Aeros - Aeroscraft prototype, *Dragon Dream*

Peter Lobner, updated 25 February 2024

1. Introduction

Igor Pasternak established a volunteer airship design bureau at Lviv Polytechnic University in Ukraine in 1981. His firm, Aeros, became one of the first private aerospace companies permitted under Mikhail Gorbachev’s Perestroika reforms in 1986. In 1994, he relocated to the U.S. and established Worldwide Aeros Corp. (Aeros) in Montebello, CA with the goal of becoming a major manufacturer of lighter-than-air (LTA) craft in the U.S.

In 2005, Aeros was one of two contractors selected by the Defense Advanced Research Projects Agency (DARPA) to conduct Phase I of Project WALRUS and develop a prototype of their variable buoyancy airship that implemented a process called “Control of Static Heaviness” (COSH). The prototype, named *Dragon Dream*, was completed under the subsequent DARPA-funded Project Pelican, which was awarded in 2011, and successfully flew in 2013.

Dragon Dream outdoor taxi test on its air bearing landing system (ABLS). Source: Aeros (2013)

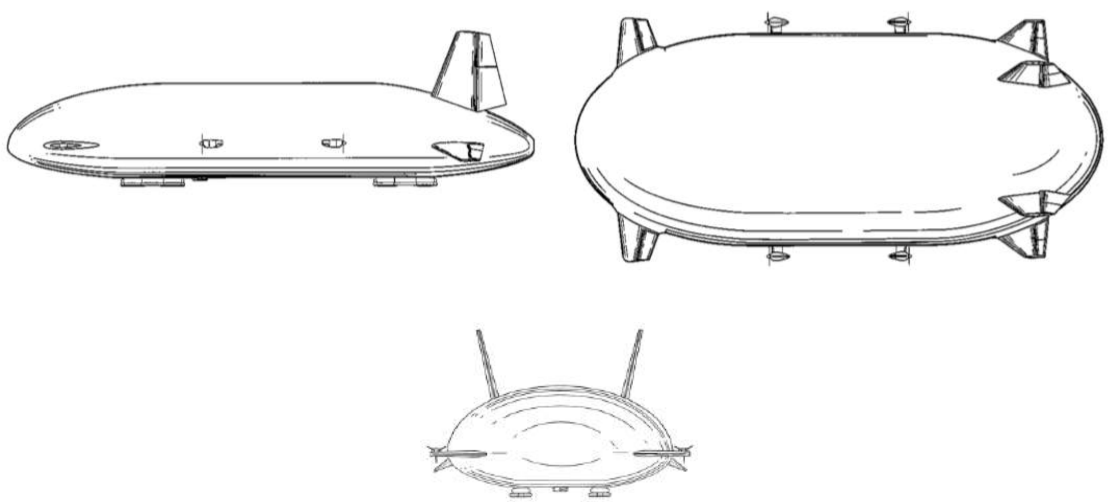
Aeros developed a family of advanced COSH airship designs, known as Aeroscraft, that are scaleable and configurable for a range of commercial, civil, military and private applications. Aeros LTA products also include the non-rigid Aeros 40E *Sky Dragon* airship and advanced tethered aerostatic systems. The Aeros website is here: http://aeroscraft.com

2. Aeros patents

During the development of *Dragon Dream* prototype, Aeros developed an impressive patent portfolio to address their key technologies for rigid airship aerostructures, an air bearing landing system (ABLS), and most importantly, the COSH flight system for a constant volume, variable buoyancy air vehicle. Following is an overview of these patents.

Patent US D663255S1 - Rigid body airship

Patent USD663255S1, which was granted on 10 July 2012, applies to the "ornamental design" of a rigid airships, which is defined in a series of figures. This design is implemented in *Dragon Dream* prototype and subsequent Aeros Aeroscraft designs.



Generic 3-view drawing of an Aeros Aeroscraft airship.
Source: Patent US D663255S1

Patent US9266597B1 - Aerostructure for rigid body airship

Patent US9266597B1, which was granted on 23 February 2016, describes the design of a rigid airship hull of the type implemented in Aeros' *Dragon Dream* prototype and subsequent Aeroscraft airship designs. The patent states:

> "An airship hull is provided that is sufficiently light and cost effective so as to make lifting body type airships practical vehicles for carrying people and cargo. The present invention hull design includes three main structural features, i.e., a rigid internal **main frame** which carries all primary moment and shear loads induced in the vehicle, the vehicle's **skin** which forms a semi-rigid barrier membrane for the lighter-than-air lifting gas, and a rigid **aeroshell frame** interposed between the main frame and the skin. The aeroshell frame and skin, in combination, are referred to as the **aeroshell**. The aeroshell carries the aerodynamic pressure loads induced on the airship"

> "A lift producing hull is highly advantageous because it allows an airship to take off in a statically negative condition, i.e., in a condition where the hull and payload weight exceed the maximum buoyancy supplied by the lifting gas."

The rigid internal main frame is the lightweight, high strength truss structure built up from triangular section trusses shown in patent Figure 7. Carbon fiber/epoxy tubes in a range of sizes are combined with aluminum tubing (future airships will incorporate all-carbon tubing). Tubes are connected with aluminum joints and adhesive bondlines to prevent galvanic corrosion

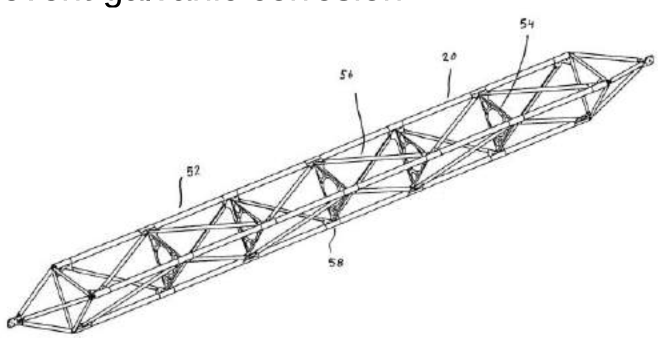


FIG.7

The rigid internal main frame (12) is comprised of 18 triangular-section trusses, as shown in perspective view in patent Figure 2. Rectangular transverse truss structures (30) form bulkheads that join the sides of the main frame.

