

Blackwater Airships / Guardian Flight Systems airships

Peter Lobner, 3 April 2021

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 a non-rigid airship known as the Polar 400, which was designed to perform a variety of aerial surveillance and security missions for US government clients. Such missions include patrolling US borders and coastal waters and performing persistent surveillance missions in conflict zones.



Rendering 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 36 foot (11 m) sub-scale blimp built by Aerostar International Blimpworks and Airworks Entertainment for Blackwater Airships. The RC36 was propelled by two vectored thrust shrouded propellers mounted to a small gondola. A small lateral propulsor in the ventral fin provided additional yaw control.



RC-36. Source: Screenshots from BlimpWorks video





RC-36. Source: Screenshots from Blimpworks video



The RC36 was used for developing airborne flight controls and practicing maneuvers before they were tried with the Polar 400. 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

3. The Polar 400

The optionally-piloted Polar 400, is a non-rigid blimp designed to be remotely controlled 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.

Blackwater planned to begin production of its blimps by mid-2008. The airships and their components were to be assembled at two facilities on the grounds of the former Weeksville Naval Air Station blimp base near Elizabeth City, NC. One was a massive blimp hangar built in the early 1940s.



*The Polar 400 (background) and the sub-scale RC35 (foreground)
In the former Weeksville NAS blimp hanger. Source: Blackwater*

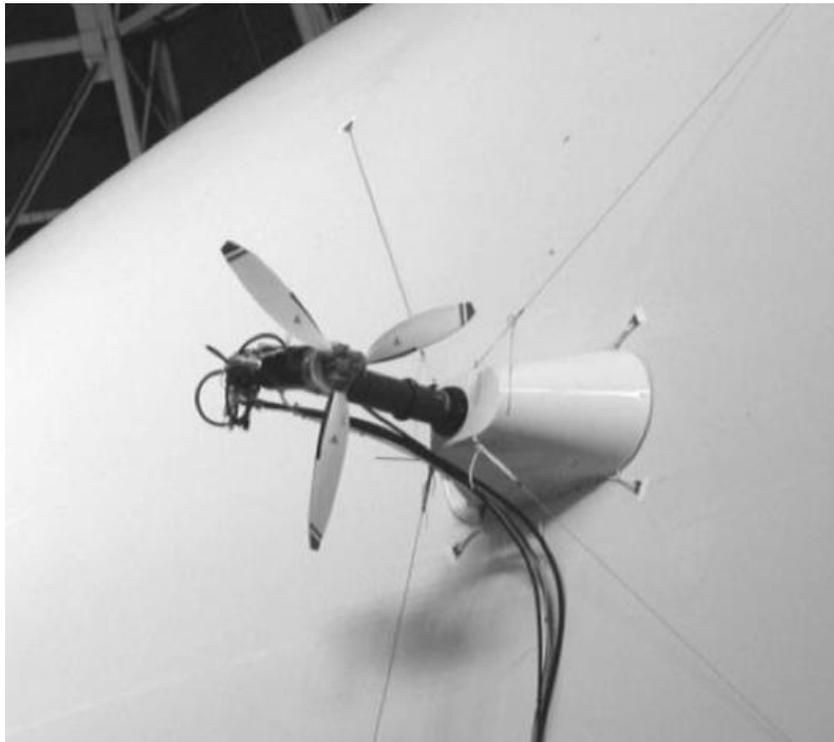
Polar 400 design features

The Polar 400 incorporated the following design features that distinguish it from a traditional non-rigid airship (blimp).

Hydraulic propulsion system: This novel propulsion system was a key feature in the design of the Polar 400. A single V-8 diesel engine rated at 270 hp maximum, 230 hp continuous, was mounted in the gondola where it drove a closed-loop hydraulic pumping system. High-pressure hydraulic fluid was distributed via small-diameter lines to four individual, light-weight, reversible hydraulic motors that drove the individual propellers:

- 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.

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



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



Propulsor arrangement: The Polar 400 propulsor arrangement is very similar to that of the Zeppelin NT with two flank-mounted vectorable propulsors at the envelope mid-plane and two aft propulsors, one providing thrust and one providing lateral thrust. A key difference is that the Polar 400's aft engines are both fixed, while the Zeppelin NT's aft longitudinal propeller can be vectored 90° down for lift and pitch control.

Motors attached to the envelope: A unique feature of the Polar 400 is that its four light-weight hydraulic motors are attached to the envelope. Straps distribute the load locally into reinforced areas of the envelope. All previous blimps have had their much heavier engines attached to the gondola. In comparison, the Zeppelin NT is a semi-rigid airship, with its engines attached to the internal rigid frame. Several hybrid airships also have developed techniques for attaching their propulsors to reinforced areas of their non-rigid fabric gas envelopes (i.e., Airlander 10, Lockheed Martin P-791 and LMH-1).

