Blackwater Airships / Guardian Flight Systems airships

Peter Lobner, updated 6 February 2024

1. Introduction

The firm Blackwater Airships LLC was established in January 2006 as a division of the firm Blackwater Security Company (BSC, rebranded in 2007 as Blackwater Worldwide) and began developing the non-rigid, sub-scale RC36 demonstrator and the larger Polar 400 airship. The latter was designed to perform a variety of aerial surveillance and security missions for U.S. government clients, such as patrolling U.S. borders and coastal waters and performing persistent surveillance missions in conflict zones.

Rendering of an early concept of Polar 400. Source: Blackwater Airships

In early 2009, as part of a general rebranding and reorganization of Blackwater and its many business units, Blackwater Airships was rebranded as Guardian Flight Systems and established as a subsidiary of the Florida firm Aviation Worldwide Services, LLC. The parent company (Blackwater) again rebranded itself, this time as Xe Services LLC. Guardian Flight Systems expanded the Polar airship product line to include larger versions, the Polar 600 and Polar 3000.

2. The RC36

The RC36 was a 11 m (36 foot) sub-scale, unmanned, remotely-piloted blimp built by Blimpworks Airships in Franklin, WI (https://www.rcblimp.net/blimp_outdoor36.htm) for Blackwater Airships. It was used for testing airborne flight controls for the Polar 400 and practicing airborne maneuvers before they were tried with the Polar 400. The RC36 was propelled by two thrust vectoring shrouded propellers mounted to a small gondola. A small lateral propulsor in the ventral fin provided additional yaw control.

RC-36 ready to launch. Source: BlimpWorks

RC36 general design characteristics

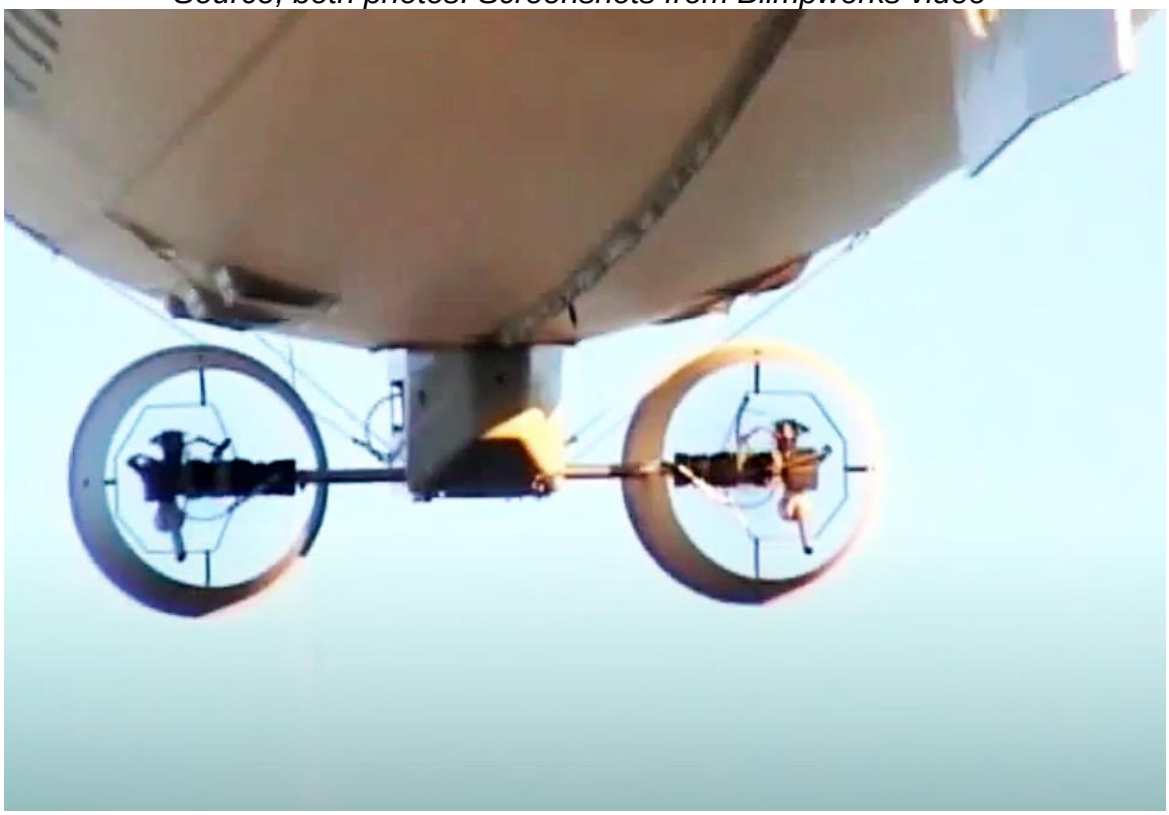
Parameter	RC36
Type	Unmanned, remotely controlled blimp
Length	11 m (36 ft)
Diameter	2.6 m (8.5 ft)
Envelope volume	45.3 m^3 (1,600 ft^3)
Envelope material	Proprietary 3-ply rip-stop nylon aircraft-grade fabric with urethane coating
Helium leak rate	< .01% volume/day
Net lift	2.2 – 3.2 kg (5 – 7 lb)
Propulsion	2 x gasoline-powered engines driving shrouded, thrust-vectoring propellers cantilevered from the gondola
Maneuvering controls	• Cruciform tail with elevator and rudder control surfaces • Small electric motor-driven propeller in the ventral fin provides lateral thrust for improved low-speed control
Batteries	Rechargeable Nickle Metal Hydride (NiMh) batteries

