Mav6 LLC - Blue Devil Block 2 (BD2) M1400 airship

Peter Lobner, updated 6 February 2024

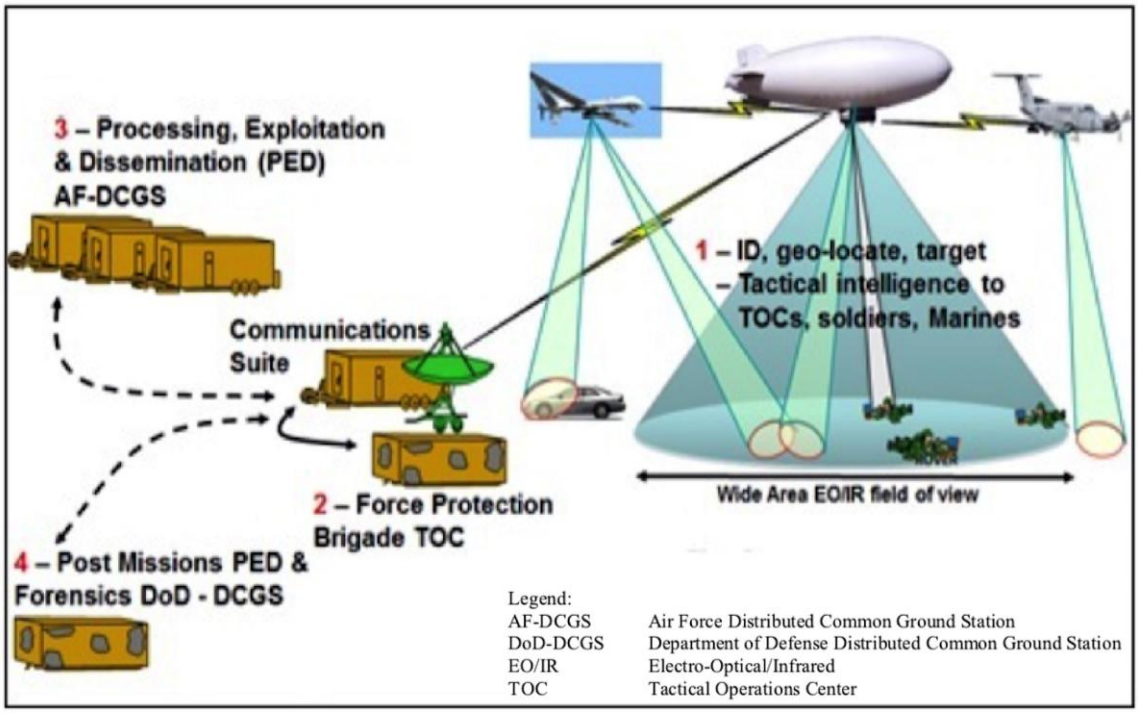
1. Introduction

The Blue Devil Block 2 (BD2) airborne platform developed for the U.S. Air Force (USAF) from 2010 to 2012 by the Virginia-based firm Mav6 LLC, was a very large, conventional, non-rigid airship (a blimp). Known originally as the Polar 1000 and then as the M1400, the airship was being developed to deliver persistent (24/7) intelligence, surveillance, and reconnaissance (ISR) and communications capabilities that filled important gaps in the USAF capabilities available from satellites and aircraft / drones. The BD2 mission package included a very powerful onboard computer system capable of processing up to 300 terabytes of data per hour and delivering processed data quickly to users on the ground.

Artist's concept of an operational USAF BD2 M1400 airship showing the two under-slung gondolas. Source: Mav6

The users on the ground, including troops in the field, could query a server on the airship and download just the specific processed information they needed. This approach greatly reduced the communications bandwidth requirements needed to deliver ISR products to the users in the field. The goal was to deliver the requested information to users in less than 15 seconds.

This basic Blue Devil Block 2 concept of operations is shown in the following diagram. Note the wide area ISR coverage provided by a BD2 airship in comparison to the more limited coverage available from ISR drones or fixed-wing manned aircraft operating at medium altitude (up to 6,096 meters / 20,000 feet). The BD2 airship provides tactical intelligence directly to military forces in the field and to Tactical Operations Centers (TOC) for further distribution.



The Blue Devil Block 2 concept of operations. Source: USAF/A2Q

2. Blue Devil Block 2 program startup and realignment

Global Security reported that the Blue Devil Block 1 (BD1) program began in 2009 with the goal of demonstrating the first-ever integration of wide area field-of-view and narrow field-of-view high definition day and night sensors cued by advanced signals intelligence (SIGINT) sensors. The BD1 sensor package was carried on a contractor-operated fixed-wing Beechcraft C90 aircraft and later on high-endurance remotely piloted vehicles. Imagery was transmitted in near-real-time to a Blue Devil ground station or to individual users on the ground.

Building on the BD1 sensor package development, the Blue Devil Block 2 (BD2) program was initiated in August 2010 under a contract for a Wide Area Surveillance Platform (WASP) issued by the Army Corps of Engineers Research and Development Center (ERDC) on behalf of the Air Force Air Headquarters (HAF) / A2Q (Air Force ISR Innovations Division). The original BD2 goal was to send a prototype persistent surveillance airship to Afghanistan about one year later, in 2011, for a one-year operational trial.