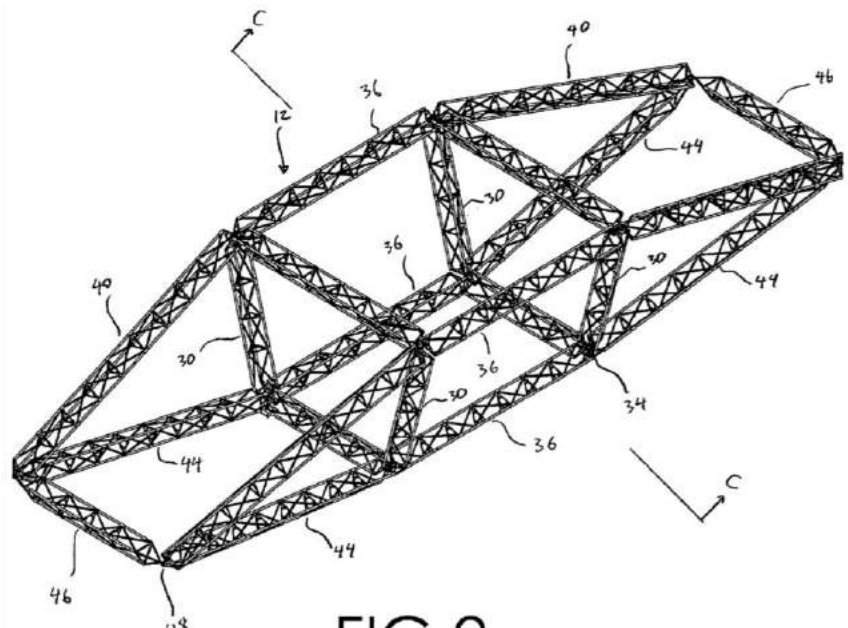


FIG.2

Patent Figure 6 shows the main frame truss structure with the tension cables (22) installed to provide the required structural rigidity.

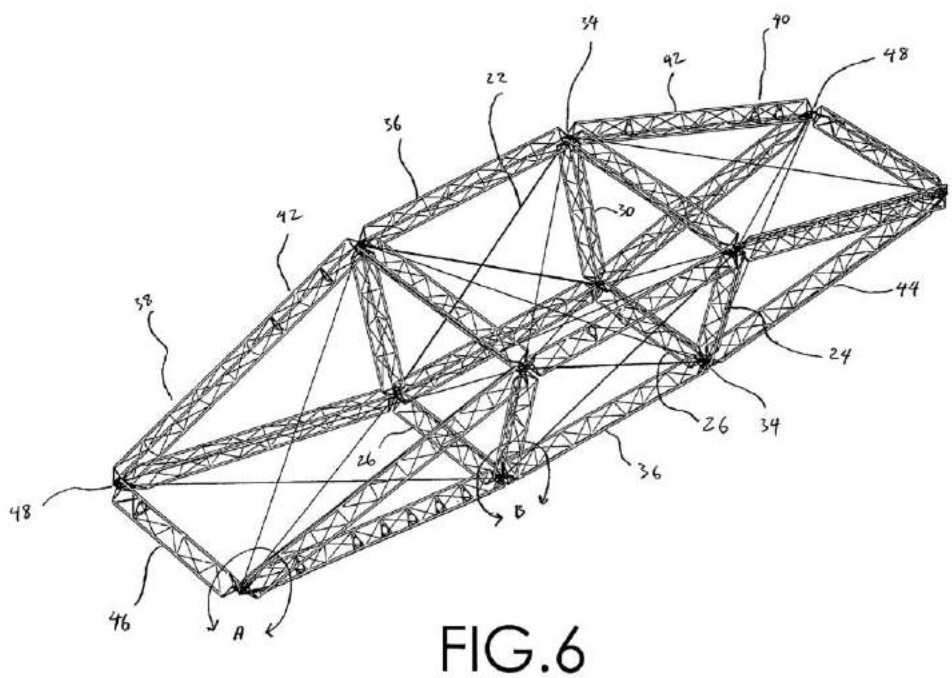


FIG.6

The rigid aeroshell frame (14) shown in patent Figure 3 defines the external shape of the airship. It is installed around, and is attached to the internal main frame and is comprised of three sections: center (122), bow (118) and stern (120). Structural elements include longitudinal formers that define the highly curved surfaces of the bow and stern sections (90), ellipsoidal transverse ribs (92) and ellipsoidal longitudinal longerons (94)

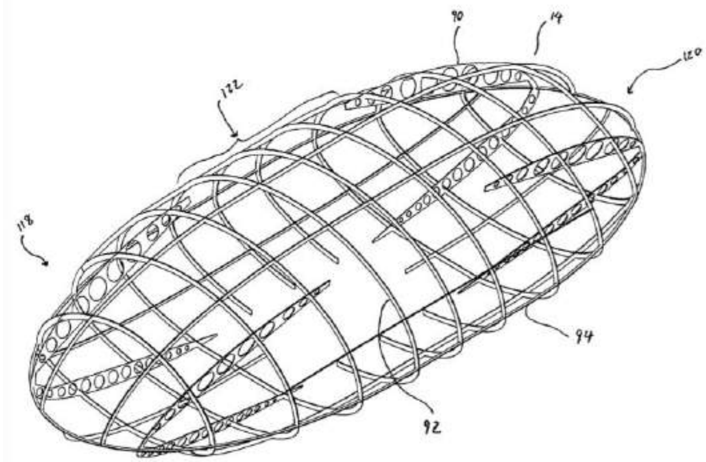


FIG.3

The fabric skin (16) shown in patent Figure 4 is a multi-layer, flexible membrane that is stretched over the aeroshell frame. It is comprised of four sections (142, 144, 146 & 148) for ease of assembly.

