Aerostatica airships

Peter Lobner, 11 February 2022

1. Introduction

Aerostatika Nauchno-Prozvodstvennaya Firma (Aerostatica Scientific-Production Company) is a small airship manufacturer and research firm founded in 1990 in Moscow, Russia, under the leadership of chief designer Aleksandr N. Kirilin. Aerostatica is affiliated with Moscow Aviation Institute (MAI).

The company's first two airships were the ultra-light, single-seat Aerostatica-01 and the larger two-seat Aerostatica-02, which first flew in 1994 and 1995, respectively. The Russian Air Force tested Aerostatica airships to assess their ability to provide increased low-level aerial reconnaissance and observation. After successful flying programs, these small airships are now stored in a warehouse at an Air Force base in Volsk, in the Saratov region.

Aerostatica-02 (left) and the smaller Aerostatica-01 (right and inset). Source: Ukuytdom-NN

In the early 2000s, the firm developed design concepts for the Aerostatica-200 and -220 twin-engine, four-seat airships. The -220 model was intended for environmental monitoring over Moscow. In the same time period, the design for a three-engine, nine-seat model named the Aerostatica-300 also was developed for tourist excursions above Moscow. Larger still was the Aerostatica A-06 that was being developed in the late 2000s, possibly in collaboration with the Russian airship firm RosAeroSystems. None of these larger airships were built.

More recently, Aerostatica has focused on research related to advanced airship applications. This article takes a brief look at the designs of the Aerostatica-01, -02, -300 and A-06 manned airships and a large, unmanned stratospheric airship.

2. Aerostatica-01

Within the framework of a research and development effort commissioned in the early 1990s by the Russian Ministry of Defense, designer Aleksandr Kirilin, in collaboration with Moscow Aviation Institute (MAI) and the Airship Building Design Bureau (at DKBA), developed the single-seat, non-rigid, ultra-light Aerostatica-01. This small blimp first flew in 1994.

The gas envelope was fabricated from a nylon fabric backed up with a polyethylene terephthalate film that was sewn together and the seams were glued. Flight tests demonstrated that the helium leak exceeded expectations.

General characteristics of the Aerostatica-01

Parameter	Aerostatica-01
Length	22 m (72 ft)
Diameter, max	5.7 m (18.7 ft)
Envelope volume	370 m^3 (13,066 ft^3)
Propulsion	1 x Russian 27 shp (20.1 kW) Rybinsk Motors RMZ-640 two-stroke, two-cylinder, air-cooled snowmobile engine
Accommodations	Single seat
Speed, max	85 kph (52.8 mph)
Speed, cruise	70 kph (43.5 mph)
Operating altitude	Up to 1,000 m (3,280 ft)
Endurance	2 hours

The airship was propelled by one Russian 27 shp (20.1 kW) Rybinsk Motors RMZ-640 two-stroke, two-cylinder, air-cooled snowmobile engine installed behind the pilot and driving a shrouded pusher propeller. Within the shroud, stacked rows of adjustable, horizontal flaps with which the pilot could manually deflect the propeller slipstream from 0° to 90° down to provide thrust vector control during vertical takeoff and landing.

The low power of the single engine limited the Aerostatica-01 to flying in low wind conditions. The airship had control problems at windspeeds above about 7 meters/sec (25 kph /15 mph).

Aerostatica-01. Source: Russian Aeronautical Society via Wikimedia Commons, circa 2012

Aerostatica-01 sitting on its tricycle landing gear. Source: Boyko (2001)

3. Aerostatica-02

The second airship, Aerostatica-02, was built based on experience gained from Aerostatica-01. It was designed and manufactured in accordance with American airworthiness regulations.

General characteristics of the Aerostatica-02

Parameter	Aerostatica-02
Length	27.6 m (90.6 ft)
Diameter, max	6.9 m (22.6 ft)
Envelope volume	650 m^3 (22,955 ft^3),
Propulsion	1 x Austrian 65 shp (48.5 kW) Rotax-582UL two-cylinder, liquid-cooled engine
Accommodations	Two seats
Speed, max	97 kph (60 mph)
Speed, cruise	75 kph (43.5 mph)
Endurance	4 hours

Like Aerostatica-01, Aerostatica-02 was a non-rigid airship with eight metal plate tail fins. The gondola was fabricated from the cabin of a single-seat Aviatik aircraft and expanded to provide seating for two. Propulsion is provided by an Austrian 65 shp (48.5 kW) Rotax-582UL two-cylinder, liquid-cooled engine installed behind the pilot and driving a shrouded pusher propeller with manually-actuated thrust vector controls similar to Aerostatica-01, enabling vertical takeoff and landing.