The prime contractor for the Blue Devil Block 2 program was the Arlington, Virginia-based firm Mav6 LLC (formerly known as ARES Systems Group, LLC), which was founded in 2007 by Adam "Jay" Harrison and Major General Buford "Buff" Blount, USA (Ret.). David Deptula, a former USAF Lt. General and Deputy Chief of Staff for ISR, was the Mav6 Chief Executive Officer.

Subcontractor TCOM LP, an established manufacturer of tethered aerostat and blimp gas envelopes headquartered in Columbia, Maryland, was responsible for manufacturing the gas envelope for the M1400 airship and integrating the airship and its systems in their Airdock #1 hangar at a former Weeksville blimp base in Elizabeth City, North Carolina. The TCOM LP website is here: https://tcomlp.com/our-company/

Subcontractor Kawak Aviation was responsible for developing the thrust vectoring Vertical Takeoff and Landing (VTOL) system, including the gas turbine engine assemblies, fuel system and test rig.

As the project progressed, Kawak received additional contracts for the Lateral Thrust System (LTS), Vectoring Gear Box (VGB) for the VTOL engines, the Propeller Speed Reduction Unit (PSRU) for the diesel engines and turbine pylon structures. Kawak accomplished these tasks in 16 months. The Kawak Aviation website is here: https://kawakaviation.com

The Blue Devil Block 2 program duplicated many of the ISR and communications capabilities that the Army was developing in approximately the same time frame in their Long Endurance Multi-Intelligence Vehicle (LEMV) program. The LEMV platform was a non-rigid, hybrid airship developed by the team of Northrop-Grumman and UK airship manufacturer Hybrid Air Vehicles (HAV). The Government Accountability Office (GAO) provided the following comparison of the BD2 and LEMV programs and noted that there was no coordination between the two similar programs.

Table 2: Comparison of LEMV and Blue Devil Block 2 Capabilities as of June 2012[a]

Airships	Long Endurance Multi-Intelligence Vehicle[b]	Blue Devil Block 2
Payload weight capacity (pounds)	2,500	2,500
Operational altitude (feet above mean sea level)	20,000[c]	20,000
Envelope volume (cubic feet)	1,342,000	1,400,000
Sensor type		
Electro-optical/infrared full motion video cameras	x	x
Wide area surveillance sensor		x
Signals intelligence sensor	x	x
Ground motion target indicator radar	x	
Communications relay system	x	x

Source: GAO-13-81

In March 2011, the Blue Devil Block 2 program was realigned under a contract issued by the Air Force 645th Aeronautical Systems Group (aka “Big Safari”), which was responsible for a variety of Air Force ISR programs, but none of them involving lighter-than-air craft. As it turned out, Big Safari was not a proponent of the Blue Devil Block 2 program.

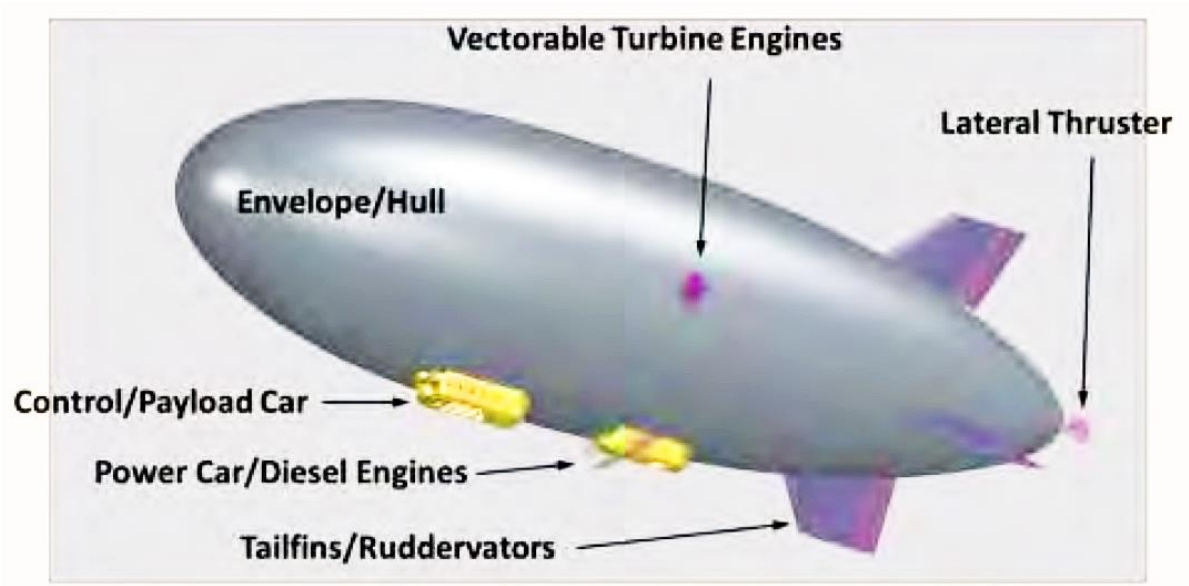
3. Blue Devil Block 2 (BD2) M1400 airship design features