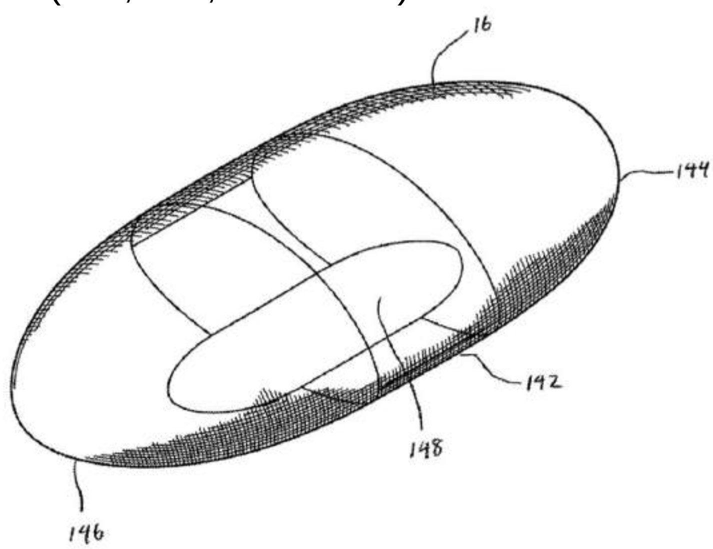
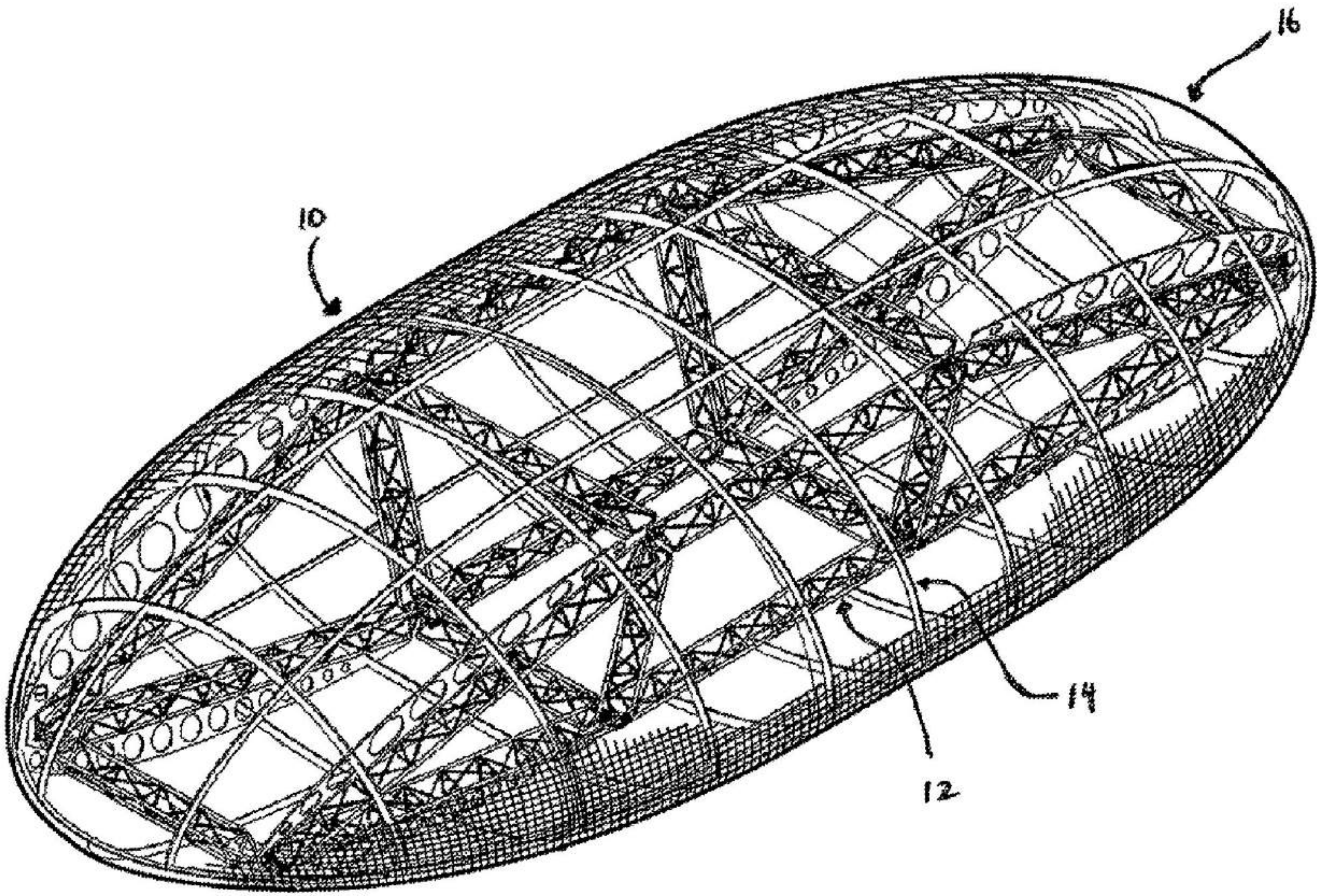
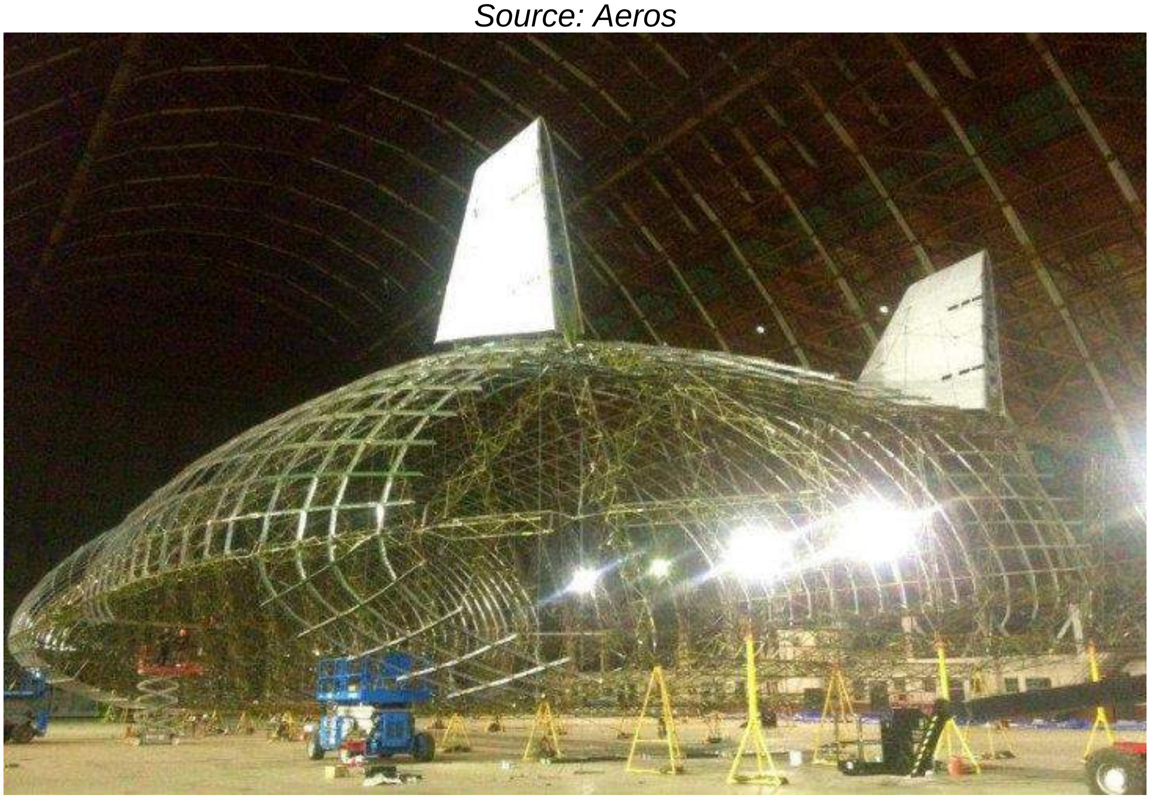