Source: Blimpworks Airships

You can watch a short BlimpWorks video of the RC36 being test flown prior to delivery to Blackwater here: https://www.youtube.com/watch?v=dYpOO0R7h_Q

RC36 in flight. Note thrust-vectoring shrouded propellers in the horizontal cruise position (above) and vectored up for dynamic lift (below). Source: Screenshots from Blimpworks Airships video

Closeup views of RC-36 thrust vectoring shrouded propellers.
Source, both photos: Screenshots from Blimpworks video



RC-36 low level flight. Source, both photos: BlimpWorks

3. Patent application for a non-rigid airship with a hydraulic propulsion system

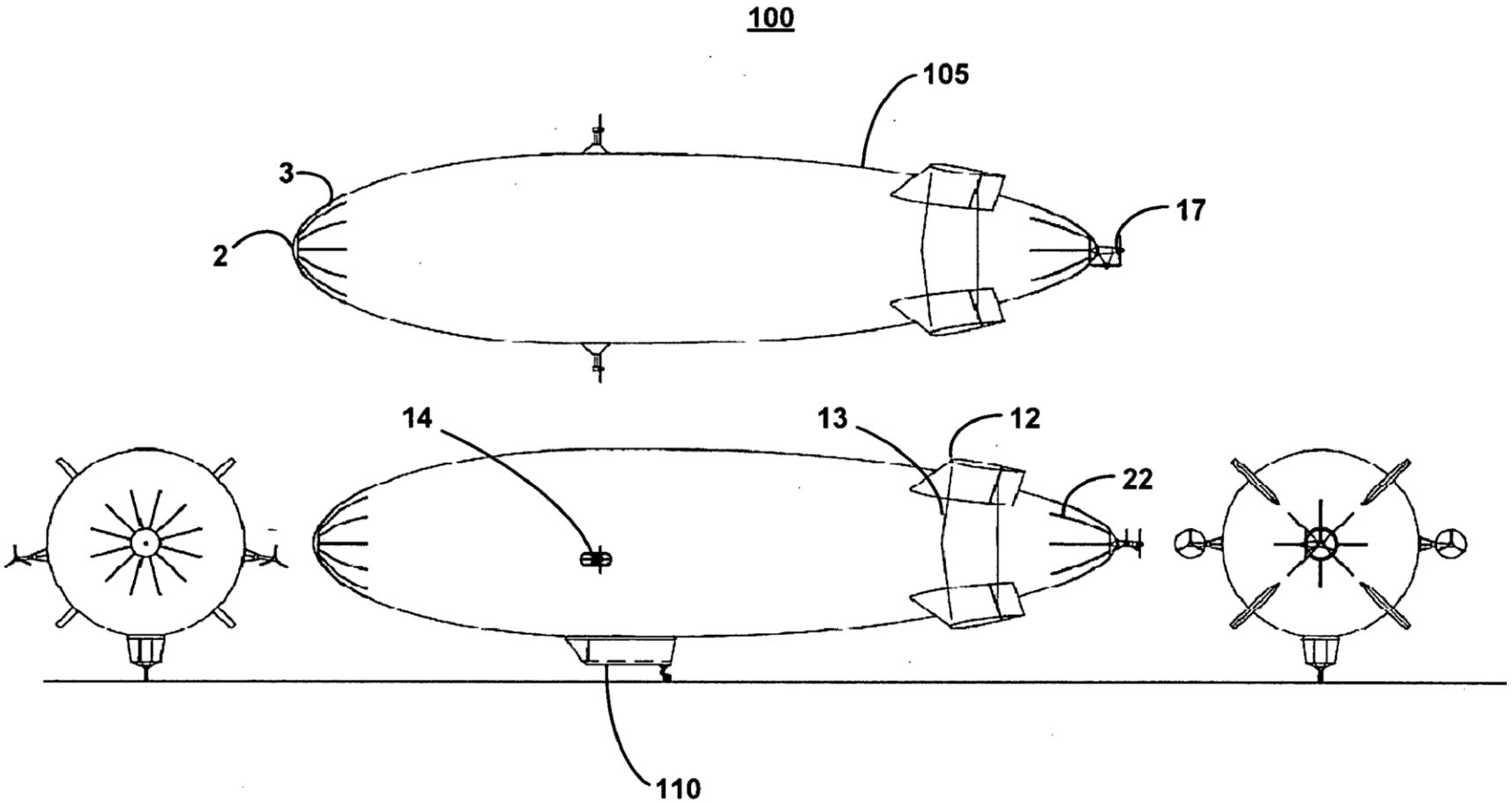
In September 2008, Blackwater Airships LLC filed a patent application for a non-rigid airship with a unique hydraulic propulsion system. This patent application was published in March 2009 as US2009/0072084A1.

General arrangement: The airship has a conventional, non-rigid, ellipsoidal gas envelope and an X-tail with cable-braced aerodynamic control surfaces. The propulsor arrangement is very similar to that of the Zeppelin NT, with two flank-mounted vectorable propulsors attached near the envelope mid-plane and two aft propulsors, one providing lateral thrust and one providing longitudinal thrust. The patent application describes two fixed aft propulsors. In contrast, the Zeppelin NT aft lateral thruster is fixed, but the longitudinal propulsor can be vectored 90° down for lift and pitch control.

Hydraulic propulsion system: The lightweight, compact nature of hydraulic motors is used to advantage to enable use of hydraulic motor-driven propellers that are light enough to be mounted on pylons in favorable locations on the hull and supported directly from the blimp's non-rigid gas envelope, without the need for an internal rigid support structure, as used in semi-rigid airships such as the Zeppelin NT and the Lockheed Martin Aerocraft. Eliminating the need for an internal support structure significantly reduces the overall weight of the LTA vehicle.