The following M1400 airship features are addressed in this section:

- General arrangement
- Gas envelope
- Control / payload car
- Power car
- Vertical takeoff and landing (VTOL) system
- Lateral Thruster System (LTS)

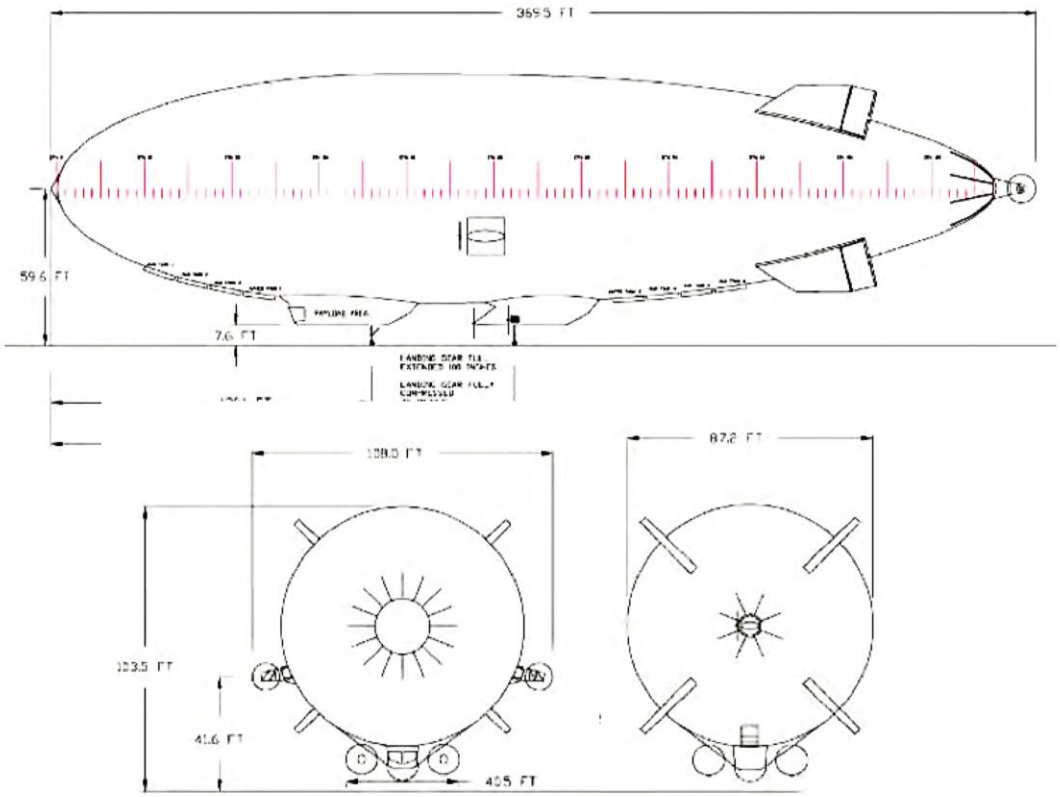
General arrangement: The BD2 was a large, conventional, non-rigid airship with a distinctive profile created by two under-slung, in-line gondolas and an X-tail.

- The forward "control/payload" car housed the airship controls, including controls for an optional human pilot and co-pilot, the modular mission sensors, the powerful on-board computer system and communications systems.
- The aft "power car" carried the three "main drive" diesel engines, each equipped with a power transfer system to drive a 3-bladed propeller, an AC electric power generator and a hydraulic power system for the ballonet fans.



Blue Devil Block 2 airship general arrangement.
Source: USAF/PM645

Rendering of a Blue Devil Block 2 airship. Source: Wired (July 2011)



Blue Devil Block 2 airship 3-view drawing.
Source: USAF/PM645

Mav6 Blue Devil 2 under construction inside Airdock #1. Source: David Axe via Medium (Jul 2012)

Front view of the M1400 airship and the control / payload car (the forward gondola). Source: Mav6

General design characteristics of the Blue Devil Block 2

Parameter	**Blue Devil Block 2 (BD2) / M1400**
Type	Non-rigid blimp
Hull	Pressure stabilized, multi-layer fabric hull
Length	123 meters (370 feet)
Diameter	26.6 meters (87.2 feet)
Envelope volume	39,643 m^3 (1.4 million ft^3), including ballonet
Aerodynamic surfaces	X-configured tail planes with “ruddervators”

Propulsion & maneuvering systems	• 3 x 261 kW (350 HP) fixed, pod-mounted Thielert V-8 Centurion 4.0 diesel engines attached to the Power Car
	  ○ Each has a belt drive that distributes power to a 3-bladed propeller, an AC generator & a hydraulic power system for ballonet fans
	• 2 x 820 kW (1,100 HP) Garrett thrust vectoring turbo-prop engines, each driving a 5-bladed propeller, attached to the flanks of the gas envelope provide vertical thrust during takeoff landing and supplementary propulsion during high speed flight
	  ○ 2,268 kg (5,000 lb) thrust
	  ○ Continuous vector range from 70º nose up to 90º nose down
	• 1 x variable pitch 336 kW (450 HP) Rolls Royce turbo-prop engine driving a 3-bladed propeller to provide lateral thrust during low speed operation.