FIG. 4



The complete rigid aeroshell (10, the hull) is comprised of the internal main frame (12), the aeroshell frame (14) and the skin (16). Source: US9266597B1, Fig 1.

The Dragon Dream's lightweight main frame, which supports the airship's COSH equipment, its cockpit, cargo, and cargo containment structures. Source: Aeros



The Dragon Dream's assembled light weight, rigid aeroshell frame is installed around the internal main frame. Source: Aeros

Patent US8864068B1 – Multi-chamber landing system for an air vehicle

Patent US8864068B1, granted on 21 October 2014, defines a lightweight, multi-chamber, air bearing landing system (ABLS) that provides an air cushion that helps absorb and redistribute energy during vertical takeoff and landing of an airship and supports the vehicle's weight when parked. The ABLS also can provide suction to increase the vehicle's stability while on the ground. The system can adjust the attitude of an airship on the ground to enable the airship to clear obstacles while taxiing on uneven ground and to facilitate loading and unloading.

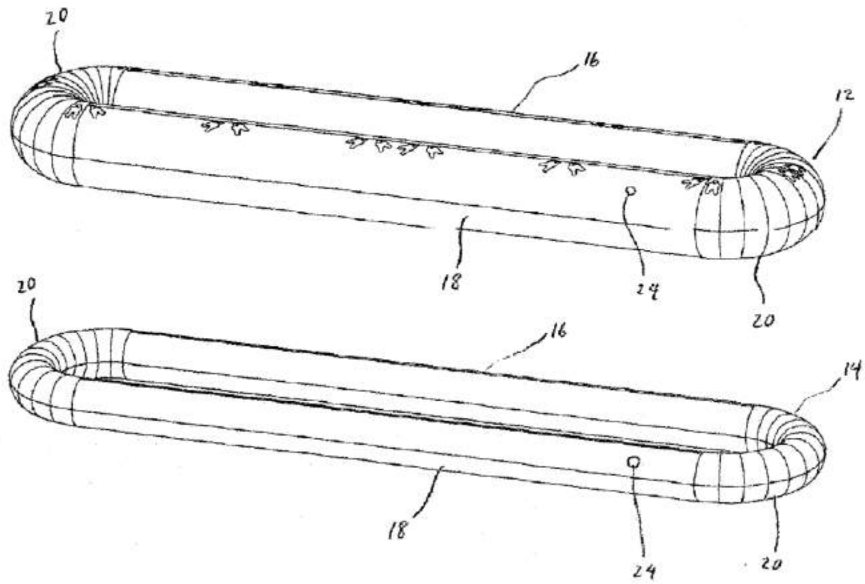


Fig. 5b

Legend: *Load-bearing upper (12) and lower (14) air chambers, each comprised of cylindrical center sections (16, 18) and semicircular end pieces (20), all manufactured from a high-density fabric (24)*

Simplified exploded view of an ABLS module showing just the upper and lower air chambers. Source: US 8864068B1, Fig 5b.

