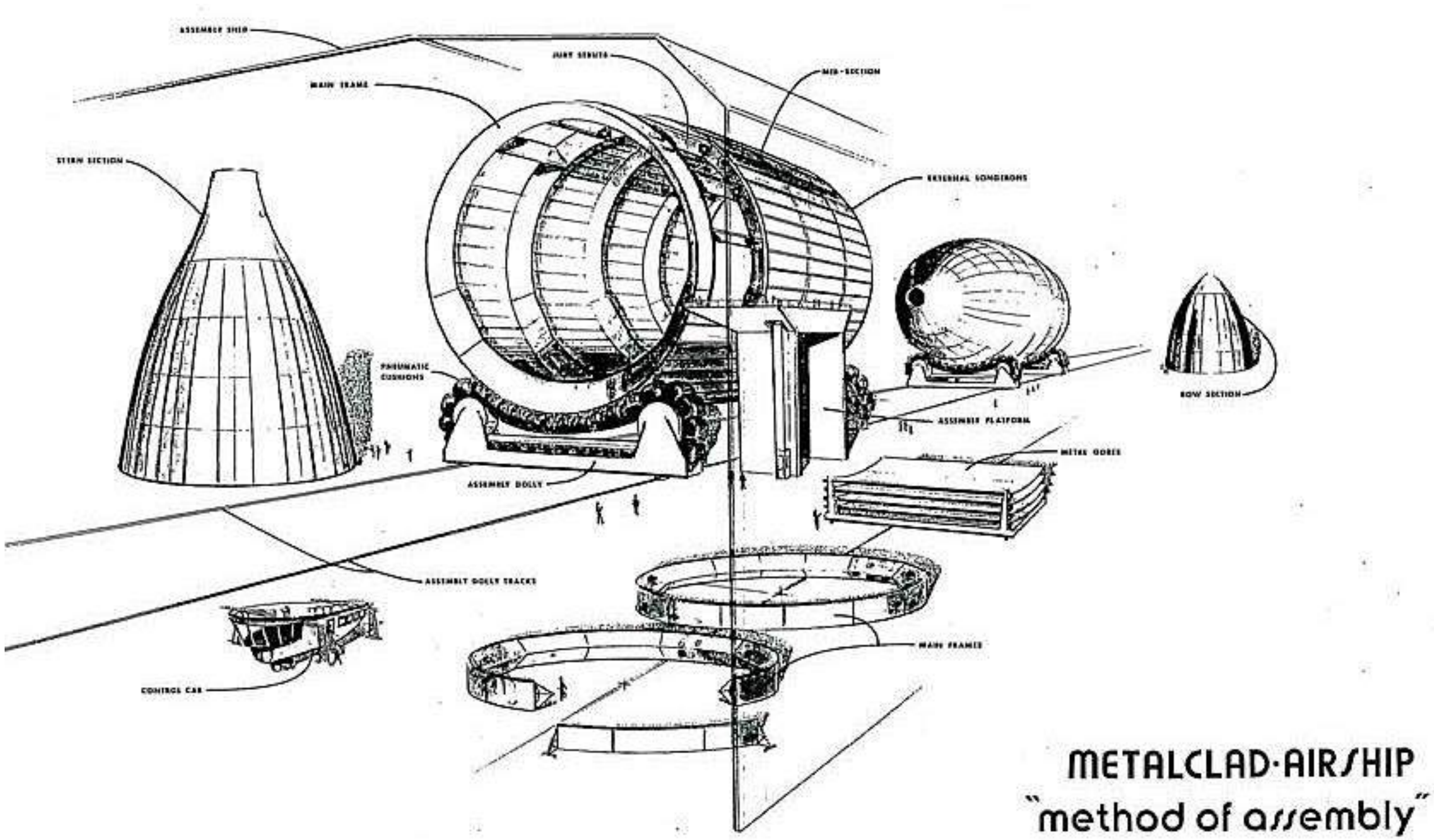
A sectional view taken along lines 2-2 of Fig. 1, showing the rotating cradle mechanism supporting the hull. Source: US4259776, Fig. 2

Fig. 3



Legend: Skin section gore paneling (44) is attached to the hull framework at the scaffolding platform (48), which provides the highest degree of accessibility, convenience, and safety for the personnel involved. The skin paneling is installed with the aid of a sling (50) and suction platen to hold the panel in place while it is being fastened. When this step has been completed, the rotary cradles are rotated in the same direction to bring the next attachment site into position. The bow and stern sections (54, 56) are separately and independently assembled in a vertical attitude, like the ZMC-2. After assembly, the bow and stern sections are lifted by slings (58, 60) and brought into horizontal positions adjacent to each end of the hull. Once horizontally positioned, stern section (56) is lowered onto a rail-mounted rotary cradle (62) and bow section (54) is placed on a similar rotary cradle (72). These sections are abutted to the main section of the hull and fastened by bonding and riveting.

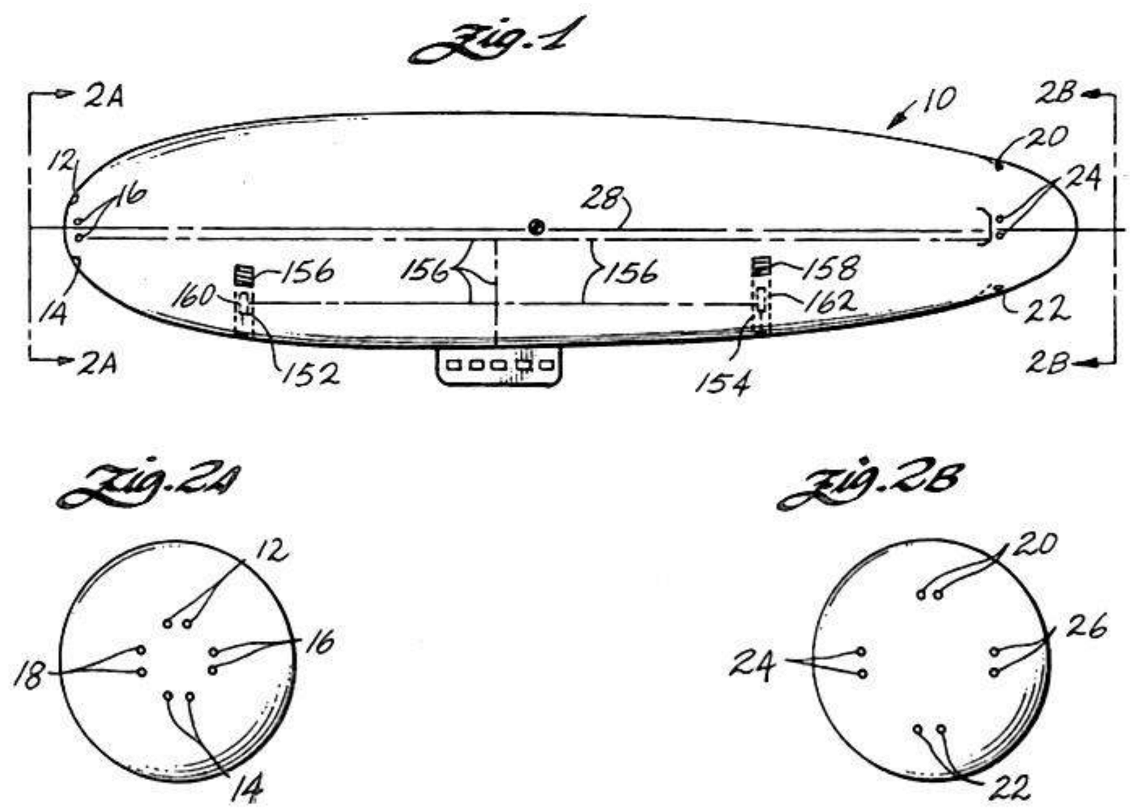
A perspective view of the final assembly stages of the hull. Source: US4259776, Figure 3



AI metalclad airships being assembled. Source: John Melberg via Deans' Garage

4.4 Patents CA1143352A & US4402475, “Thrusters for airship control,” Filed 22 June 1979 & 20 May 1980, respectively

These patents by Vladimir Pavlecka describe the use of thrusters at the bow and stern of an airship for control of the direction, attitude and lateral position of the airship. The thrusters are arranged in pairs at the top, bottom, and each side of the bow and stern of the airship. Additional pairs of lifting thrusters directed downwardly from the bottom of the hull provide dynamic lift to augment the static lift capability of the airship when under heavy load.