Power generation	3 x 30 kW 400 Hz AC generators driven by the diesel engines
Crew accommodations	Optionally manned, pilot & co-pilot during flight tests
Payload weight	Up to 2,722 kg (6,000 lb)

Mission payloads	Up to 8 modular, independent ISR payloads, such as:
	• Wide area EO/IR camera systems for day / night wide area surveillance
	  ○ Originally designed to use DARPA *Argus* system
	  ○ Less capable *Angle Fire* system installed.
	• High-power high-definition full-motion video
	• Synthetic aperture radar (SAR) / Ground Moving Target Indicator (GMTI) radar package
	• Multi-mode radar
	• Electronic eavesdropping systems such as the “Pennant Race” signal-intelligence (SIGINT) collector
	• High bandwidth data links
	• Weapons module

On board computer	Most powerful UAV-based computer to date, capable of processing up to 300 terabytes of data per hour (2012)
Speed, cruise	129 kph (80 mph)
Speed, max.	161 kph (100 mph)
Altitude, operating	Up to 6,096 meters (20,000 feet)
Mission duration	2 to 7 days, depending on payload weight and altitude

Gas envelope: The gas envelope for the M1400 airship was manufactured by subcontractor TCOM LP and was completed in August 2011. At that time, the 39,643 m^3 (1.4 million ft^3) gas envelope was the largest blimp envelope manufactured in more than 50 years. It was about 7 times the volume of a contemporary Goodyear GZ-20A civilian blimp and approached the volume of the U.S. Navy's Goodyear ZPG-3W airborne early warning (AEW) blimps, which retired from service in 1961. The price to fill the M1400 gas envelope with helium was $350,000 - $400,000 in 2012 prices.

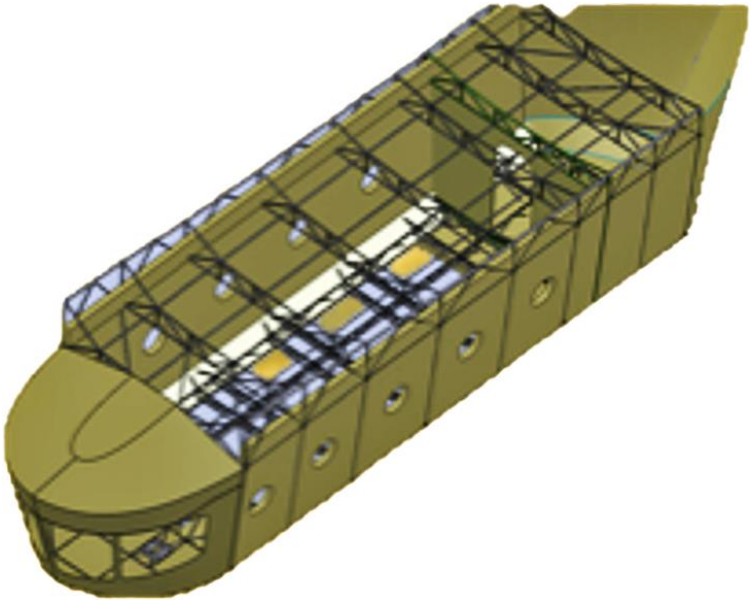
The 123 m (370-foot-long) M1400 gas envelope prior to final assembly in the TCOM hangar in Elizabeth City, NC. Sources: (Above) UASVision (March 2012) (Below) The Register (November 2011)

The ballonet fans were powered by closed hydraulic systems driven by the three diesel engines in the power car. This hydraulic power feature also was found on the earlier Blackwater Airships / Guardian Flight Systems Polar 400 airship.

<u>Control / payload car:</u> This was the forward gondola under the gas envelope. It measured 7 L x 3 W x 2.1 H meters (23 L x 10 W x 7 H feet), with an interior volume of 45.6 m^3 (1,610 ft^3) and was designed to carry up to 2,722 kg (6,000 lb) of payload in multiple equipment bays behind the optionally-manned cockpit.