Author and aeronautical engineer Y.S. Boyko (2001) reported, “Flight tests of the Aerostatica-02 airship showed high efficiency of the thrust vector deflection system and low values of thrust losses in the jet deflection system. The airship showed good controllability in pitch, which made it possible to improve its maneuverable characteristics, especially in take-off and landing modes…….. According to the developers, such devices for turning the thrust vector can be installed on engines with a power of up to 500 kW (670 shp) with multi-blade air propellers with a diameter of up to 1,500 mm (4.9 ft)”

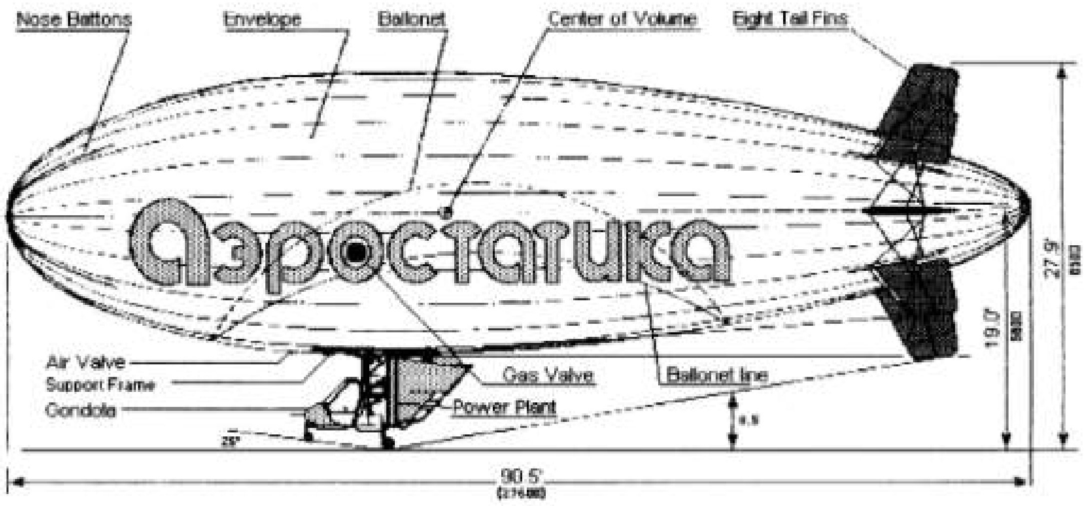
The first flight of this airship took place in 1995 from an airfield in Zhukovsky, near Moscow. The appearance of the Aerostatic-02 airship at the MAKS-95 aviation exhibition was a notable event.

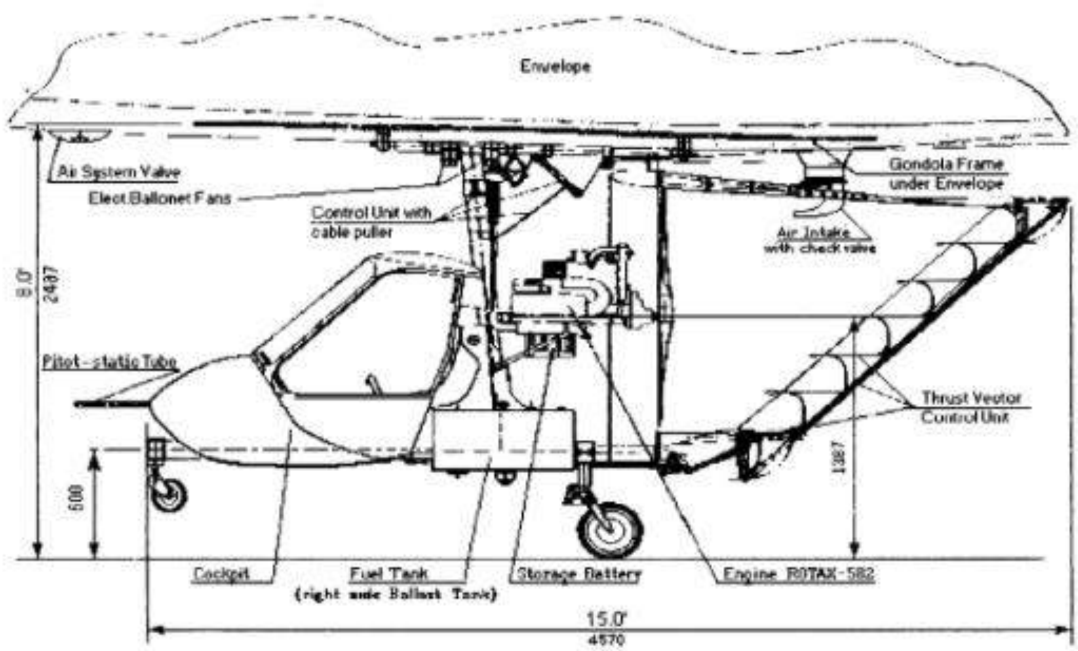
The Aerostatic-02 airship also was exhibited at the MAKS-97 (Zhukovsky, 1997) and Tushino (Moscow, 1999) exhibitions.