The distributed propulsion system is powered by a closed-loop hydraulic power system. Centrally-located engine-driven hydraulic pumps discharge high-pressure hydraulic fluid to supply lines routed to the hydraulic motors for each propeller, which are independently controlled. Each hydraulic motor discharges hydraulic fluid to a low-pressure line that returns the fluid back to the pumps.

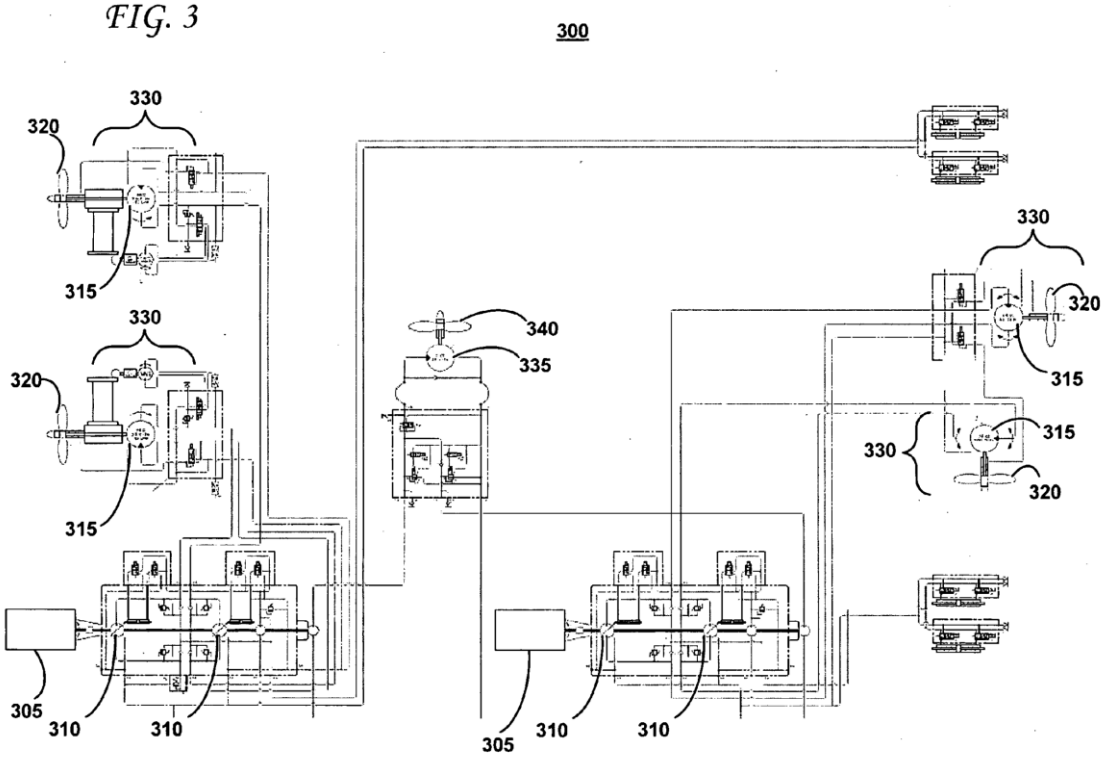
The closed-loop hydraulic power system also powers the ballonet fans.



Legend: *Nose cone (2), nose battens (3), X-configured tail fins (12), tail fin support cables (13), flank thruster mounted via pylon to the gas envelope (14), stern thruster pylon & thrusters (17), stern thruster battens (22), the complete lighter-than-air vehicle system (100), non-rigid gas envelope (105), payload module (gondola) (110)*

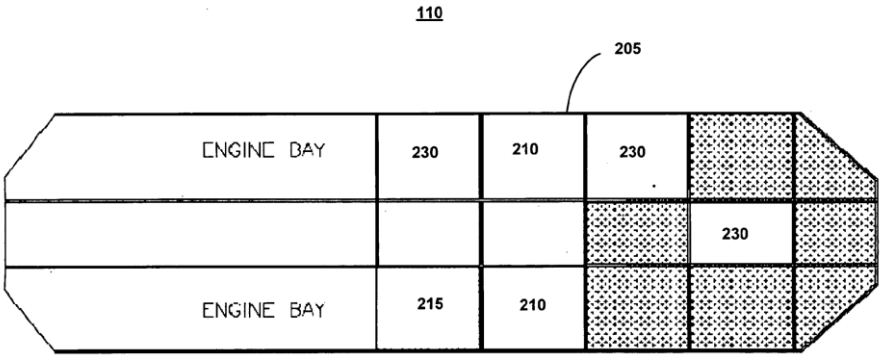
Four-view diagram of non-rigid airship with hydraulic propulsion system. Source: US2009/0072084A1

FIG. 3



Legend: *Propulsion system (300), diesel engines (305), hydraulic pumps (two per engine) (310), hydraulic pumps (315), propeller (320),hydraulically-powered thrusters (330), hydraulic motor for ballonet fan (335), hydraulically-powered ballonet fan (340). While not specifically described in the patent application, the diagram also appears to show two pairs of hydraulic actuators for the elevators and rudders (top & bottom, right).*

Schematic of the closed-loop hydraulic propulsion system. Source: US2009/0072084A1, Fig. 3



Legend: *Payload module (110), rigid frame (205), fuel tanks (210), water ballast tanks (215), equipment bay (230)*

Layout of the Payload Module. Source: US2009/0072084A1, Fig. 2

Ballonet system: The airship has a conventional air ballonet that is used to manage the pressure inside the gas envelope. The ballonet is pressurized by hydraulically-driven fans and can be depressurized to the atmosphere through two large-diameter valves.