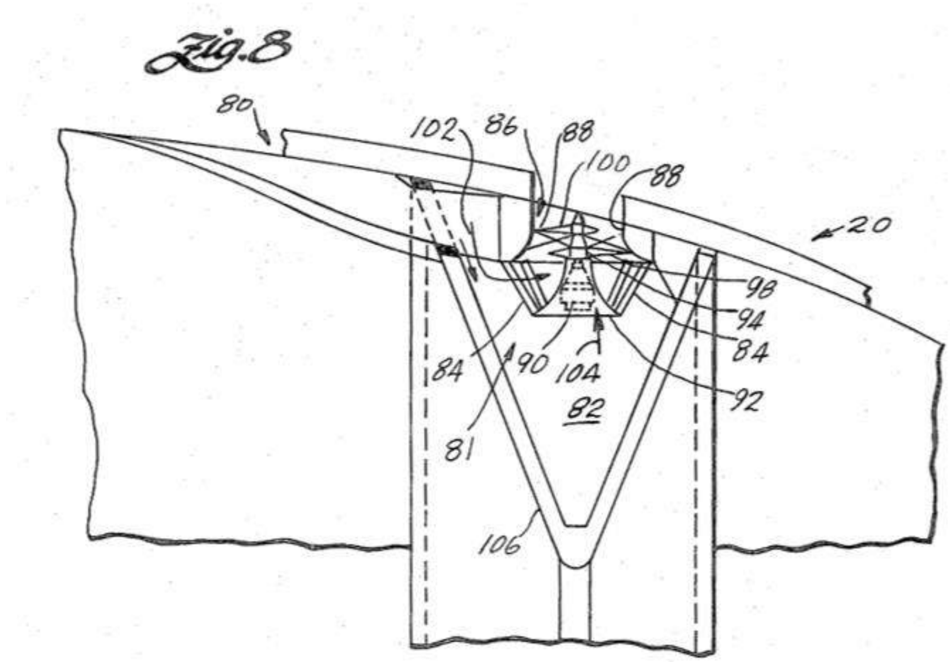


Legend: The airship (10) has a set of eight variable-speed electric motor-driven thrusters located at the bow to provide up, down, left (port) & right (starboard) thrust (12, 14, 16 & 18). A similar set of eight thrusters is located at the stern (20, 22, 24 & 26). Intake ducts at the bow and stern provide the source of air for these thrusters. Flank mounted air intakes (156, 158) supply air to the lifting thrusters (152, 154) and their gas turbine prime movers (160, 162). An operational airship would have at least four lifting thrusters aligned in pairs along the bottom of the hull, on the port and starboard sides of the airship’s centerline.

Side elevation, bow and stern views of an airship equipped with thrusters. Source: US4402475, Figs. 1 & 2

The set of eight bow and eight stern thrusters are arranged in pairs, each with their own air intake. When not operating, the thrusters are allowed to “windmill” in their housings. In operation, they direct powerful, controlled jets of air radially out from the hull. The reaction forces push the hull in the opposite direction. Each thruster is driven at variable speed by an asynchronous (induction) motor with a variable frequency power source. A central control system coordinates the operation of all thrusters.

The design of a stern thruster is shown in patent Figure 8, which is reproduced below. The more complex design of a bow thruster is shown in patent Figures 3 and 7.



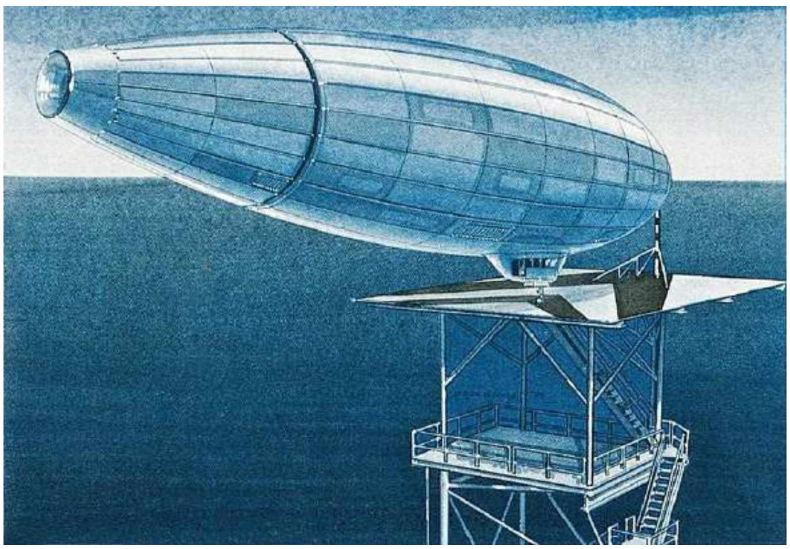
Legend: The top thruster (20) in this figure is one of a pair of top thrusters installed at the stern to generate thrust in the upward direction and thereby push the stern down when in operation. The machine consists of a pair of contra-rotating propellers (98, 100) driven by an variable-speed asynchronous (induction) electric motor (90). Ambient air enters the intake (80) on the surface of the airship and this air mass is directed through ductwork into a plenum chamber (82) and then to the inlet side of the thruster (102). The exhaust of this thruster is directed vertically upward through the exit duct (86). The thruster assembly and ductwork are supported by an internal structural framework (106). The seven other thrusters at the stern are similar.

Details of the flow path of air through the intake duct to a typical bow thruster and thence to the exit. Source: US4402475, Fig. 8.

5. AI’s metalclad airship design concepts based on the MC-7

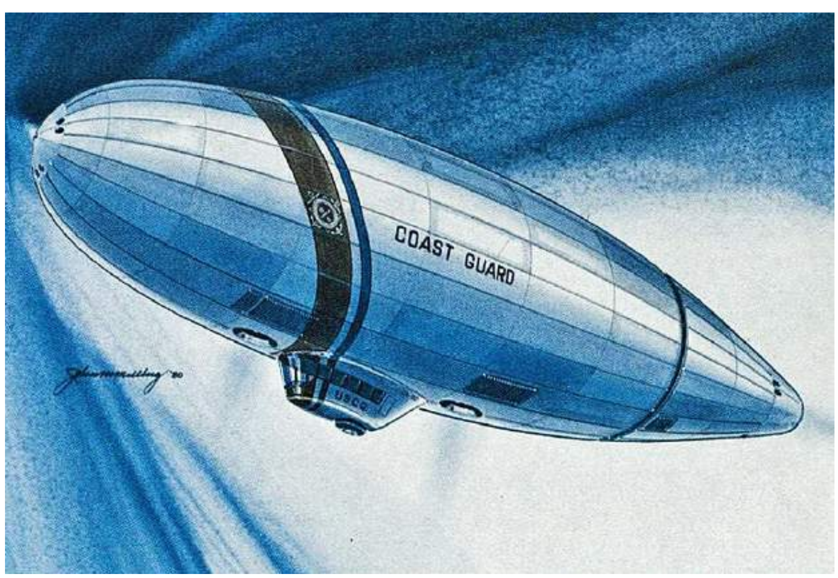
This section presents many of the variants of AI’s basic MC-7 metalclad airship design concept.