This small airship flew often over Moscow and made several long distance flights. For example, starting on 12 September 2000, and operating from the Russian Air Force base in Volsk, Aerostatica-02 established a record flight duration of 18 hours. The airship flew along the route Volsk-Saratov-Volgograd-Akhtubinsk, the length of which was 650 km (404 miles).

Aerostatica-02. Source: Russian Aeronautical Society via Wikimedia Commons, circa 2012

Shrouded propeller & thrust deflection louvers. Source: Boyko (2001)





Aerostatica-02 side view and gondola details.
Source, both graphics: Robert Recks (1997)

4. Aerostatica-300

The non-rigid, three-engine, nine-seat model Aerostatica-300 was developed by order of the Russian Ministry of Defense, which planned to use the airship for military applications such as reconnaissance, patrolling, search and detection of submarines and surface targets, mining and de-mining of coastal seaways. Aerostatica-300 also was suitable for civilian applications, such as for tourist excursions above Moscow.

General characteristics of the Aerostatica-300

Parameter	**Aerostatica-300**
Length	50.5 m (165.7 ft)
Diameter, max	12.6 m (41.3 ft)
Height, overall	16.2 m (53.1 ft)
Envelope volume	4,000 m^3 (141,260 ft^3)
Ballonet volume	1,000 m^3 (35,315 ft^3) in fore and aft ballonets (25% of envelope volume)
Propulsion	Originally: • 2 x Rotax-914 gasoline engines rated @ 74 kW (99.2 shp) installed outside on the tail of the gondola, and • 1 x LOM M337 inverted six-cylinder, air-cooled, inline engine rated @ 154.5 kW (207 shp) under the tail Later design: • 3 x 20CNE 20 01A diesel engines rated @ 110 kW (147.5 shp) All driving separate shrouded, thrust vectoring propellers.
Gondola dimensions	7.45 L x 2.39 W meters (24.4 L x 7.8 W feet)
Payload	1,000 kg (2,205 lb)
Accommodations	Up to nine seats, depending on mission configuration
Speed, max	120 kph (74.6 mph)
Speed, cruise	110 kph (68.4 mph)
Operating altitude	Up to 2,700 m (8,858 ft ft)
Range	1,000 km (621 miles)
Endurance	24 hours @ 50 kph (31 mph)

The gondola could be equipped with seating for up to nine people, or a combination of mission equipment and a smaller crew. The gondola cabin was equipped a toilet, a wardrobe, and luggage compartments. In addition, water and dry ballast tanks and a fuel tank are installed in the gondola. A three wheel castering landing gear is installed under the gondola. The Aerostatica-300 was capable of operating with any single engine.

This airship was estimated to cost USD $1.5 million. None were built.

Aerostatica-300, with the characteristic eight tail fins.
Source: Boyko (2001)

5. Aerostatica VK-7 and VK-9

Yu.S. Boyko (2001) reported, “In the portfolio of Aerostatica there are two other projects of airships, but with a rigid scheme: the VK-7 airship with a volume of 13,000 m^3 (459,091 ft^3) for 40-50 passengers and VK-9 with a volume of 70,000 m^3 (2,472,000 ft^3) for 100 passengers. To receive and disembark passengers from an airship hovering at an altitude of 30 - 40 m (98 – 131 ft), it is proposed to use elevators, lowered with the help of onboard winches to the ground.”