Exhaust gas water recovery system: The airship may have a water recovery system to help minimize the change in buoyancy as fuel is consumed. The water recovery system captures water vapor in diesel engine exhaust gas and converts it into water via a heat exchange system. The water can be stored in ballast tanks (215) in the payload module. Electrically actuated dump valves can release excess water.

4. The Polar 400

The optionally-piloted Polar 400 was a non-rigid airship (blimp) designed to be remotely piloted from a ground station. It can be configured to carry mission-specific payloads such as cameras, communications gear, radar and infrared sensors. Commercial off-the-shelf (COTS) technologies were used where practical to reduce risk and cost.

The Polar 400 (background) and the sub-scale RC36 (foreground) in the TCOM hangar. Source: Blackwater

The Blackwater Airships team completed design work at the end of 2006 and planned to begin production of the Polar 400 by mid-2008. TCOM was selected to manufacture the gas envelope, and the airships was assembled and tested at TCOM's facilities on the grounds of the former Weeksville Naval Air Station near Elizabeth City, NC, which includes the huge Airdock #1 steel blimp hangar built in the early 1940s.

3.1 Polar 400 design features

A simplified version of the non-rigid airship design in Blackwater's 2008 patent application was implemented in the Polar 400 airship. The general arrangement of the airship shown in the patent application closely resembles the Polar 400.

The following features are described in more detail in this section.

- Hydraulic propulsion system
- Propulsors attached directly to the gas envelope
- Reduced ground crew requirements
- Optional pilot-on-board

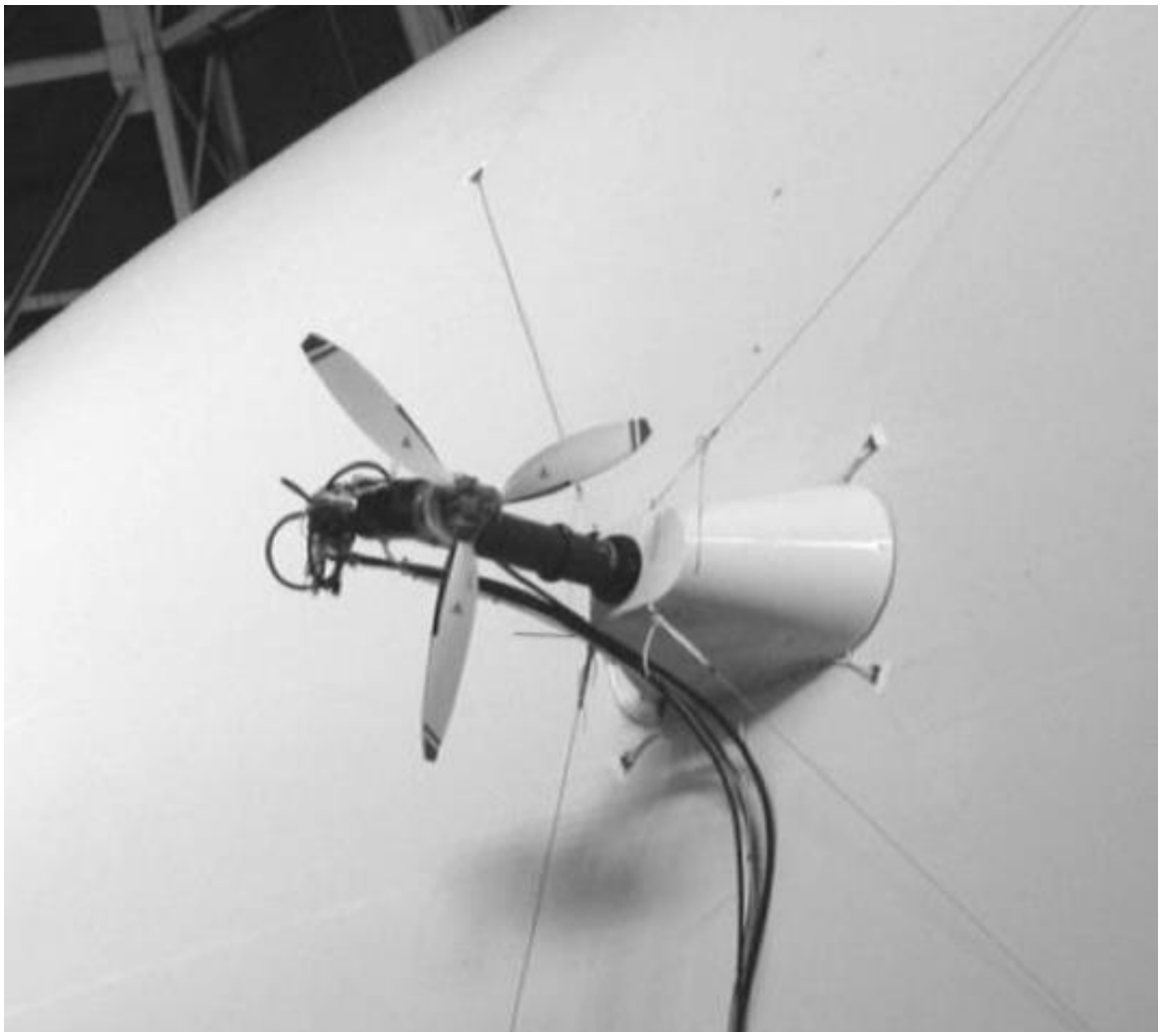
Hydraulic propulsion system: This novel power system was a key feature in the design of the Polar 400. The design and operation of the hydraulic power system is described in patent application US2009/0072084A1.