Explorer: A basic MC-7 can be configured to support a wide range of remote sensing and mapping applications and can deliver equipment, people and supplies into inaccessible areas. Here it has been configured for survey and exploration and has landed at a mooring mast on a remote platform. Note the main engine annular air inlet, which appears as a dark ring about ¾ of the way back along the hull. The propulsion engine exhaust is at the tail.



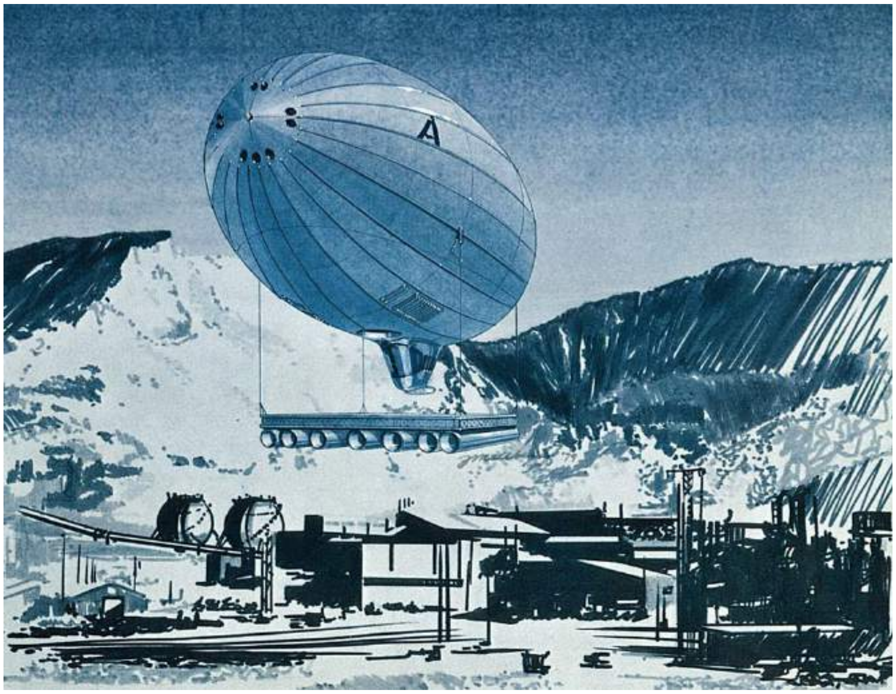
Explorer.
Source: AI company brochure, 1980.

Sentinel: The basic MC-7 is capable of providing year-round surveillance over land and sea. Here it is shown configured for Coast Guard duty. Note the lifting thruster ports are located fore and aft of the control car (gondola) and are flanked by screened air intakes.



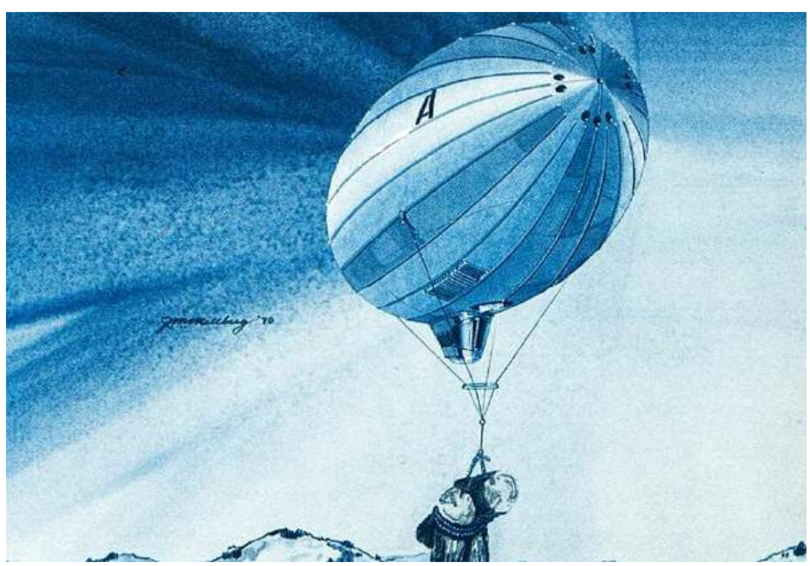
Sentinel.
Source: AI company brochure, 1980.

Lifter: This is a basic MC-7 configured for external cargo carrying operations. In this case, a sling load of construction material is suspended from four load points on the rigid hull. Loads can be picked up and delivered without landing.



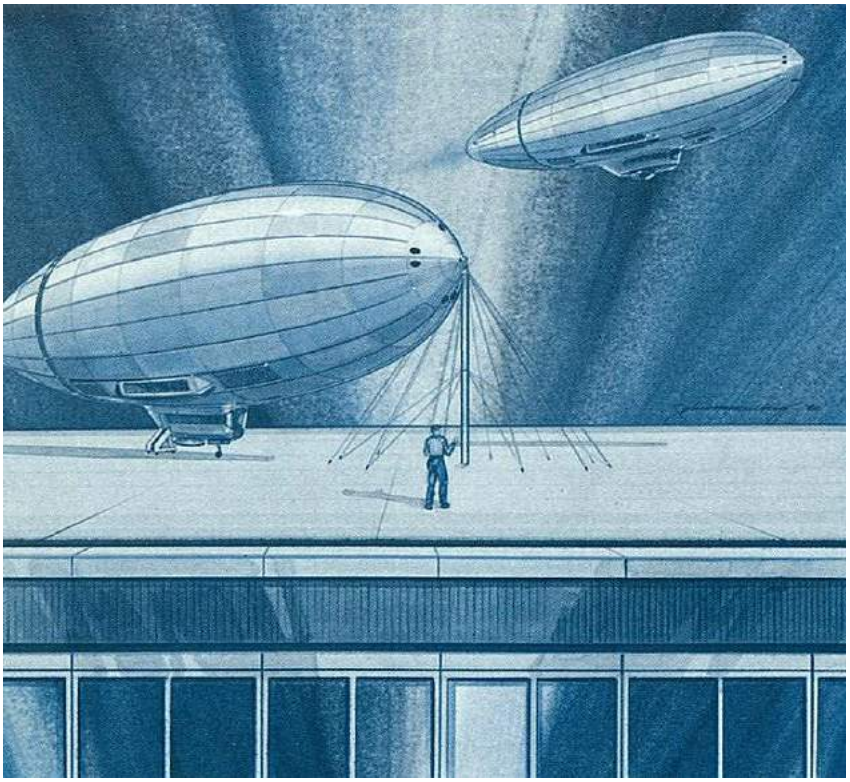
Lifter. Source: AI company brochure, 1980.

Logger: A basic MC-7 can perform precisely controlled descents and ascents and can lift and deliver large loads over long distances. Here it is configured for logging operations, with a heavy sling load of timber suspended from four load points on the rigid hull. The airship's ability to directly access remote areas in difficult terrain eliminates the need to construct costly and environmentally damaging access roads into logging areas for specialized logging vehicles.