6. Aerostatica A-06

The Aerostatica A-06 was a design concept for a mid-size, multi-purpose (passengers and cargo), conventional, rigid airship. This airship design was developed in the late 2000s in a collaboration between Aerostatica and another the Russian airship firm, RosAeroSystems.

The A-06 retained the characteristic Aerostatica eight tail fin configuration. A large passenger and freight gondola is located under the rigid gas envelope, with two smaller gondola-like structures located fore and aft to support four turboprop engines on stub wings.

Aerostatica A-06. Source: Alastair Reid, Russian Airships (2016)

General arrangement of the Aerostatica A-06 rigid airship.
Source: RosAeroSystems IsoPolar presentation (2009)

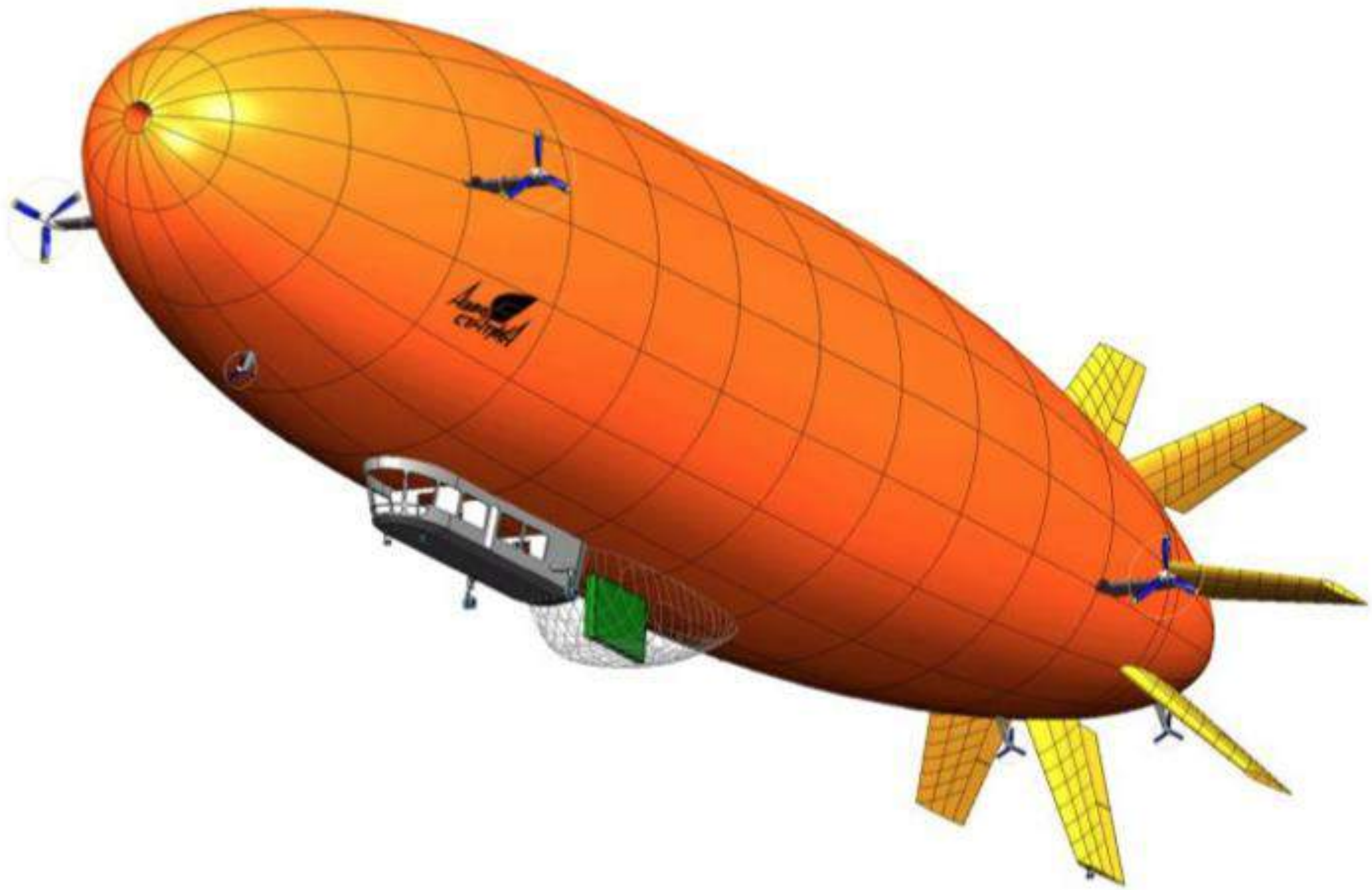
7. Aerostatica A-35

Aerostatica proposed a design for the large, comfortable A-35 dirigible for tourist and international passenger flights. The A-35 was based on a heavy-duty freight dirigible they were developing at the same time (likely circa 2010).