In the Polar 400, a simpler system was installed in the gondola, with only a single Thielert Aircraft Engines Centurion 4.0 V-8 diesel engine rated at 201 kW (270 hp) maximum, 172 kW (230 hp) continuous, with full authority digital engine control (FADEC). The engine had an exhaust gas water recovery system, which reduced the airship's mass change due to fuel consumption and also reduced the airship's in-flight thermal signature.

This diesel engine drove the closed-loop hydraulic power system. High-pressure hydraulic fluid was distributed via small-diameter lines to individual, light-weight, reversible hydraulic motors that drove the following equipment:

- Two thrust vectoring, flank-mounted propellers attached to the envelope provide horizontal thrust for cruise, vertical (up / down) thrust for vertical takeoff and landing (VTOL), and adjustable thrust vectoring for maneuvering close to the ground.
- Two fixed propellers mounted at the stern, one for longitudinal (fore / aft) propulsive thrust and the other for lateral (port / starboard) thrust for yaw control at low speed.
- Ballonet fans

The hydraulic fluid was returned via small-diameter lines to the hydraulic pumps.



Flank hydraulically-driven, thrust vectoring propeller mounted to the envelope. Note the hydraulic lines and the small size of the hydraulic motor. Source: Guardian Flight Systems

Tail mounted hydraulically-driven fixed propellers mounted to the envelope. Note the hydraulic lines. Source, both photos: Guardian Flight Systems

Propulsors attached directly to the gas envelope: A unique feature of the Polar 400 was that its four light-weight hydraulic motor-driven propellers were attached via pylons directly to the gas envelope and stabilized with cables, and, at the stern, with battens. The cables and battens distributed loads into reinforced areas on the flanks and at the stern of the gas envelope.

The semi-rigid Zeppelin NT's propulsors are in similar locations, but are supported by an internal rigid frame. Almost all previous blimps have had their much heavier engines attached to the gondola.

This array of four hydraulically-driven propellers provided excellent low speed control and maneuverability, even at zero airspeed while hovering or during VTOL operations, and when the airship was on the ground.

Reduced ground crew requirements: The excellent maneuverability during takeoff, landing and while on the ground reduced the size of the ground crew relative to traditional blimps, which typically require 12 to 20 handlers. The Polar 400 needed just five people to attach and release the airship from its mooring, including the remote pilot. One more person was needed when refueling. The Polar 400 could taxi on its own, in a manner similar to an airplane.

Optional pilot-on-board: The Polar 400 was designed to be piloted remotely and was programmed with its autonomous flight plans through an L-3 Ground Control Station (GCS).

The Polar 400 also could be flown with a conventional flight crew. This was a useful capability for some customers, such as for manned border patrol flights in the continental U.S. and operating under an FAA Certificate of Authorization. In addition, the crewed capability could enable delivery of a complete airship directly from the factory, thereby eliminating disassembly, shipping and reassembly time and cost.

3.2 Polar 400 operations

The 163 ft (49.7 m) Polar 400, with FAA registration N6542B, made its first flight in early November 2007 on the grounds of the former Weeksville Naval Air Station blimp base near Elizabeth City, NC. During its development program, it conducted a total of more than 300 flight test hours with more than 10 different communication / surveillance payloads.

In November 2008, Guardian Flight Systems and sensor integrator PSI Origin equipped and flew the Polar 400 to demonstrate improved broad area persistent surveillance with an 80 megapixel compound focal plane camera that produced images with a 90-degree field of view that covered a trapezoid of 65 -100 km^2 (65 - 38.6 mi^2) with 0.75 m (2.5 ft) best resolution. This is about 10 times the area viewed by traditional electro-optical sensors at nearly twice the resolution. These were manned test flights sponsored by the Office of the Secretary of Defense, Advanced Systems and Concepts, and managed by the Air Force Research Laboratory.

Originally, Blackwater Airships planned to develop the Polar 400 into a production surveillance airship with a unit price in the $3 million to $5 million range, about half the price of a typical fixed-wing UAV. Fully-loaded operating cost was estimated to be $800 to $1,200 per hour, much lower than the $3,000 to $5,000 per hour cost of operating a Predator or comparable UAV in 2008.

Both Blackwater Airships and Guardian Flight Systems regarded the Polar 400 as a scaleable proof-of-concept vehicle for newer, larger airship designs in the Polar family of airships. In early 2009, Guardian was planning to build a slightly larger Polar 450 airship that would have been compatible with generic ground controls stations used by the US military and NATO.

No orders were placed for the Polar 400 or 450. Polar 400, registry N6542B, was deregistered by the FAA on 31 May 2017.