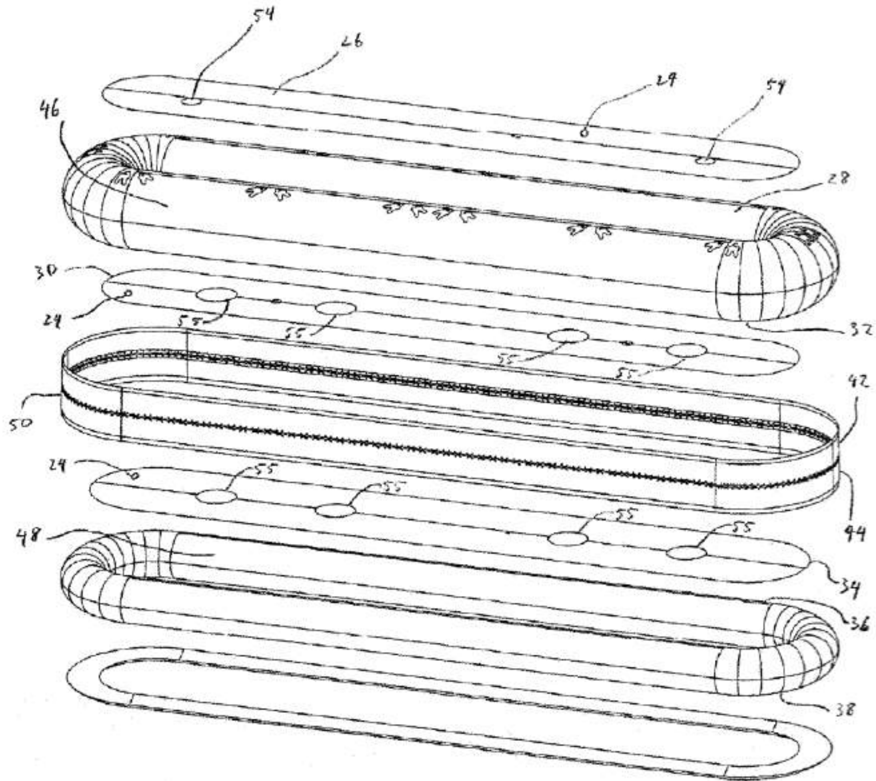


Fig. 6

Legend: *Load-bearing upper (28, 32 & 46) and lower (36, 38 & 48) air chambers,
ABLS top cover (26) is bonded to the top surface of the upper chamber (28),
debris shield with air ports (30) is bonded to the bottom surface of the top chamber (32),
another debris shield with air ports (24) is bonded to the top surface of the lower chamber (36),
an abrasion-resistant coating (40) on the bottom surface of the lower chamber.
Upper and lower curtains (42, 44) around the periphery of the air chambers are joined
by tension cords (50) that allow a degree of flexing between the upper and lower air chambers.*

Detailed exploded view of an ABLS module. Source: US 8864068B1, Fig 6

*Four ABLS modules are installed under Dragon Dream's aeroshell.
This view is during the indoor airship float test in January 2013. Source: Aeros*

Patent US9016622B1 – Flight System for a Constant Volume, Variable Buoyancy Air Vehicle

Patent US9016622B1, which was granted on 28 April 2015, describes Aeros' variable buoyancy technology known as "Control of Static Heaviness" (COSH).

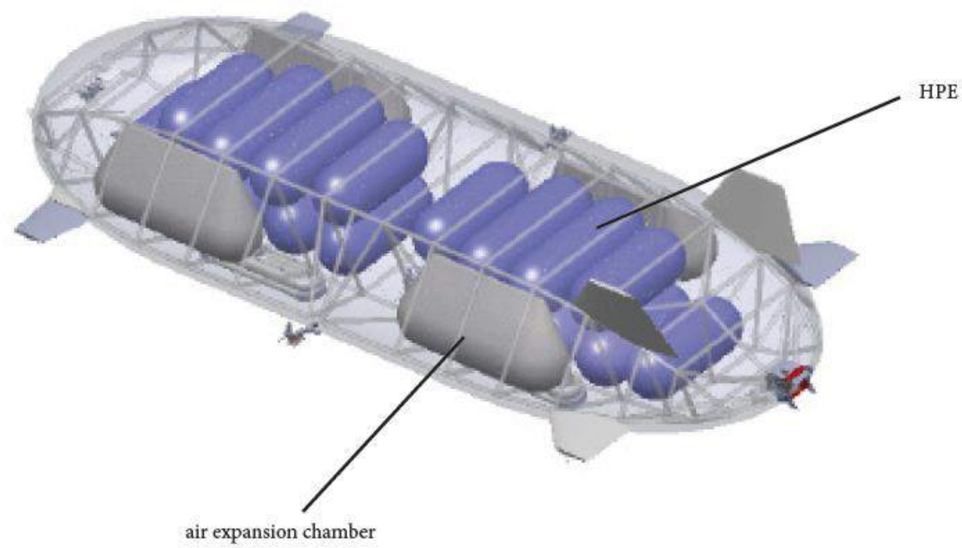
> "The invention relates generally to the flight system for a constant volume, variable buoyancy air vehicle able to achieve vertical takeoff and landing utilizing lighter-than-air static lift principals and achieving forward flight by utilizing heavier-than-air dynamic lift principals. More particularly, this invention relates to a flight system combining an aerodynamically efficient hull filled with lifting gas and incorporating a system for controlling the pressure of a lifting gas in a constant volume envelope and the ability to adjust buoyancy by actively compressing or decompressing the lifting gas, with the resulting pressure differential being borne essentially by an internal pressure tank."

> "A low pressure system is required because only a low pressure system can compress lifting gas at high speed and in sufficiently large volumes for practical use."

COSH is the variable buoyancy system implemented into the *Dragon Dream* prototype airship and in subsequent Aeros Aeroscraft airship designs.

3. Implementing variable buoyancy control on *Dragon Dream*

The airship's rigid aeroshell contains the helium envelope. Within the helium envelope, the COSH system manages airship buoyancy using the Helium Pressure Envelopes (HPE, the blue tanks in the following diagram) and Air Expansion Chambers (AEC, the grey bladders).



Aeroscraft cutaway showing HPE and AEC. Source: Aeros

The COSH variable buoyancy system works as follows:

- **To reduce buoyancy**: The COSH system compresses helium from the helium envelope into the HPEs, which contain the compressed helium in a smaller volume. The compression of helium into the HPEs creates a slight negative pressure within the helium envelope, permitting the AECs to expand and fill with heavier ambient air. The greater mass of the air within the aeroshell and the reduced helium lift make the airship heavier when desired.

- **To increase buoyancy:** The COSH system releases pressurized helium from the HPEs into the helium envelope. This creates a slight positive pressure within the helium envelope, causing the AECs to compress slightly and discharge some air overboard. With reduced ambient air ballast and greater helium lift, overall buoyancy of the airship is increased when desired.

The operation of a variable buoyancy system is illustrated in the following diagrams from Aeros patent US9016622B1.