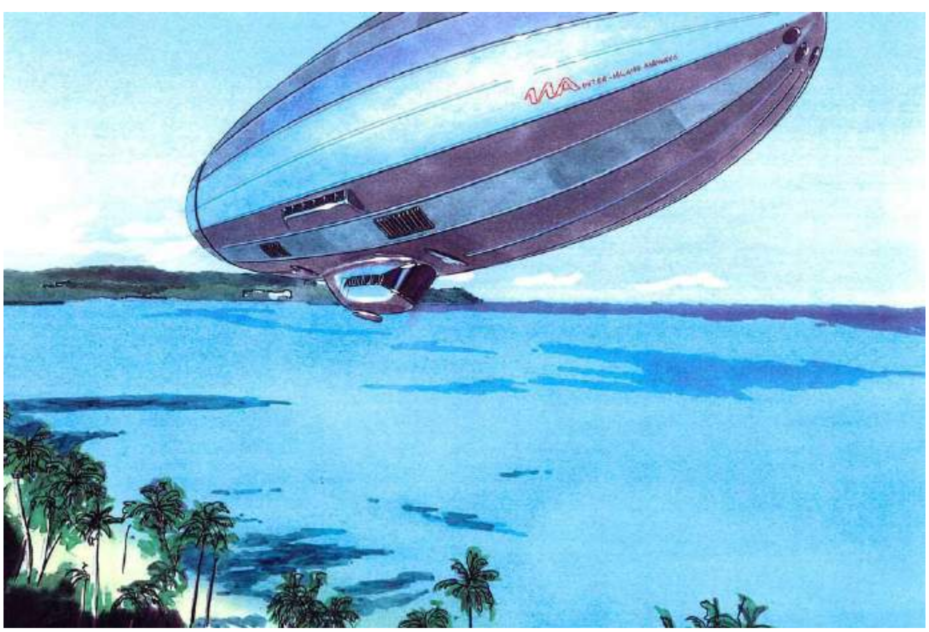
Logger. Source: AI company brochure, 1980.

Commuter / tourist: This passenger version of the MC-7 has an extended gondola to accommodate passengers and an upper level passenger compartment that extends into the lowest level of the rigid hull. Commuter operations from city center rooftop terminals would be possible.

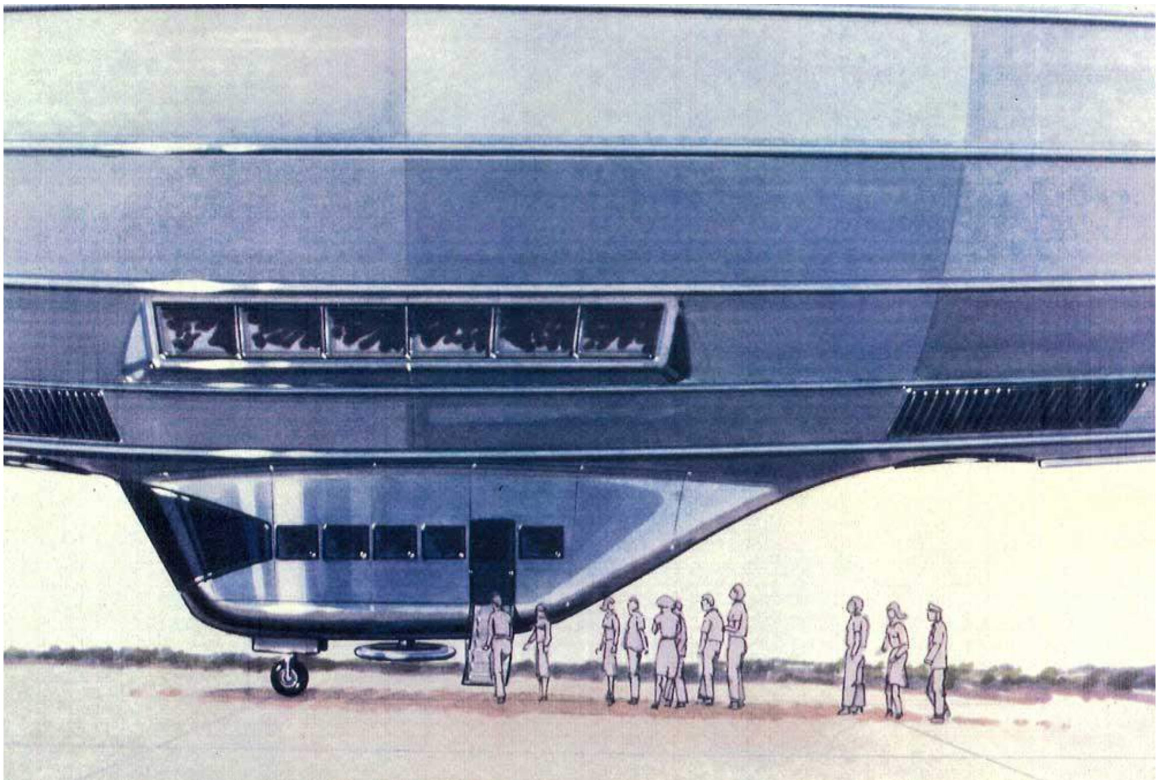


Commuter. Source: AI company brochure, 1980.

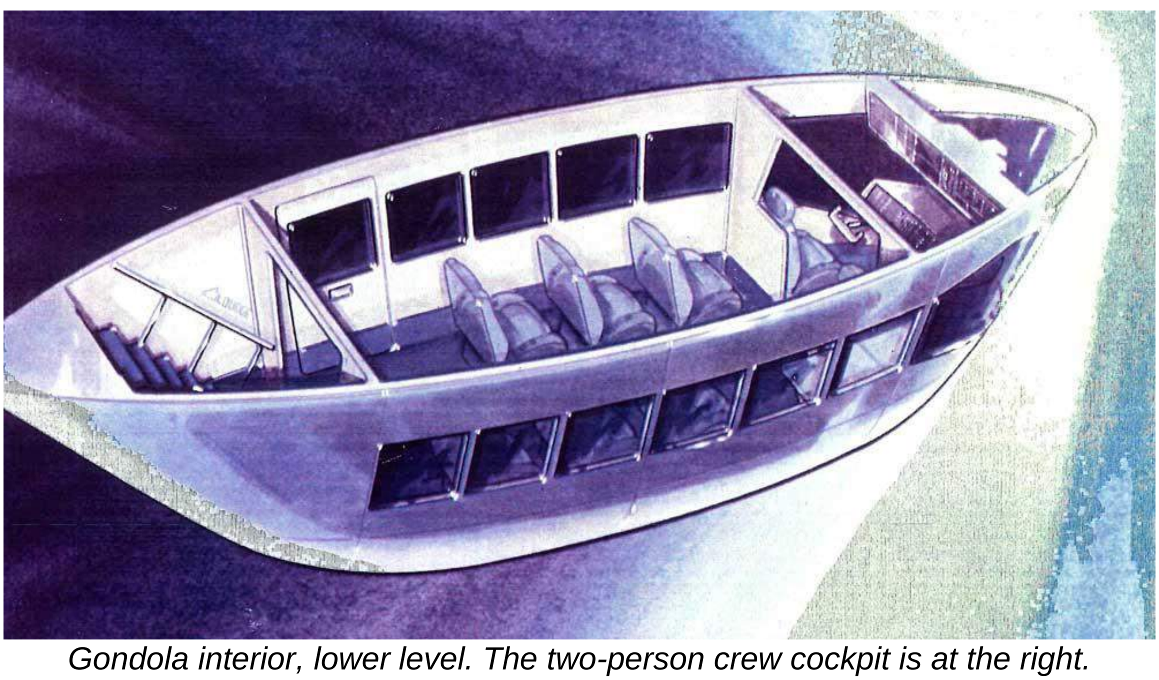
Good visibility from the broad windows in the upper and lower passenger compartments makes the Commuter model an attractive vehicle for scenic day tours.