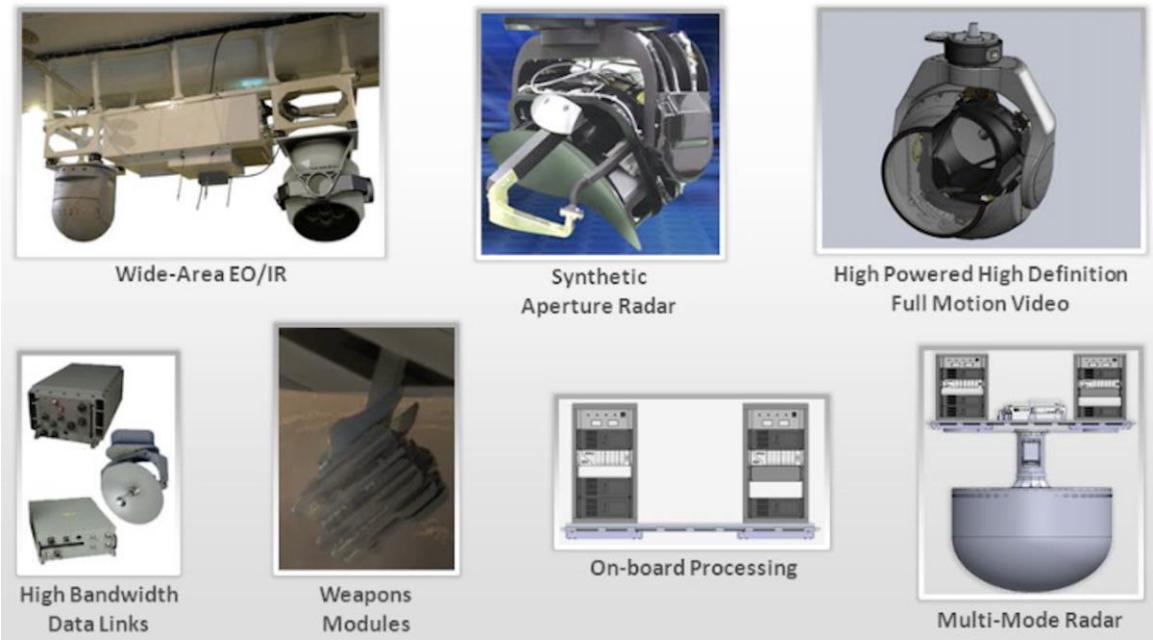
Forward quarter view of the control / payload car showing the optionally-manned cockpit. Behind is the separate power car, showing two of the three fixed, pod-mounted diesel engines. Source: Kawak Aviation

Rear quarter view of the control / payload car. Source: Mav6



Structural design of the control / payload car. Optionally-manned cockpit is at the left, with payload bays behind. Source: Mav6

The M1400 was designed to support the simultaneous deployment of a 6 to 8 of independent, modular payloads designed to simplify integration with the on-board computer, processing, and data storage systems and enable rapid payload reconfiguration (< 4 hours) for a specific mission without modifying the airframe.

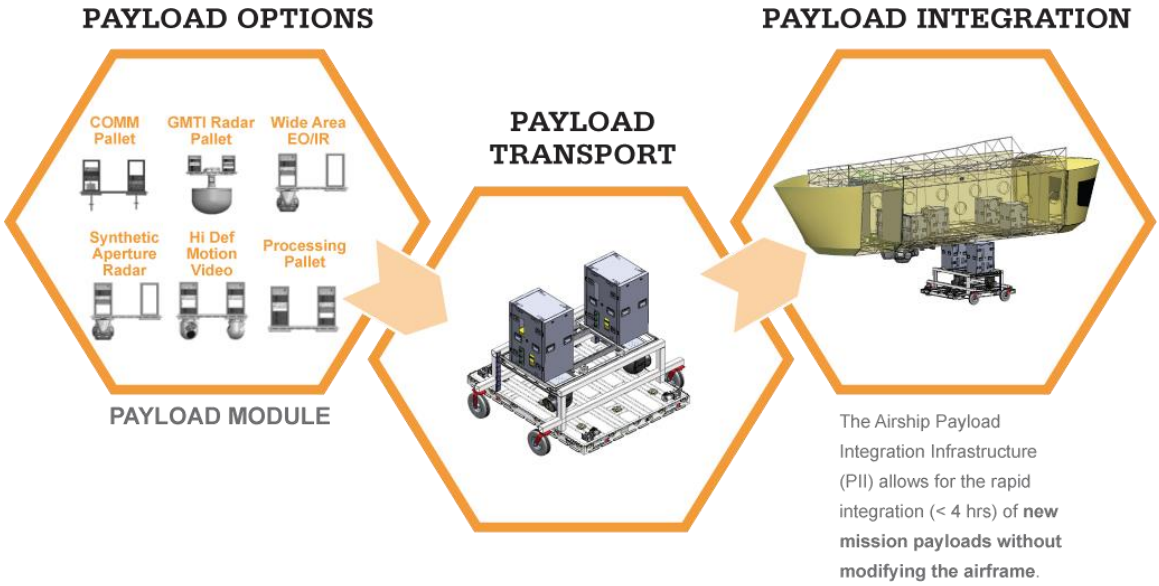


Types of mission payloads for the M1400. Source: Mav6

For the BD2 mission, the M1400 originally was intended to carry the Defense Advanced Research Projects Agency's (DARPA) Autonomous Real-Time Ground Ubiquitous Imaging System (*Argus*), which could track every moving target in its 64 km^2 (24.7 mi^2) field of view. Due to *Argus* development delays, the much less capable *Angle Fire* system, with a 4 km^2 (1.5 mi^2) field of view, was installed.

A synthetic aperture radar (SAR) / Ground Moving Target Indicator (GMTI) radar package had a planned range of > 241 km (150 mi), providing coverage of > 196,840 km^2 (76,000 mi^2).

An electronic / communications eavesdropping system such as the "Pennant Race" SIGINT collector had a planned monitoring range of 322 km (200 mi), providing coverage of 324,000 km^2 (125,000 mi^2).