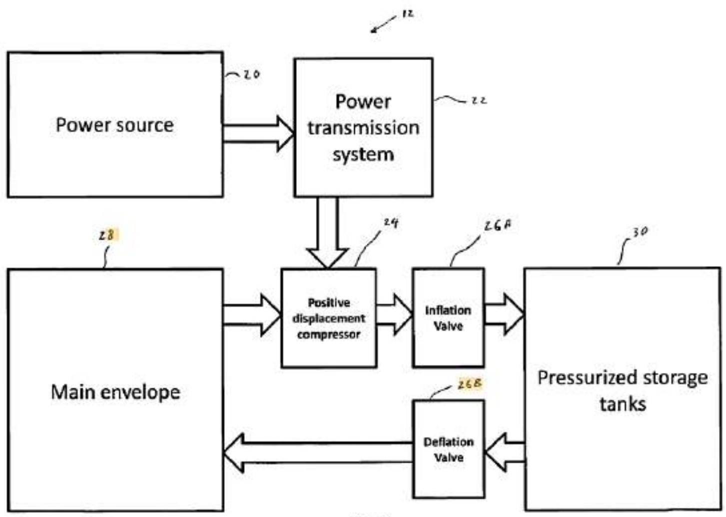
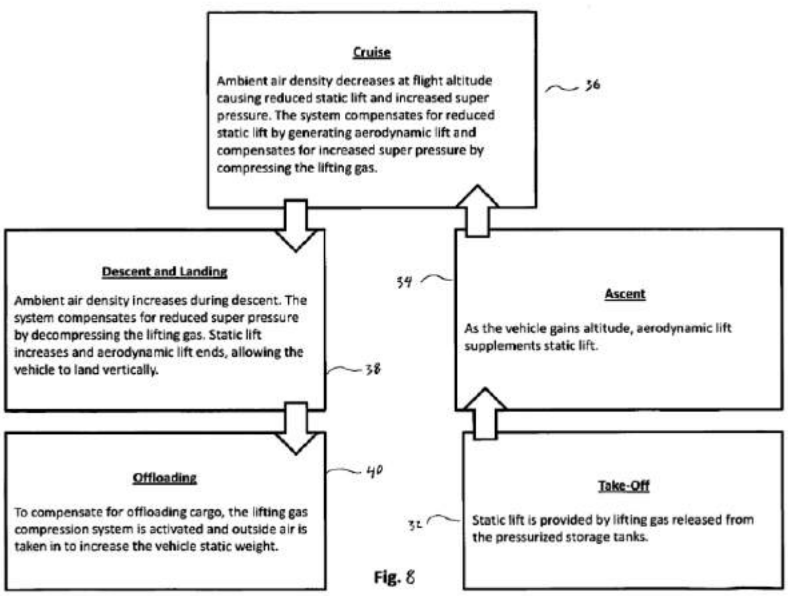


Fig. 9

Simple mechanical process for transferring helium back and forth between the main envelope and the pressurized storage tanks. Source: Patent US9016622B1, Fig. 9



Operation of the variable buoyancy system in different flight modes: takeoff, ascent, cruise, descent and landing, and off-loading cargo. Source: Patent US9016622B1, Fig. 8

You can view a brief YouTube video describing the operation of an airship with this type of variable buoyancy system here: https://www.youtube.com/watch?v=8b-qBoFku_o

4. Proof-of-concept of variable buoyancy control

In 2005, Aeros and Lockheed Martin were the two contractors selected by the Defense Advanced Research Projects Agency (DARPA) to conduct Phase I of Project WALRUS, which sought to develop new technologies and design concepts for a strategic, heavy-lift cargo airship. Under its $3,267,000 Phase 1 contract, Aeros successfully demonstrated the operation of their COSH variable buoyancy system in a ground-based test rig in 2006. Project WALRUS was terminated in mid-2006, after completion of Phase I.

Under a follow-on DARPA contract issued in October 2007, Aeros modified an Aeros 40D Sky Dragon non-rigid airship by installing two inflatable collars that were controlled by an on-board, flight-weight, prototype COSH system. Aeros announced on 17 July 2008 that a successful flight test of the modified Aeros 40D validated the operation of COSH. Aeros CEO Igor Pasternak explained, “We want to demonstrate we can change the static heaviness enough in a short time to be operationally acceptable.”

Modified Aeros 40D with two inflatable collars for the COSH system. Source: (Above) Aeros, (Below) screenshot from Aeros video.

5. Proof-of-concept of the lightweight rigid aerostructures

In September 2008, Aeros was awarded a DARPA contract for a Buoyancy Assisted Lift Vehicle (BAAV) Rigid Aerostructure Technology Demonstration. Under this contract, Aeros conducted scale demonstrations to validate that a full-scale airship with a rigid aerostructure can be both light and strong enough to accommodate high-speed dynamic air loads without failure. Aeros announced successful completion of the BAAV program on 10 September 2009.

6. The *Dragon Dream* prototype airship

Following the successful proof-of-concept demonstrations, Aeros was awarded a $60 million DARPA contract in 2011 for Project Pelican. Under this contract, Aeros developed their half-scale, proof-of-design vehicle named *Dragon Dream*, which embodied the following design features that also are incorporated on later Aeroscraft airships:

- Control-of-static-heaviness (COSH) system for variable buoyancy control. The system was expected to vary the airship's buoyant lift by 1,361 to 1,814 kg (3,000 to 4,000 lb).
- Rigid structure, with hard points for mounting the cockpit, propulsion system, aerodynamic control surfaces, and the cargo compartment.
- Ceiling suspension cargo deployment system for managing cargo with minimal requirements for ground support infrastructure. This system supports cargo containers and pallets from rails in the ceiling of the cargo compartment and adjusts cargo positioning to accommodate changes in center of gravity, such as when other cargo is loaded or unloaded.
- Air bearing landing system (ABLS) for operation on unimproved surfaces, including ice and water. Airflow in the system can be reversed to provide a suction to grip the ground and hold the airship in place for added stability on the ground.
- Vectored thrust engines propel the vehicle in forward flight and while taxiing on the ground and improve low-speed control.
- The Low-Speed Control (LSC) system manages the engines and maintains position and orientation during vertical takeoff and landing (VTOL) and hover in low wind conditions.