Tourist. Source: John Melberg via Deans' Garage

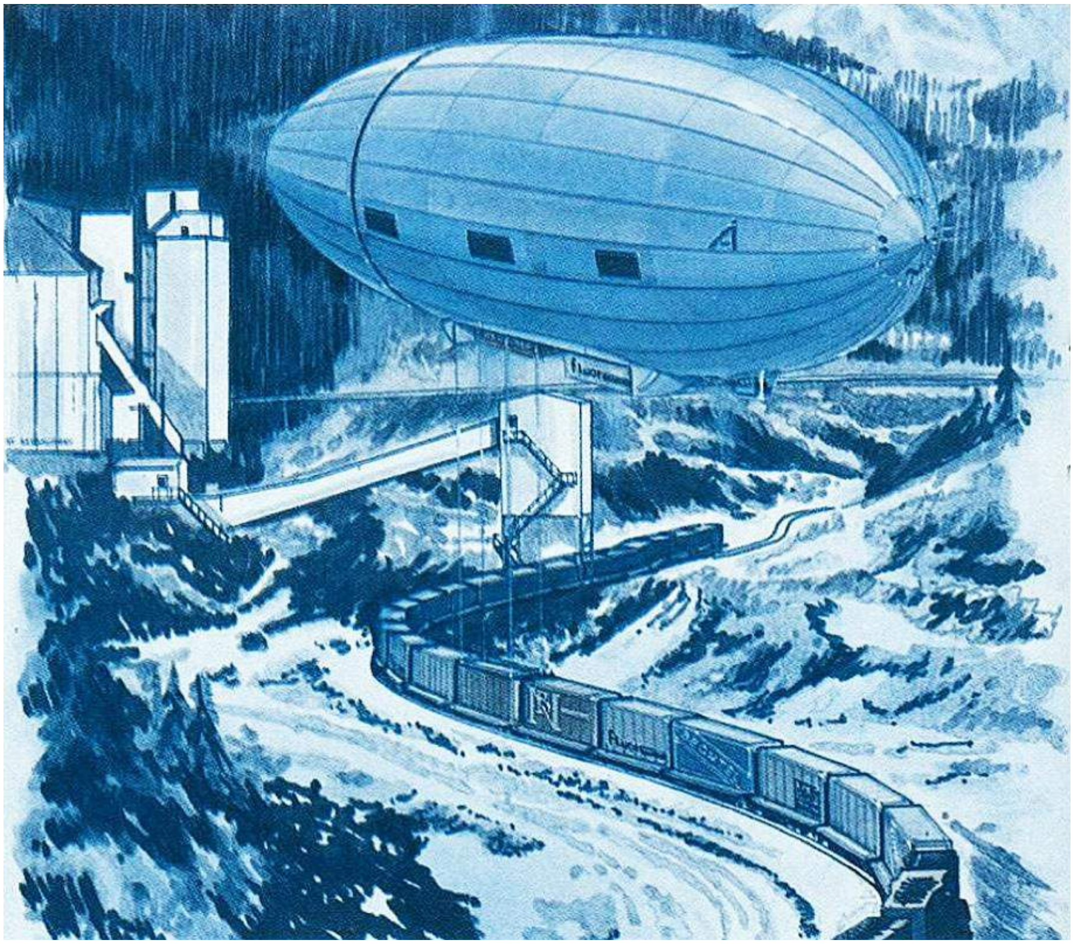


Closeup showing the passenger gondola and the additional passenger section in the lower hull. Note the screened air intake ports for the lifting thrusters fore and aft of the passenger compartment. Source: John Melberg via Deans' Garage



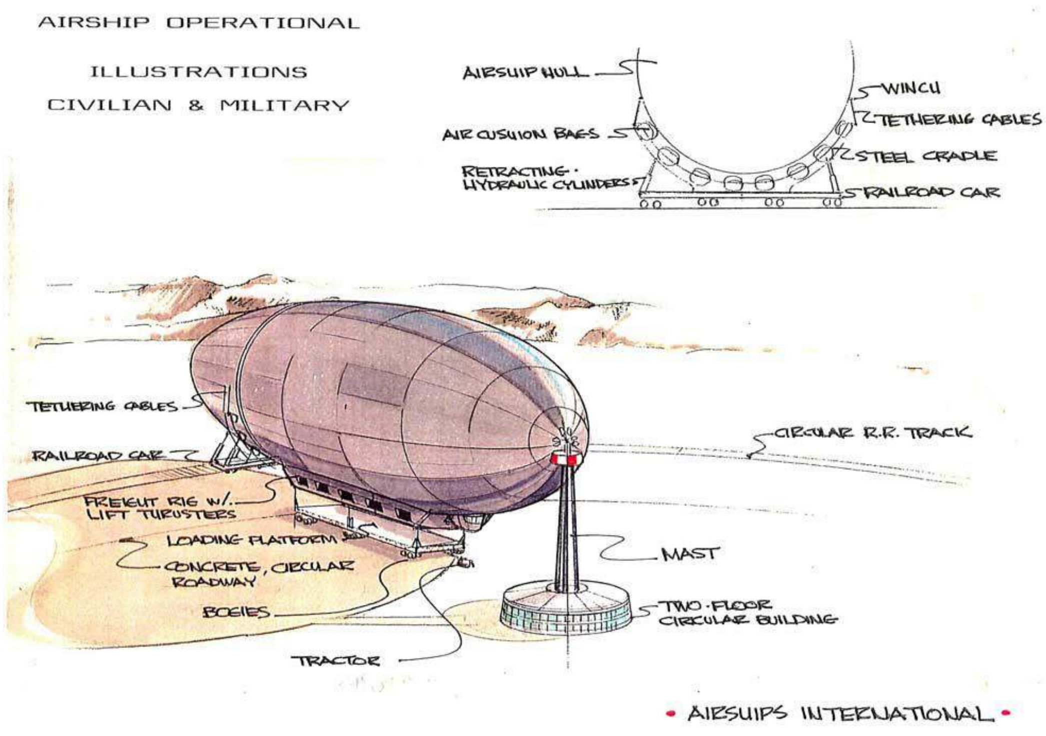
Gondola interior, lower level. The two-person crew cockpit is at the right. The stairway to the upper level passenger compartment is at the left. Source: John Melberg via Deans' Garage

Freighter: These are scaled-up and strengthened variants of the MC-7 with a large internal cargo bay under the hull. One freighter variant has an internal crane for picking up or delivering cargo from a hover, without landing. Some variants augmented with additional lifting thruster power have 50% greater payload capacity.

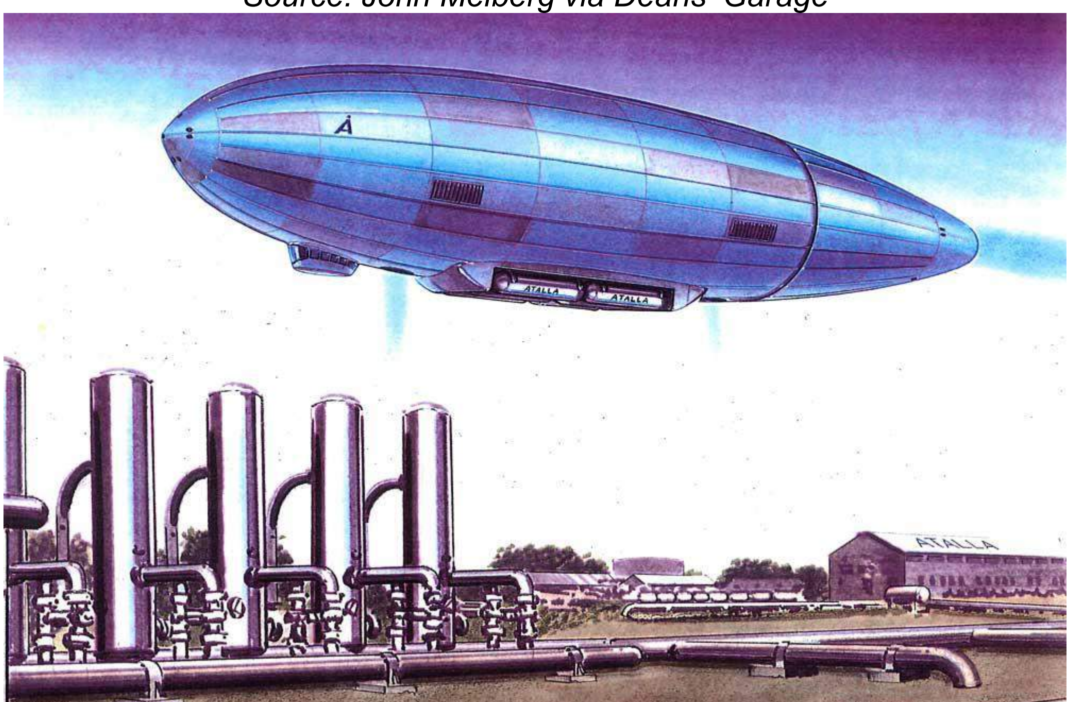


Freighter: Cargo variant with an internal crane, shown picking up or delivering a standard shipping container on a rail car. Source: AI company brochure, 1980.