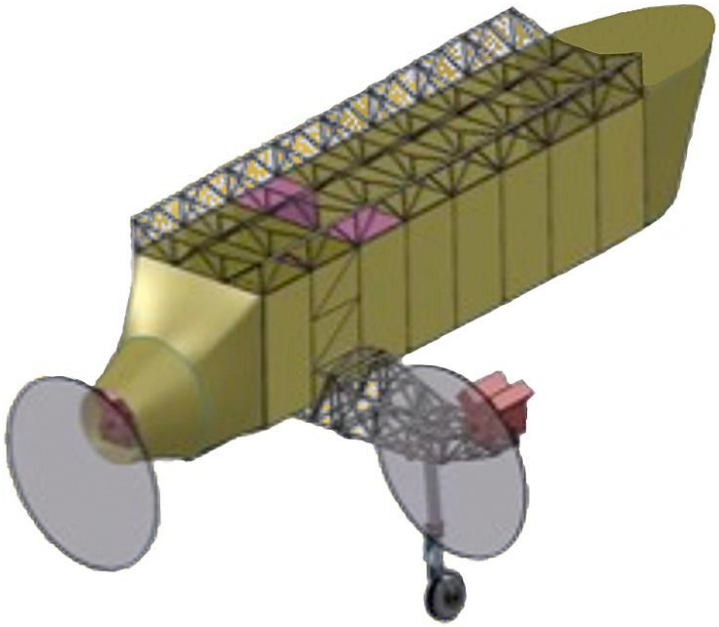
Modular payload integration in the M1400 payload bays. Source: Mav6

Power car: This was the aft gondola under the gas envelope. Three 261 kW (350 HP) fixed, pod-mounted Thielert Aircraft Engines Centurion 4.0 V-8 diesel engines with full authority digital engine control (FADEC) were attached via pylons to the Power Car, one at the nose of the car and two on outrigger pylons extending transversely, near the front of the car. These engines burn Jet A fuel.

The Centurion 4.0 received European EASA type certification in October 2004, but had not yet been certified by the U.S.

Each diesel engine drove a belt-driven Propeller Speed Reduction Unit (PSRU) that transmitted power to drive a 3-bladed main propulsion propeller, an AC power generator and a hydraulic power system.

Forward quarter view of the power car during construction showing one transverse outrigger pylon / diesel engine and the nose-mounted pylon / diesel engine. Source: Kawak Aviation

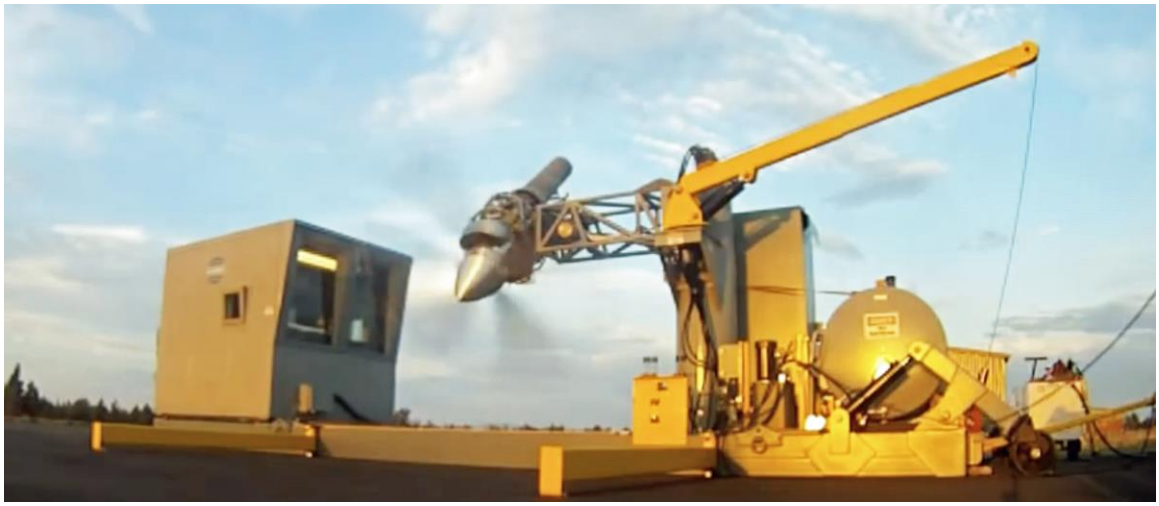


Structural design of the power car. Source: Mav6

Rear quarter view of the M1400 airship prototype floating in its hangar.
The completed power car, with three podded diesel engines, is in the foreground.
One of the flank-mounted, vectorable VTOL system turboprop engines
can be seen attached near the mid-plane of the hull.
Photo: Alex Washburn via Wired 6 Jul 2012

Vertical takeoff and landing (VTOL) system: This system is comprised of two self-contained, thrust vectoring, 820 kW (1,100 HP) Garrett turboprop engines that are mounted to the flanks of the gas envelope via thin-wall aluminum and steel tubing frameworks that distribute deadweight, aerodynamic and propulsion loads into the gas envelope. The primary purpose of the system is to assist with short takeoffs and landings (STOL) and slow speed maneuvering. It also can be used for supplementary propulsion power during maximum speed forward flight. Fly-by-wire operation of these propulsors was enabled by an RS422 communications network. You can watch a short video of VTOL engine and vector testing here.

One of two vectorable Garrett turboprop engines mounted amidships via a lightweight structural framework. Sources: (Left) David Axe via Wired, 6 Jul 2012, (Above) Kawak Aviation video screenshot, 3 Dec 2012.