General characteristics of the Aeros *Dragon Dream*

Parameter	***Dragon Dream***
Type	Rigid, fixed volume, variable buoyancy
Length	81.1 m (266 ft)
Width, max	29.3 m (96 ft), wingspan
Height, max	15.7 m (51 ft)
Volume	17,000 m^3 (600,000 ft^3)
Gross weight	16,329 kg (36,000 lb)
Propulsion & low-speed control	• 2 x engine-driven, flank-mounted thrust vectoring propellers • 1 x stern mounted thrust vectoring propeller
Speed, cruise	40 knots (46 mph / 74 kph)
Operating altitude	2,987 m (9,800 ft)
Crew + pax accommodations	Midships gondola, 2 x flight crew + 2 to 3 passengers

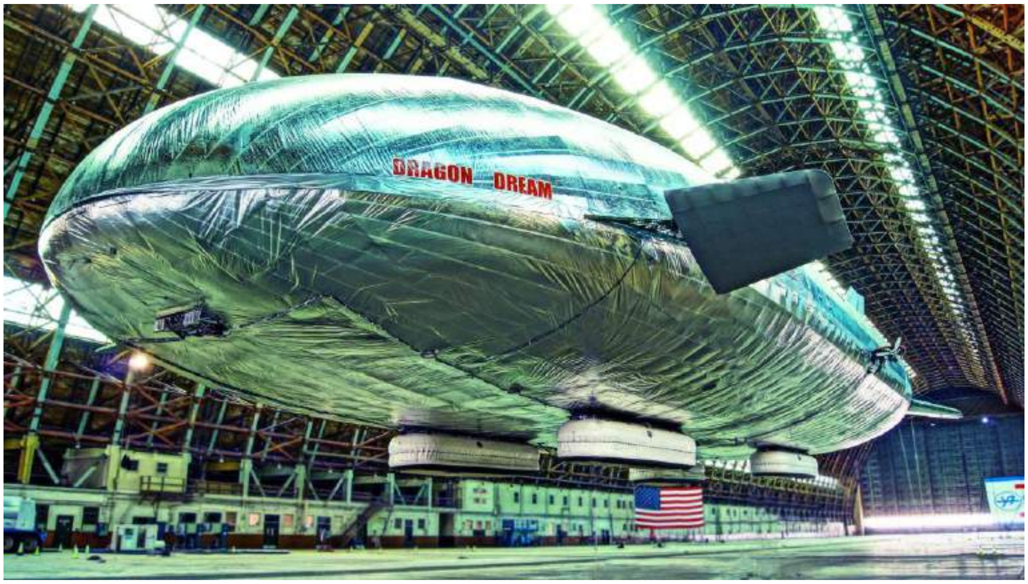
Starboard flank-mounted thrust-vectoring engine & 3-bladed propeller in the cruise position. Source: screenshot from Aeros video

Stern-mounted, fixed engine & 3-bladed propeller with thrust-vectoring "paddles" to divert the propeller slipstream (to vector thrust).
Source: Aeros

7. Testing the *Dragon Dream* prototype

Dragon Dream was first “float tested” on 3 January 2013 inside a World War II-era blimp hangar at a former Marine Corps Air Station in Tustin, CA, which was under license to the Navy. The Pentagon declared that the hangar tests of the *Dragon Dream* were a success, with the craft meeting its demonstration objectives, which were to confirm the operation of the COSH system.

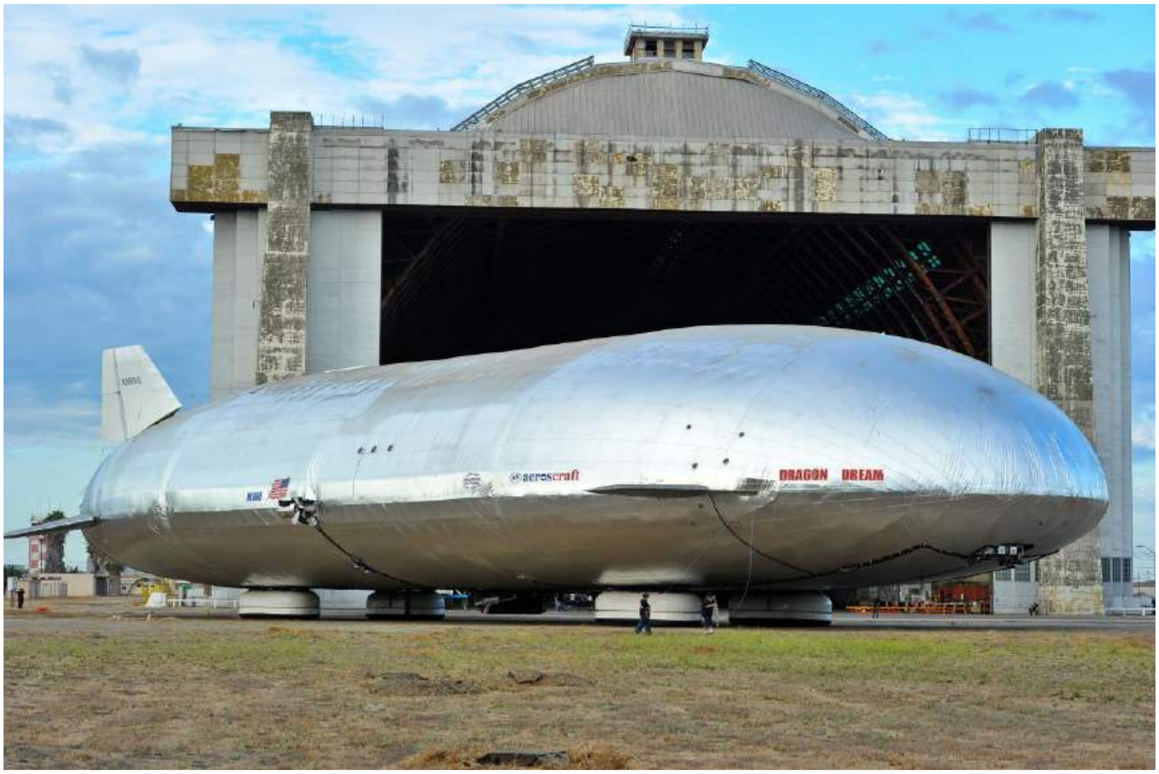
Dragon Dream bow view on first “static float test” in January 2013 (above); stern view showing the fixed aft propulsor and diverter flaps (below). Source, both photos: Aeros



Dragon Dream first "static float test" in January 2013. Source: Aeros

The airship was moved out of its hangar on 4 July 2013. Outdoor taxi tests on the air bearing landing system, COSH tests, and low speed control (LSC) system tests were conducted. DoD and NASA acknowledged that work under Project Pelican was completed within budget on 21 August 2013.

Dragon Dream moved outside the hangar in July 2013. Source: Aeros



Dragon Dream moved outside the hangar in July 2013.
Source: REX/Aeros via Daily Mail

Taxi test on the ABLS, July 2013. Source: Aeros

The *Dragon Dream's* cockpit is located under the gas envelope, approximately in line with the mid-ships, flank-mounted propulsors.