Freighters also can operate from fixed bases with traditional mooring facilities and transfer cargo on the ground. To secure a large freighter at a mooring mast and allow it to safely weathercock in the wind, AI developed a concept for large cradle mounted on a railroad car that would secure the stern of the airship and move around a circular track to keep the airship facing into the wind. This freighter design had a large cargo platform that would be lowered to the ground during a load exchange.



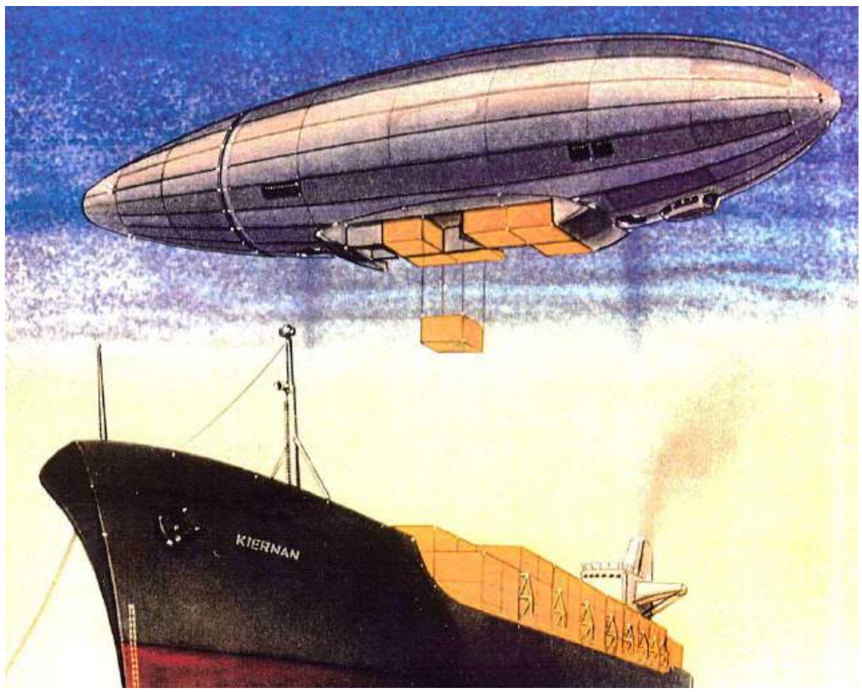
Freighter: Airship is at a mooring mast with its stern tethered to a railroad car on a circular track. The cargo loading platform has been lowered. Source: John Melberg via Deans' Garage

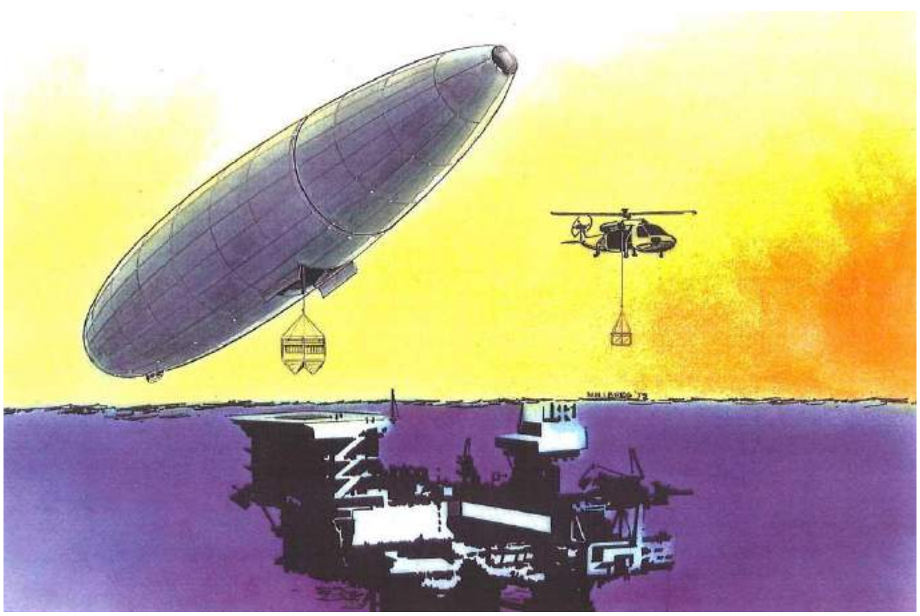


Freighter: Note the lifting thrusters fore and aft of the cargo bay are shown operating in this graphic. The control car has been moved forward of the lifting thrusters. Source: John Melberg via Deans' Garage

Another freighter variant was designed to handle a large volume of containerized cargo and move the containers between offshore ships and a port or other location on land. The freighter hovers over the ship while conducting a load exchange. These freighters can help reduce port congestion, reduce cargo delivery time to the end-user and enable ship-to-shore cargo operations in areas where suitable port facilities don't exist. The freighter also can be used to provide logistics support for offshore facilities and other remote sites.

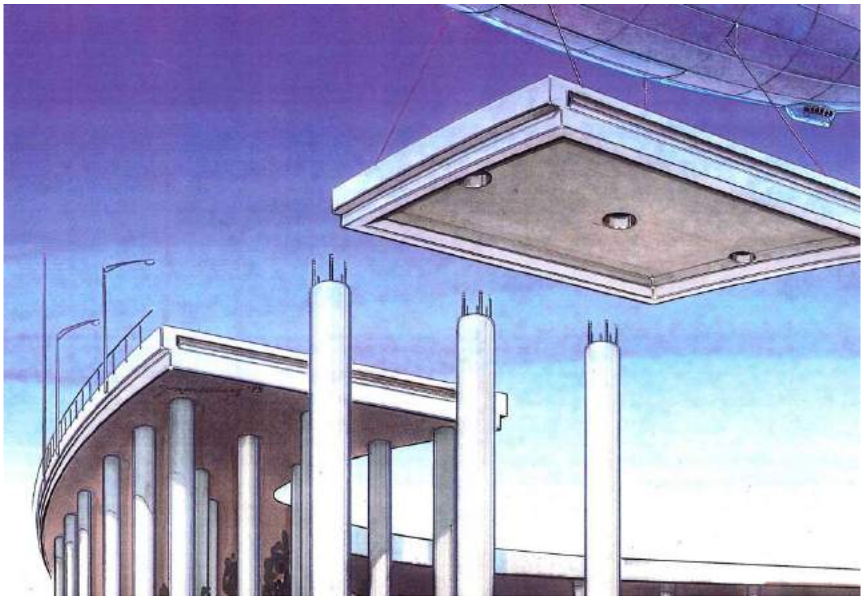
Freighter: Ship-to-shore cargo transfer. Source: John Melberg via Deans' Garage