Thrust vector test rig demonstrated a continuous range from 70º nose up to 90º nose down. Source: Kawak Aviation video screenshot, 3 Dec 2012.

<u>Lateral Thruster System (LTS)</u>: The LTS is comprised of a single, fly-by-wire, variable pitch, 336 kW (450 HP) Rolls Royce turbo-prop engine driving a 3-bladed propeller attached at the tail of the gas envelope to provide lateral thrust during low speed operation, such as during takeoff and landing, when the aerodynamic control surfaces are ineffective. The turboprop engine is installed in a fixed horizontal position on a thin-wall aluminum and steel tubing pylon attached at the extreme aft end of the M1400, which has been strengthened with battens. The engine's thrust axis is aligned perpendicular to the longitudinal axis of the airship. Kawak Aviation used a symmetrical propeller blade profile and modified the engine's power and propeller pitch controls to deliver 0 to 100% thrust in forward and reverse blade pitch.

LTS installed on test pylon (left) & tail-mounted engine and pylon with battens to stiffen and help distribute loads into the tail of the gas envelope (right). Source: Kawak Aviation

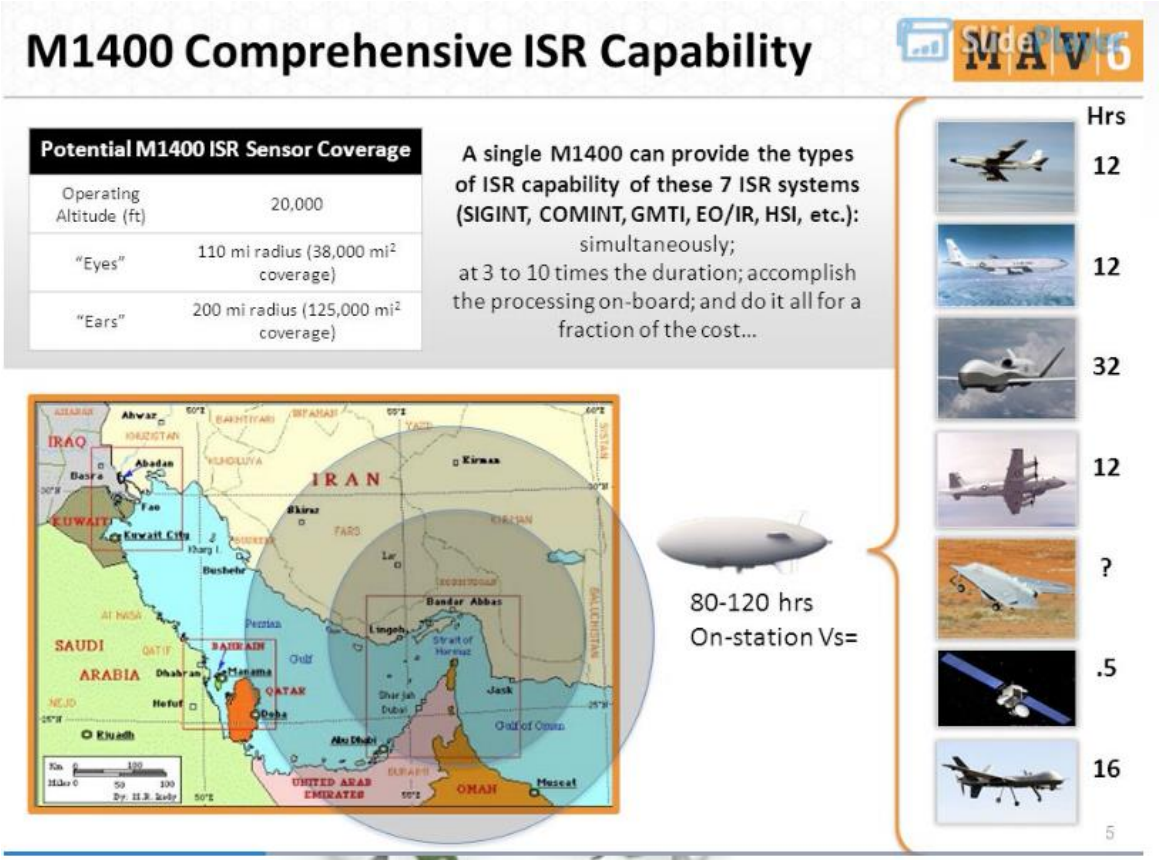
4. Planned implementation of advanced optical laser communications downlinks

In November 2011, the UK publication *The Register* reported that DARPA (Defense Advanced Research Projects Agency) had announced plans to outfit the BD2 with "up to two Free-space Optical Experimental Network Experiment (FOENEX)" systems for use in communications downlinks. FOENEX is a line-of-sight laser system for point-to-point communications with data rates and quality approaching that of fiber optic data links. This is achieved using

adaptive-optics technology similar to that developed for high-powered astronomical telescopes to eliminate distortions caused by viewing through the Earth's turbulent atmosphere.