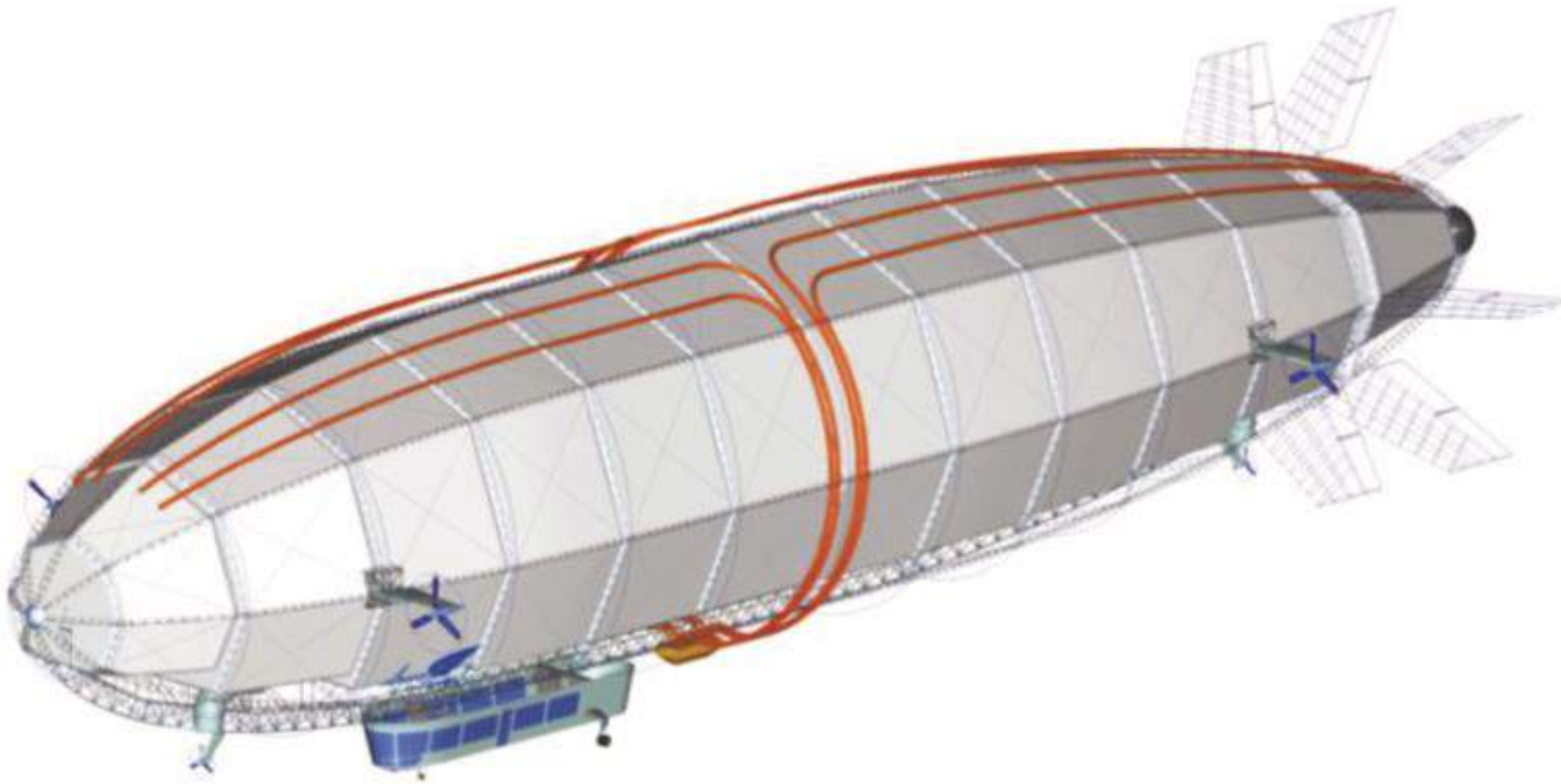
8. Aerostatica 2015 – 2016 study of airship ice and snow protection