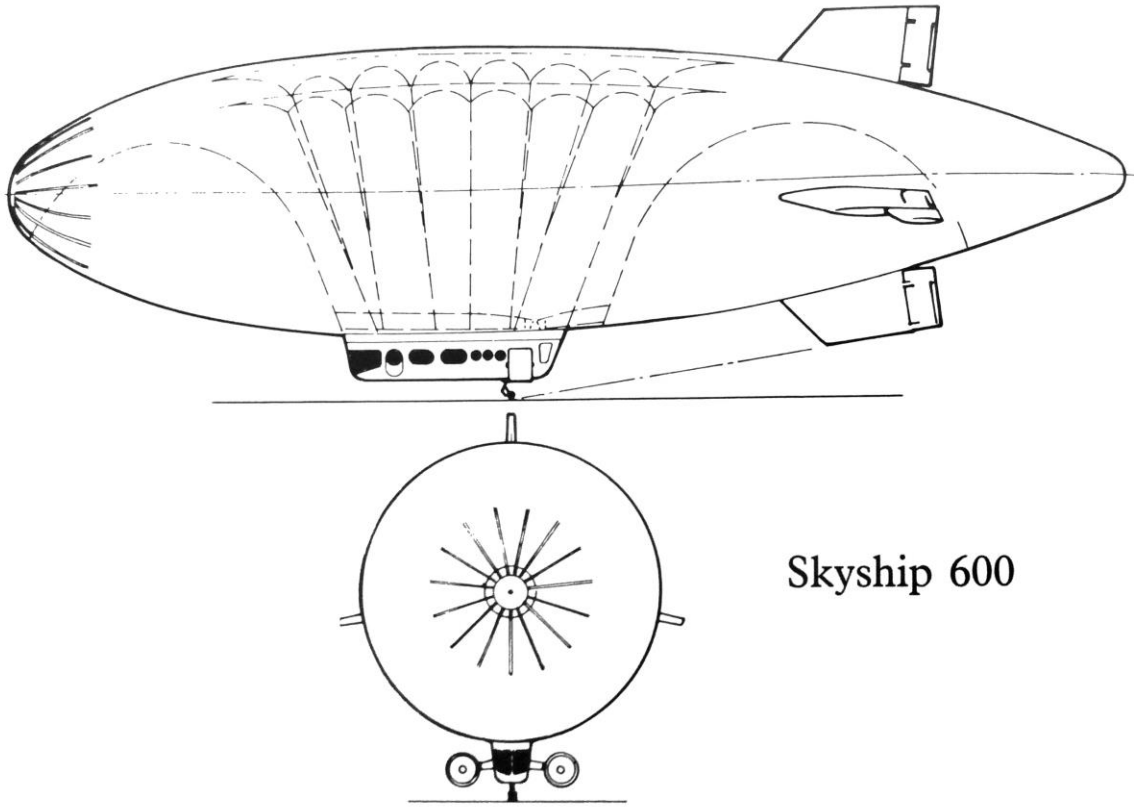
Polar 400 airship. Note the hydraulic lines run externally to the flank-mounted hydraulically-driven propulsor. Source: Guardian Flight Systems

Polar 400 in flight. Source: Guardian Flight Systems

4. Polar 600

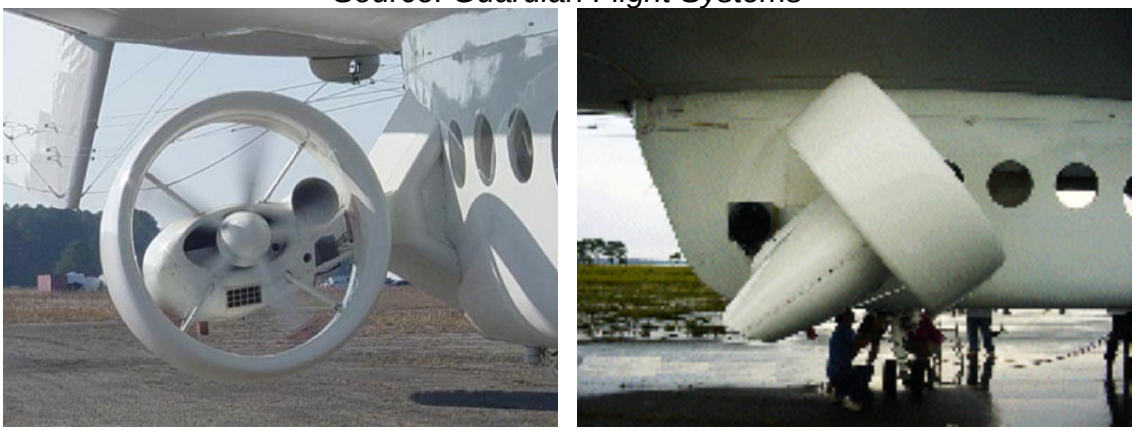
The Polar 600 was a 2009 design concept for an Airships Industries (AI) Skyship 600 non-rigid airship modified with the addition of a stern-mounted, hydraulically-powered lateral thruster as used on the Polar 400 to improve yaw stability and control. Like the Skyship 600, the Polar 600 was to be powered by two 224 kW (300 hp) Lycoming IO-540 engines directly driving shrouded propellers cantilevered from the gondola and vectorable from 85° up to 110° down.

The Polar 600 type certificate was to be derived from the Skyship 600 US Type Certificate AS1EU. The Polar 600's primary mission was persistent aerial surveillance.