Excellent maneuverability: This array of four hydraulically-driven thrusters provides 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 needed compared to traditional blimps, which required 12 to 20 handlers. The Polar 400 needs just five people to attach and release the airship from its mooring, including the remote pilot. One more person is needed when refueling. The Polar 400 can taxi on its own, in a manner similar to an airplane.

Small radar and infra-red signature: The envelope materials and lack of internal structures give the airship a small radar cross section. The engine is mounted inside the gondola and has a water recovery system on the exhaust. This results a low thermal signature.

Remote control ground station: The Polar 400 demonstrator was flown remotely and programmed with autonomous flight plans through an L-3 Ground Control Station (GCS).

Optional pilot-on-board: This was a useful capability for some customers, such as for manned border patrol flights in the continental US operating under an FAA Certificate of Authorization. In addition, the capability could be used to simplify factory deliveries by eliminating disassembly, shipping and reassembly time and cost.

Polar 400 operations

The 163 ft (49.7 m) Polar 400, 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 over 300 total 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 covers a trapezoid of 65 to 100 square kilometers with 0.75 meter 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. The demonstration was sponsored by the Office of the Secretary of Defense, Advanced Systems and Concepts, and managed by the Air Force Research Laboratory.



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



Polar 400 in flight. Source: Guardian

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 about \$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.

Both Blackwater Airships and Guardian Flight Systems regarded the Polar 400 as a scalable 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.

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, and the Polar 600 was to be powered by two 300 hp, vectorable, direct-drive Lycoming IO-540 engines. 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.

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.

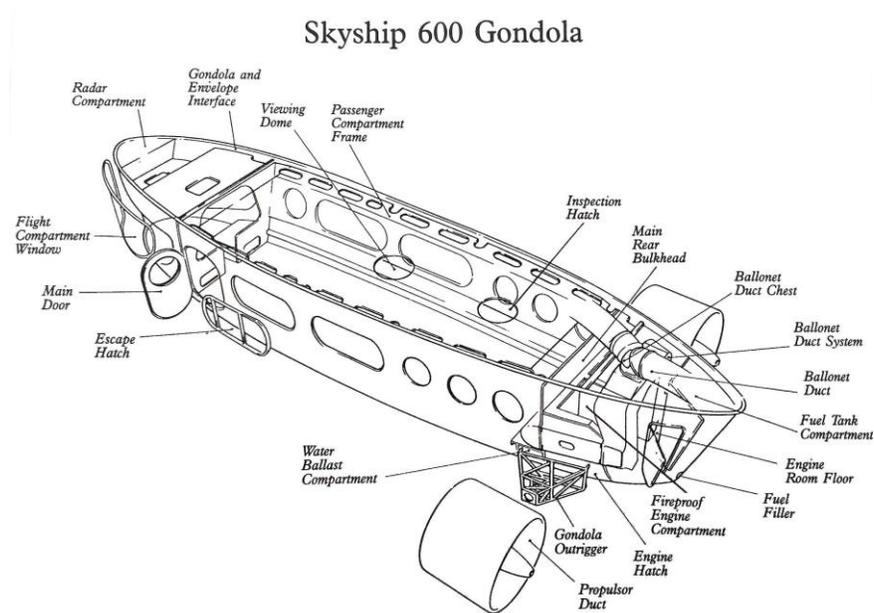


Airships Industries Skyship 600 with Lycoming IO-540 vectored thrusters. Source: Guardian Flight Systems



Lycoming IO-540 vectored thrusters on a Skyship 600.

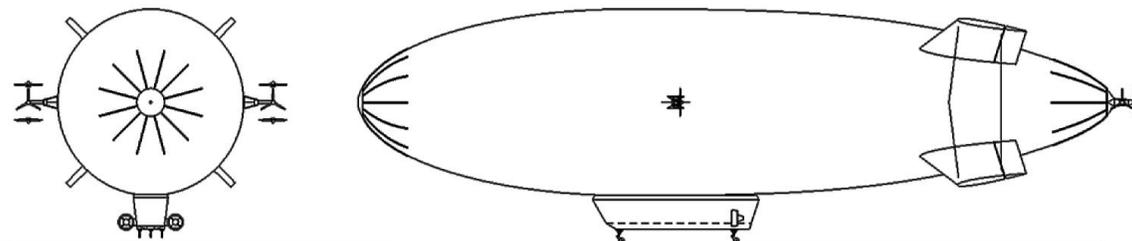
Source: Guardian Flight Systems (left), Airship Heritage Trust (right)



Source: Airship Heritage Trust

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 fins. The propulsion system was a combination of the original Polar 400 system (4 x light-weight, hydraulically-driven propulsors mounted on the envelope) and the Polar 600 (2 x direct-drive, vectorable 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 100 mile (161 km) radius mission with 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.



Polar 3000. Source: Guardian Flight Systems, circa 2009

6. Summary of Polar Airship 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 ballonnet 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
- 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>

8. Videos

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