In 2015 and 2016 studies of airship hull protection from ice and snow, Aleksandr Kirilin and a team of researchers from Aerostatica and MAI built an airship computational model based on a "real" airship design that appears to be generally similar the Aerostatica A-06 design. Their airship computational models, shown below, had a length of 104 m (341.2 ft) and a diameter of 20.8 m (68.2 ft).

Their study determined that the most efficient anti-icing system (AIS) strategy involved using manifolds to distribute hot air along the top of the rigid airship, in the gap between the inner and outer shells. On a mid-size airship (like the Aerostatica A-06), such a system required more than 2.7 MW of thermal power to operate effectively at -10º C (14º F) in a wind speed of 30 m/s. (108 kph, 67 mph). In this case, the AIS was able to maintain external shell temperature at or above 2º C (35.6º F). While the airship propulsion engines could provide this heat, the authors recommended using a separate, ground-based heat source to protect a parked airship from icing without adding many hours of operating time to the airship's engines.



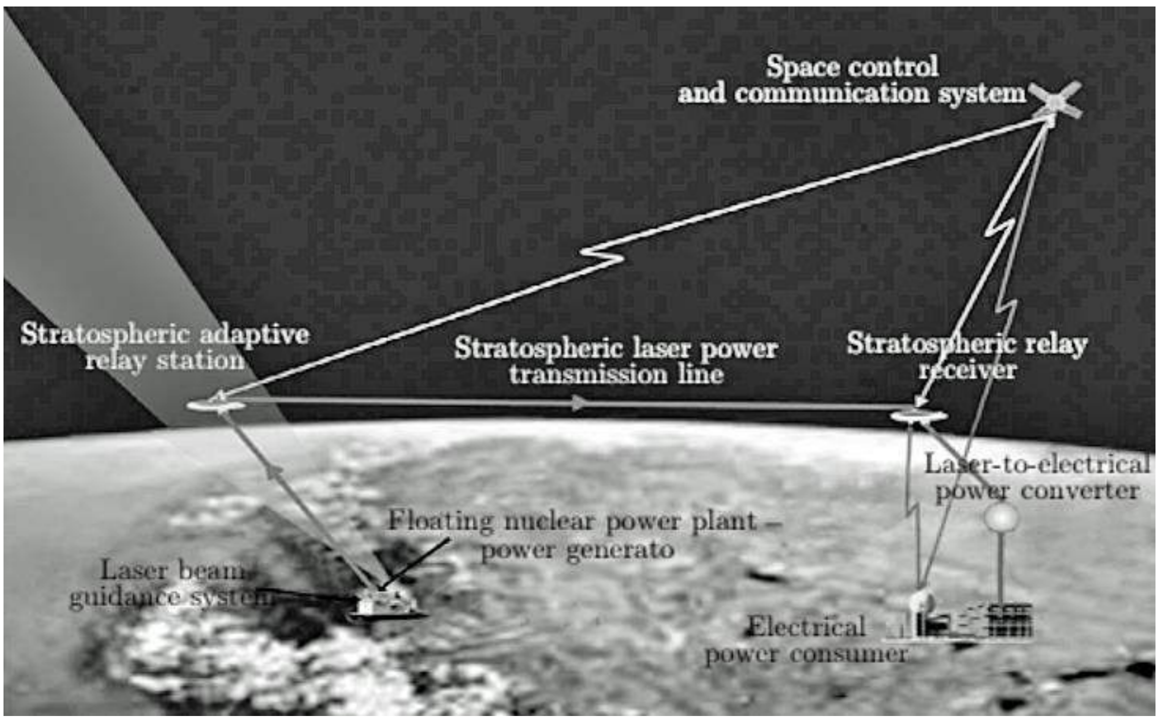
General exterior arrangement of the rigid airship in the computational model.
Source: Aleksandr Kirilin, et al. (2016)



Schematic illustration showing the airship's rigid structure and the array of hull anti-icing system manifolds. Source: Aleksandr Kirilin, et al. (2015)

9. Stratospheric airship for laser power transmission

In 2012, Kishko and Matyukhin described the operation of a stratospheric airship-based laser power transmission system (LPTS) for moving power from a terrestrial electric power station to a remote terrestrial site that requires electric power. Between those to points, orbital spacecraft provide a system control function and stratospheric airships operating at 16 – 32 km (52,500 – 105,000 ft) altitude serve as nodes in a laser energy transmission network, as shown in the following diagram.