5. Expected operational capability

The key selling points of the optionally-manned M1400 airship included its large, mission-specific, multi-sensor payload capacity, its very wide area sensor coverage operating at medium altitudes, its unique onboard raw data processing capability, its ability to rapidly deliver processed information to users in the field, its long-duration mission profile and its lower cost for delivering such services. In the following graphic, Mav6 compared the M1400's ISR capabilities to other available ISR resources.



Source: Mav6

6. Program issues leading to delays and cancellation

The unrealistically short BD2 program development cycle did not proceed well. While TCOM LP completed the gas envelope for the airship in August 2011, program milestones slipped to a planned first flight in late 2011 and an initial deployment to Afghanistan in February 2012. Mav6 reported that the USAF caused programmatic delays and cost increases by repeatedly changing system requirements and the Federal Aviation Administration (FAA) belatedly requiring type certification of the airship before a human pilot could be on board for initial tests that would be conducted un U.S. airspace.

Various technical problems also caused the program schedule to slip and cost to increase. For example:

- The airship as a whole was overweight by more than 4,536 kg (10,000 pounds), which reduced airship performance.
- The tail fins were overweight and failed initial structural load testing, rendering the airship not flyable.
- The flight control software experienced problems due to issues related to scaling. While the control software worked well when tested on the Polar 400 blimp (in 2008 – 2009 flight tests, on a different program managed by Blackwater Airships / Guardian Flight Systems), it did no work well on the full-scale M1400.
- The inability to integrate the original wide-area surveillance Argus camera system with other systems resulted in the adoption of the much less capable Angel Fire camera system, which provided coverage of only four square kilometers (1/16th of the coverage of the Argus camera system).

In the fall of 2011, the Air Force cancelled the planned 2012 test deployment to Afghanistan. The Air Force estimated the cost of that deployment would have been between $100 to 120 million. The project continued to unravel in the spring of 2012, culminating with the USAF issuing a programmatic stop work order on 23 May 2012, with directions to “deflate and crate” the M1400 by 30 June 2012. At that time, the M1400 airship was largely complete, inflated and tethered in its hangar in Elizabeth City, North Carolina. FAA tests on the redesigned tail fin had been completed successfully at 80.5 kph (50 mph) airspeed in early May, and a test at 129 kph (80 mph) was

scheduled at the end of May. The updated flight control software was scheduled for delivery by the end of May. Mav6 estimated that they had completed 90 – 95% of the development work.

The M1400 airship never made its first flight. The huge gas envelope was deflated and its entire helium inventory was vented to the atmosphere. The envelope, the six engines and the two gondolas were dismantled, packed into shipping containers and transported to an Air Force storage facility. This disposition cost was about $2.6 million.

Artist's rendering of the M1400 airship prototype in flight.
Source. Mav6 via Naval Airship Association Summer 2012.

In October 2012, the Government Accountability Office (GAO) issued report GAO-13-81, which included the following details on BD2 program termination.

> "The program was terminated effective June 2012. It had been scheduled to deploy "beyond September 2012," at least one year later than originally scheduled. However, the contractor has been directed to pack and crate the airframe and transport it to an Air Force storage facility at the end of the contract

> period. As a result, the Air Force will not deploy the Blue Devil Block 2 airship to Afghanistan as planned."
>
> "DOD also significantly underestimated the risk of the Blue Devil Block 2 development effort……. According to program officials, it was thought that the Blue Devil Block 2 airship would be a variant of commercially-available conventional airships and therefore deemed the technologies associated with the platform to be mature. However, the part of the program considered to be the lowest risk—the airship platform—turned out to be a high risk development effort….."

The GAO reported that FY10 to FY12 total program costs were $243.6 mission.

In September 2013, the U.S. Department of Defense Inspector General issued their report DODIG 2013-128, "*Air Force and Army Corps of Engineers Improperly Managed the Award of Contracts for the Blue Devil Block 2 Persistent Surveillance System*."

In their conclusions, the IG found that the USAF had "wasted $149 million on the uncompleted Blue Devil Block 2 system."

Mav6 LLC ceased operation in mid-2012 and no longer maintains a website.

In 2015, the Air Force barred former CEO Dave Deptula and Mav6 from conducting business with the U.S. government until February 2016 as punishment over a perceived conflict of interest related to Deptula retiring from his USAF position as deputy chief of staff for ISR in 2011 and then violating USAF post-employment rules, in particular, returning as the Mav6 CEO to market his former USAF colleagues for a major new ISR project: Blue Devil Block 2.

The diesel engine supplier, Lichtenstein-based Thielert Aircraft Engines, filed for bankruptcy in 2013 and was purchased by Continental Motors, which will retain Centurion as the model nameplate for its line of aviation diesel engines.

6. For more information

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- Dave Majumdar, “The General Who Loved Blimps Too Much,” The daily Beast, 10 February 2015, updated 14 April 2017: https://www.thedailybeast.com/the-general-who-loved-blimps-too-much

Video

- “Blue Devil Engine and Vectoring Testing,” (3:36 min), posted by Kawak Aviation, 3 December 2012: https://www.youtube.com/watch?v=miRMD6C92mg&t=1s

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Goodyear - N-Class blimps (ZPG-2W, -3W)
    - HAV & Northrop Grumman - LEMV
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - Blackwater Airships / Guardian Flight Systems – Polar-series airships
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/