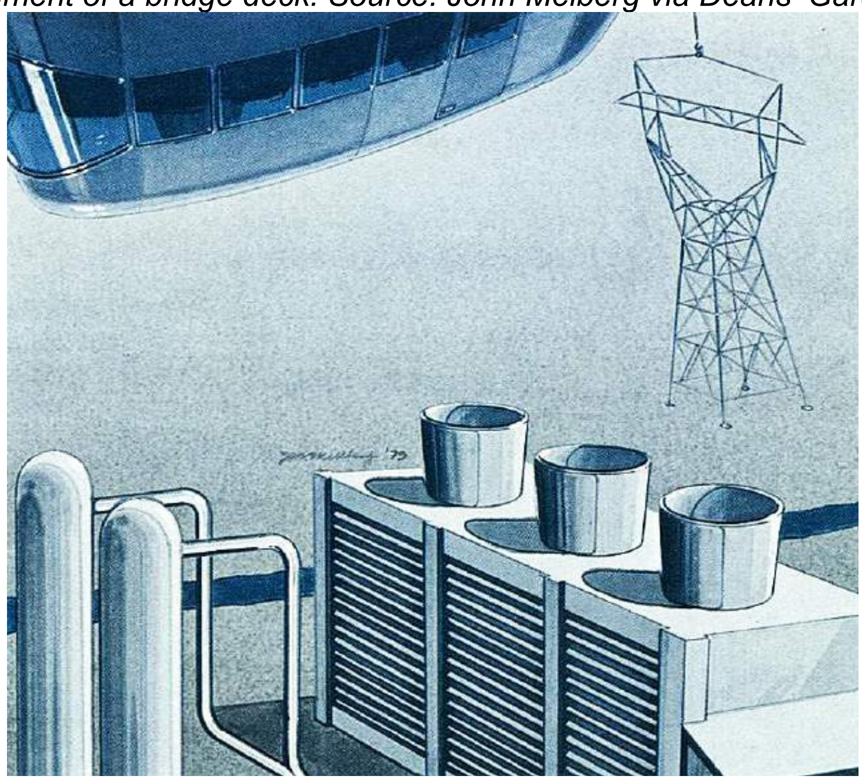


Freighter: Delivering cargo to an offshore platform. Source: John Melberg via Deans' Garage

<u>Big lifter:</u> These are scaled-up and strengthened variants of the MC-7 that are designed to pick up a very heavy unitary external load without landing and deliver it precisely from a hover.



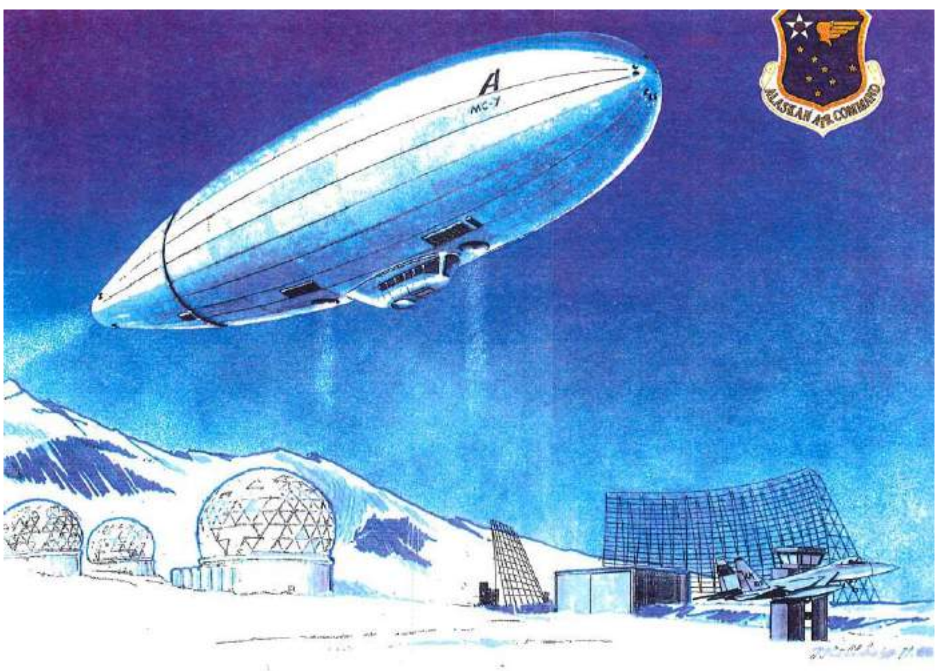
Big lifter: In this case, the heavy lifter airship is delivering an entire segment of a bridge deck. Source: John Melberg via Deans' Garage



Big lifter: Configured with an external sling to pick up, transport, and deliver a large, indivisible load, in this case, an assembled electric transmission tower. Source: AI company brochure, 1980.

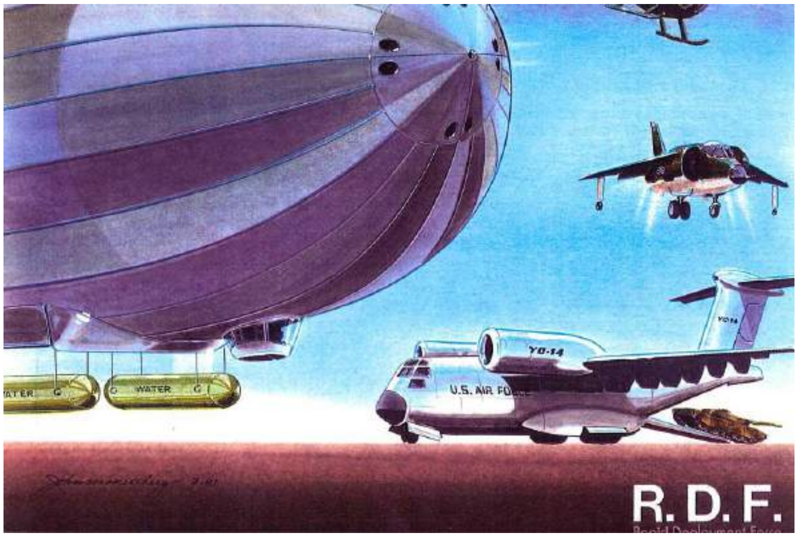
Big lifter: This large airship has been scaled up and strengthened to handle 60-ton (54.4 metric ton) payloads and transport them between any two points up to 300 miles (483 km) apart. Additional lifting thrusters are installed in long pods along the flanks of the hull. The control car is moved forward, under the nose. Source: AI company brochure, 1980.

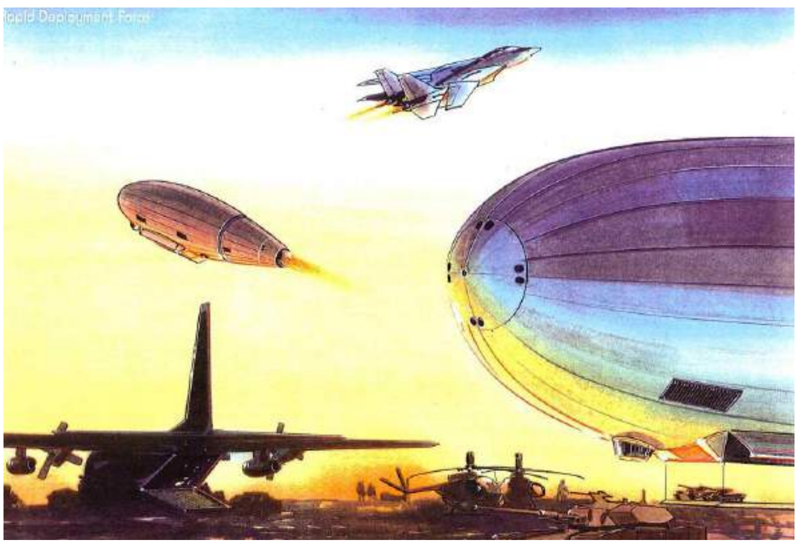
Military applications – Remote facility logistics support



Military remote facility logistics support: MC-7 variant operating in the Arctic providing logistics support for a remote Distant Early Warning (DEW) line radar station. Source: John Melberg via Deans' Garage