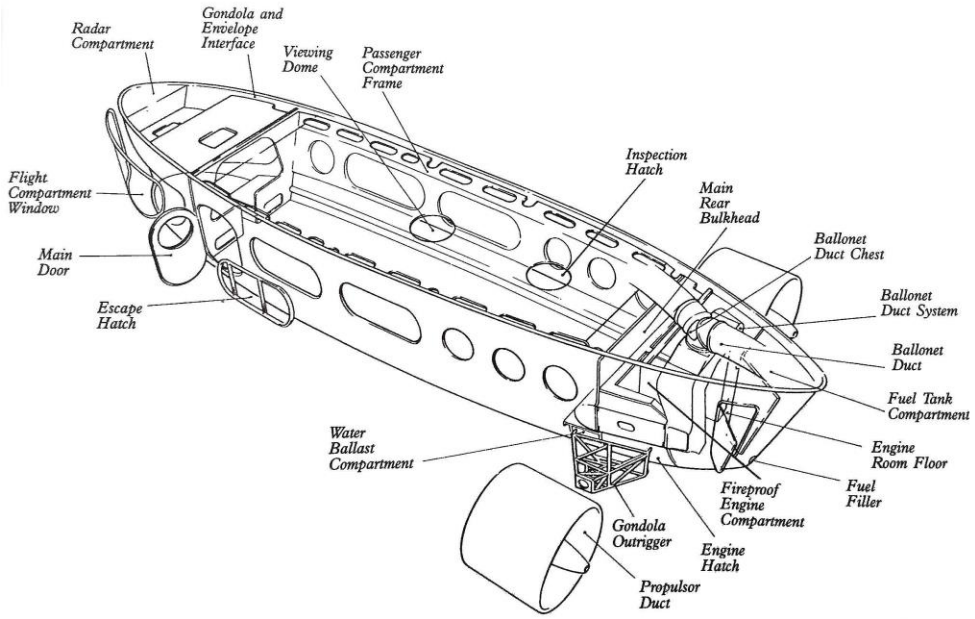


Airships Industries Skyship 600 general arrangement, not showing the stern-mounted lateral thruster to be added for the Polar 600 configuration. Source: Adapted from R.L. Rimell, "Skyship!"

Airships Industries Skyship 600, with Lycoming IO-540 vectored thrusters, was the basis for the Polar 600.
Source: Guardian Flight Systems



Lycoming IO-540 vectored thrusters on a Skyship 600, in cruise (horizontal) position (left) and vectored partially up (right).
Source: Guardian Flight Systems (left), Airship Heritage Trust (right)



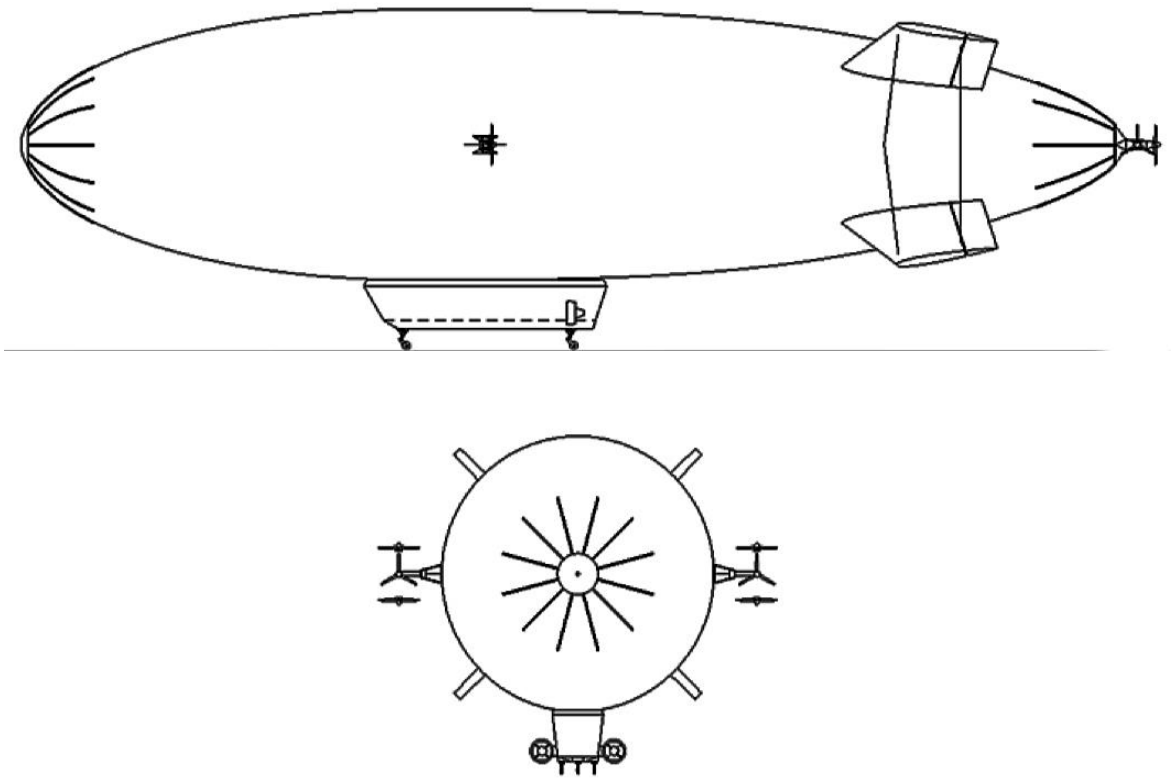
Skyship 600 Gondola details. Source: Airship Heritage Trust

Guardian offered to deliver a Polar 600 airship for first flight in 6 months, with final delivery in 12 months. In parallel, mission package integration would be done using the existing Polar 400 as a test-bed. The complete mission package would be installed before the Polar 600 was delivered. No orders were placed for the Polar 600.

5. Polar 3000

This was a new airship design based on a 1:2 linear scale-up of the Polar 400, with the same hull form and X-configured tail fins. The propulsion system was a combination of the original Polar 400 system (4 x light-weight, hydraulically-driven propulsors mounted on the envelope; two on the flanks of the envelope and two at the tail) and the Polar 600 (2 x direct-drive, vectorable ducted propulsors mounted on the gondola).

This was planned to be a low-risk cargo airship with a 10 metric ton (11 ton) cargo capacity on a 161 km (100 mile) radius mission with vertical takeoff and landing (VTOL). Guardian offered a development schedule with the first flight in 16 months and certification in 36 months, for a cost of about $20 million. The Polar 3000 was not developed.