Gondola side view. Source: Screenshot, The New Yorker video

Cockpit interior view. Source: Aeros

External view of cockpit during taxi on ABLS.
Source: Screenshot, Aeros video.

On 5 September 2013, Aeros announced that the FAA had granted an R&D Airworthiness Certificate for *Dragon Dream*, permitting flight testing in designated controlled airspace. *Dragon Dream* made its first flight on 11 September 2013.

Dragon Dream ABLS raising dust.
Source: Aeros

Dragon Dream flight test, September 2013. The cockpit is visible amidships, under the gas envelope. Source: Aeros

Dragon Dream flight test, bow view, September 2013.
Source: Aeros

Dragon Dream flight test, profile view, September 2013.
Source: Screenshot from Spike Jacobs YouTube video (2013)

Dragon Dream flight test, September 2013.
Source, both photos: Aeros

The *Dragon Dream* airship was damaged on 7 October 2013 when a 6-by-6 meter (20-by-20 foot) section of the roof of its World War II-era hangar collapsed and fell onto the airship. Aeros determined that the airship was not repairable.

Part of the central roof of the North Tustin blimp hangar collapsed.
Source: Associated Press via Daily Mail

Damage to the rear part of the Dragon Dream.
Source: Allan Ripp via The LTA Society

The undamaged front part of Dragon Dream deflating after the roof collapse. Source: ZUMAPRESS via Daily Mail

The General Accounting Office (GAO) reported that $42.4 million had been spent in *Dragon Dream* under Project Pelican between FY2008 and FY2011 (Oct 2007 - Sep 2011). Aeros also received DARPA funding under the separate BAAV (2008 - 2009) and COSH (2007 - 2008) proof-of-concept contracts and $3.267 million under the WALRUS Phase 1 contract (2005 – 2006).

Aeros disassembled the damaged airship and salvaged what it could. In 2015, Aeros filed a lawsuit (Case No. CV15-1712-PJW) in the U.S. District Court for the Central District of California against the Navy related to the loss of *Dragon Dream* and its impact on future Aeros business. The lawsuit was settled on 20 November 2017 with a ruling in favor of Aeros with a determination that they were entitled to damages in the amount of $6,882,918.

The Aeros Aeroscraft family of airships, which incorporate key technologies demonstrated by *Dragon Dream,* is addressed in a separate article.

8. For more information

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- Lin Lao & Igor Pasternak, "A review of airship structural research and development," Progress in Aerospace Science, Vol. 45, Issues 4 – 5, pp. 83 – 96, May – July 2009: https://www.sciencedirect.com/science/article/abs/pii/S0376042109000153
- Report to Congress, "Summary Report of DoD Funded Lighter-Than-Air-Vehicles," DoD Office of the Assistant Secretary of Defense for Research and Engineering, 1 November 2012: https://www.hsdl.org/?view&did=728733
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- Sara Black, "Don't call it a blimp!" Composite World, 30 April 2014: https://www.compositesworld.com/articles/dont-call-it-a-blimp
- Melody Petersen, "Airship dedication reminds Worldwide Aeros chief of deferred dream," Los Angeles Times, 17 October 2014: https://www.latimes.com/business/la-fi-airship-dedication-20141018-story.html
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- "AEROS AERONAUTICAL SYSTEMS CORP. v. U.S." Case No. CV 15-1712-PJW, Leagle, 20 November 2017: https://www.leagle.com/decision/infdco20171121909#

Patents

- US D663255S1, "Rigid body airship," Inventor: Igor Pasternak, Filed 2 August 2011, Granted 10 July 2012, Assigned to: Worldwide Aeros Corp.: https://patents.google.com/patent/USD663255S1/en
- US8864068B1, "Multi-chamber landing system for an air vehicle," Inventor: Igor Pasternak, Filed 2 April 2012, Granted 21 October 2014, Assigned to Worldwide Aeros Corp.: https://patents.google.com/patent/US8864068B1/en
- US9016622B1, "Flight system for a constant volume, variable buoyancy air vehicle," Inventor: Igor Pasternak, Filed 8 March 2012, Granted 28 April 2015, Assigned to: Igor Pasternak: https://patents.google.com/patent/US9016622B1/en
- US 9266597B1, "Aerostructure for rigid body airship," Inventor: Igor Pasternak, Eugene Nemirovsky & Mansoor Kouchak, Filed 1 August 2011, Granted 23 February 2016, Assigned to Worldwide Aeros Corp.: https://patents.google.com/patent/US9266597B1/en

Videos

- "Aeroscraft Dragon Dream air cargo ship 1st flight," (1:51 min), posted by Big Chris, 31 August 2013: https://www.youtube.com/watch?v=L95wkPmWePg
- "Dragon Dream airship first flight," (2:23 min), posted by Spike Jacobs, 11 September 2013: https://www.youtube.com/watch?v=GcJZiMhkw9Y
- "Dragon Dreams' First Flight," (1:31 min), posted by WorldwideAeros, 17 December 2013: https://www.youtube.com/watch?v=WjQ8PL1Y6SU&t=6s

- “AEROSCRAFT - World's Most Advanced Airship First Flight Commercial,” (2:44 min), posted by CarJamTV, 10 July 2014: https://www.youtube.com/watch?v=8b-qBoFku_o
- “Aeroscraft airship Dragon Dream Roll out,” (0:25 min), Aeros video posted by 42 – Everything About Earth and Beyond, 2015: https://www.dailymotion.com/video/x2fgnub
- “Inventing a Lighter-Than-Air Aircraft,” (5:50 min), posted by The New Yorker, 21 February 2016: https://www.youtube.com/watch?v=QwLa24BO7oI

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
  - Aeros - Aeroscraft variable buoyancy rigid airships
  - DARPA Project WALRUS
  - Walden Aerospace / LTAS - T-90 & T-280 variable buoyancy rigid airships
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
  - Aeros – Aeros 40 *Sky Dragon* blimp
  - Atlas LTA Advanced Technology – ATLANT variable buoyancy rigid airships
  - Euro Airship – 10T, 50T & 400T variable buoyancy rigid airships
  - Varialift - ARH50 & ARH 250 variable buoyancy rigid airships
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/
  - Aeros - *Neona*
  - Halo luxury airship