Military applications - Heavy lift freighter

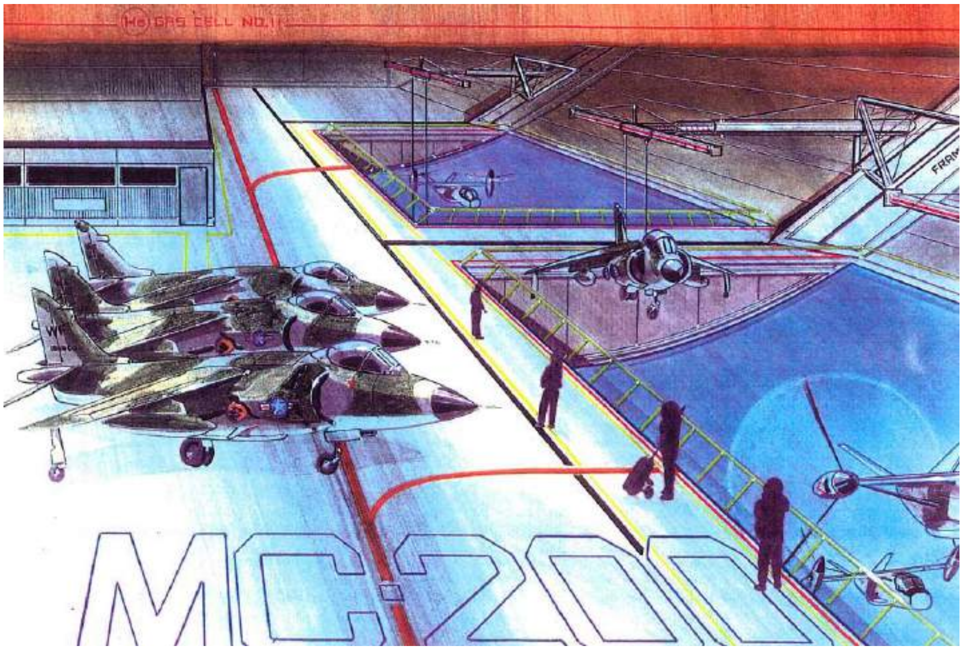




An MC-7 variant could be configured as a heavy military transport to operate as part of a military airborne rapid deployment force (RDF). In this role, the airship could move large quantities of cargo, and perhaps personnel,, between U.S. logistics centers and a protected forward operating base.

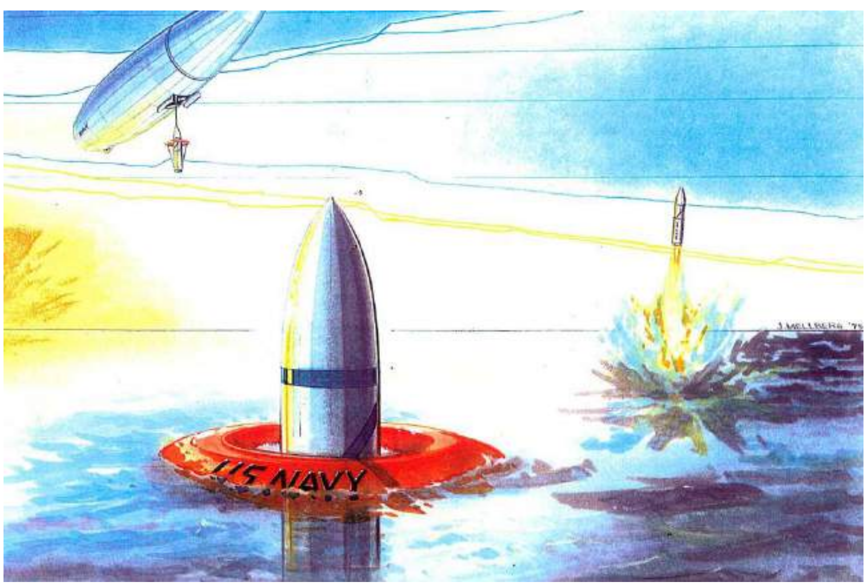
Military heavy lift freighters. Source, three graphics: John Melberg via Deans' Garage

Military applications – Flying aircraft carrier



Source: John Melberg via Deans' Garage

Military applications – Naval strategic missile deployment platform



Source: John Melberg via Deans' Garage

6. Epilogue

In spite of the successful operating experience of the U.S. Navy's ZMC-2 metalclad airship from 1929 to 1939, the merits of this type of rigid airship did not led to its adoption by military or civilian airship operators. Airships International's plans to develop modern metalclad airships in the late 1970s and early 1980s didn't materialize and they never got the opportunity to build and fly their novel designs.

7. For more information

- Vladimir Pavlecka & J. Roda," State of the art of metalclad airships," Turbomachines, Inc. paper, MIT Proc. of the Interagency Workshop on Lighter than Air Vehicles, 1 January 1975: https://ntrs.nasa.gov/citations/19760007957
- L.R. Campbell, V.H. Pavlecka, J.W. Rode, E.V. Stephens & G. Szuladzinski, "Metalclad Airship Hull Study," Volumes I & II, Report NADC 76328-30, prepared by Turbomachines, Inc. for Naval Air Development Center, Warminster, PA, December 1976: https://www.researchgate.net/publication/235075713_Metalclad_Airship_Hull_Study_Volume_1_and_Volume_2/link/55e8f87808ae3e12184396d0/download
- T.E. Hess, "Structures Technology for Lighter-Than-Air Vehicles," Report No. NADC-VT-TM-1891, Chapter V, "Evaluation of Modern Metalclad Design," pp. 10 – 19, 2 March 1977: https://apps.dtic.mil/sti/pdfs/ADA081353.pdf
- Vladimir Pavlecka, "Metalclad Airship Hulls," AIAA, published online 16 August 2012: https://arc.aiaa.org/doi/10.2514/6.1977-1196
- Lee Payne, "Lighter than air: An illustrated history of the airship," Chapter 12, "The Airship and the Future," A.S. Barnes, ISBN-13: 978-0498017520, 1st edition, 1 January 1977
- "Airships International – Home of the metalclad airship," Airships International, Inc., company brochure, circa 1980: https://vladimirhpavlecka.com/uploads/download/904/Airships_International__Inc._Brochure.pdf
- Gary Dean Smith, "John M. Melberg's Career—Part One," (Melberg worked on and off for Airships International from the

late 1970s through the late 1990s as the graphic artist for AI's presentation & promotional material), Dean's Garage – The Future is Back, 26 April 2011: http://www.deansgarage.com/2011/john-mellbergs-career/

AI patents for metalclad airships

- US4208027, "Gradation of skin thickness on metal-clad airship hulls," Inventor: Vladimir Pavlecka, Filed 9 August 1978, Granted 17 June 1980, Assigned to Airships International, Inc.: https://patents.google.com/patent/US4208027A/en?oq=•US4208027
- US4259776A, "Method of assembly of airship hull," Inventor: John Roda, Filed 9 August 1978, Granted 7 April 1981, Assigned to Airships International, Inc.: https://patents.google.com/patent/US4259776A/en
- CA1168644A, "Metal-clad airship hull construction," Inventor: Vladimir Pavlecka, Filed 22 June 1979, Granted 5 June 1984, Assigned to Airships International, Inc.: https://patents.google.com/patent/CA1168644A/en
- CA1143352A, "Thrusters for airship control," Inventor: Vladimir Pavlecka, Filed 22 June 1979, Granted 22 March 1983, Assigned to Airships International, Inc.: https://patents.google.com/patent/CA1143352A/en?inventor=Vladimir+H+Pavlecka
- US4402475, "Thrusters for airship control," Inventor: Vladimir Pavlecka, Filed 20 May 1980, Granted 6 September 1983, Assigned to Airships International, Inc.: https://patents.google.com/patent/US4402475A/en?oq=•US4402475

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- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Airship Industries - R150 metalclad airship
    - Detroit Aircraft Corporation - ZMC-2 metalclad airship
    - LTA Research and Exploration – rigid airship manufacturing process

    - Wren Skyships Ltd. - R.30 & RS.1 metalclad airships
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    - Varialift Airships Plc. - ARH-PT, ARH 50 & ARH 250 metalclad variable buoyancy airship
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/