General arrangement of the Polar 3000.

Rendering of the Polar 3000.
Source, both graphics: Guardian Flight Systems, circa 2009

6. Summary of Polar Airship general design characteristics

Design parameters	Polar 400		Polar 600		Polar 3000	
Length	163 ft	49.7 m	200 ft	61 m	322 ft	98 m
Diameter	40.2 ft	12.27 m	50 ft	15.2 m	114.8 ft	35 m
Envelope volume	140,000 ft^3	4,000 m^3	235,400 ft^3	6,666 m^3	1,060,000 ft^3	30,000 m^3
Air ballonet maximum	25%		25%		25%	
Engines	1 x V-8 diesel engine, 270 hp (201 kW) maximum, 230 hp (172 kW) continuous, with exhaust water recovery system. The diesel drives a hydraulic power plant.		2 x 300 hp (224 kW), vectorable, direct-drive Lycoming IO-540 engines mounted to the gondola, and 1 x hydraulic power plant driven by an unspecified prime mover.		2 x 1,000 hp (746 kW), vectorable, direct-drive PT6 turboprops mounted to the gondola, and 3 x 300 hp (224 kW) Ford diesel engines driving hydraulic power plants.	
Propulsors	4 x hydraulically-driven propellers mounted to the non-rigid envelop: 2 x flank-mounted vectorable propellers, 1 x fixed stern longitudinal propeller and 1 x fixed stern lateral propeller		2 vectorable direct-drive, shrouded propulsors mounted to the gondola, and 1 x fixed stern hydraulically-driven lateral thruster (propeller)		2 vectorable direct-drive, shrouded propulsors mounted to the gondola; and 4 x hydraulically-driven propellers mounted to the non-rigid envelop: 2 x flank-mounted vectorable propellers, 1 x fixed stern longitudinal propeller and 1 x fixed stern lateral propeller	
Speed (cruise)	up to 30 knots		up to 40 knots		up to 45 knots	
Speed (max)	50 knots		50 knots		50 knots (est)	
Altitude (max)	5,000 ft msl	1,524 m msl	5,000 ft msl	1,524 m msl	10,000 ft msl	3,048 m msl
Range	about 360 nautical miles	about 667 km	about 600 nautical miles	about 1,111 km	up to 1,000 nautical miles	up to 1,852 km
Payload	2,600 lb (1,179 kg) fuel & payload, about 1,000 lb (454 kg) payload		2,094 lb (950 kg) payload in addition to fuel and crew. 3 kW available to the payload.		10 metric tons (11 tons), 100 naut mile (185 km) radius, VTOL	
Endurance	12 hours max.		> 20 hours on station at 20 knots at 100 naut mile (185 km) radius + transit time		>22 hours at 45 knots cruise at 500 naut mile (926 km) radius with VTOL and 8.8 metric ton (9.7 ton) cargo	

7. For more information

- “Blackwater Unveils Its Airship,” Security InfoWatch (Blackwater press release), 13 November 2007: https://www.securityinfowatch.com/home/article/10551796/blackwater-unveils-its-airship
- Jon Glass, “Blackwater aims high with unmanned aircraft,” The Virginian-Pilot, 23 November 2007: https://www.pilotonline.com/business/article_5fe16343-7a7e-5a7b-a26f-72f53b4af9fa.html
- David Ax, “Blackwater's All-Seeing Airships,” Wired, 23 July 2008: https://www.wired.com/2008/07/blackwater-want/
- August Cole, “Blackwater Puts on a New Public Face,” The Wall Street Journal, 14 February 2009: https://www.wsj.com/articles/SB123454232273983709
- Frank Colucci, “Enduring Oversight,” Aviation Today, 1 March 2009: https://www.aviationtoday.com/2009/03/01/enduring-oversight/
- “Ready to go: Polar Family Airships for Surveillance and Cargo,” Guardian Flight Systems, presentation at the Airships to the Arctic V Conference, Calgary, 7 – 9 October 2009: https://isopolar.com/wp-content/uploads/2013/03/Brandon-Buerge-presentation-Ready-to-Go-A-Proven-Approach-and-a-Deliverable-Airship-for-the-North.pdf
- “Airship Industries SkyShip 600,” The Airship Heritage Trust: https://www.airshipsonline.com/airships/ss600/index.html
- R.L. Rimell, “Skyship! Renaissance of the British Airship Industry,” Skyship Services, Inc.: https://manualzz.com/doc/7401088/skyship-magazine----skyship-services--inc

FAA registry

- Federal Aviation Administration N-Number N6542B, Serial No. 400-001, Manufactured by Blackwater Airships LLC: https://registry.faa.gov/aircraftinquiry/Search/NNumberResult?NNumberTxt=6542B

Patent application

- US2009/0072084A1, “Lighter-than-air vehicles,” filed 19 September 2008, published 19 March 2009, assigned originally to Blackwater Airships LLC, then to Guardian Flight Systems LLC: https://patents.google.com/patent/US20090072084A1/en?oq=US2009%2f0072084A1

Video

- “36 ft Outdoor Nylon Airship built for Blackwater Airship” (3:53 minutes), BlimpWorks, 8 December 2009: https://www.youtube.com/watch?v=dYpOO0R7h_Q

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Airship Industries – Skyship 600
    - Lockheed Martin – Aerocraft
    - Zeppelin NT
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - Aerovehicles, Inc. (AVI) – AV-10
    - Mav6 LLC - Blue Devil Block 2 (BD2) - M1400
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/