LPTS network concept. Source: Kishko & Matyukhin (2012)

In simple terms, the energy transmission system operates as follows:

- A ground based power plant generates the electric power needed to operate a system of many powerful lasers. Their optical beams are merged and focused on a photovoltaic (PV) array on a large stratospheric airship (a "stratospheric adaptive relay station").
- On this relay station, the PV array converts the incident laser energy to electrical energy that powers another laser to forward the energy to another similarly equipped stratospheric airship,

forming a “stratospheric laser power transmission line.” Alternatively, the laser could deliver power to a user facility on the ground and within the field of view from the stratospheric airship (and not at too oblique an angle to create a long laser transmission path through the atmosphere).

- One or more “jumps” (PV receive-convert-laser transmit cycle) may be required before the energy can be delivered as electric power to a distant user on the ground.

For this type of system, laser efficiency (laser beam power out / electric power in) in the range of 30% appears to be feasible.

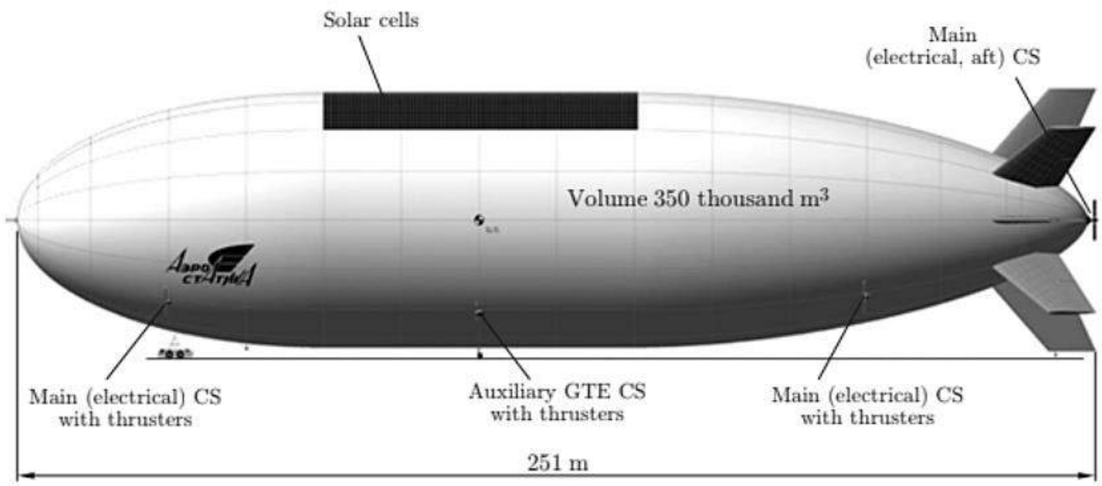
Regarding PV energy conversion performance, the authors claimed:

> “Laser radiation energy can be efficiently converted to electrical energy using photovoltaic cells (PVCs)….. Providing high performance of photovoltaic conversion of incident laser radiation over a wide range of its intensity is a major practical problem. In a real GaAs (gallium arsenide)-based PVC optimized for moderate-intensity (0.1–1.0 W/cm^2) laser radiation (λ = 0.8 μm), an efficiency of 40–43% was obtained.”

That’s for just one “jump” along the energy transmission network. System end-to-end energy transmission efficiency will be quite low.

In their paper, Kishko and Matyukhin described the following large stratospheric airship design from Aerostatica, which is slightly longer than the Hindenburg LZ-129, with 75% greater envelope volume.

This stratospheric airship was not built.



Aerostatica stratospheric airship concept. For the LPTS mission, the airship presumably would steer a course and roll so the PV array would be perpendicular to the direction of the incoming laser beam. (CS stands for control system; GTE for gas turbine engine). Source: Kishko & Matyukhin (2012)

General characteristics of the Aerostatica stratospheric airship

Parameter	**Aerostatics stratospheric airship**
Length, overall	251 m (823.5 ft)
Length, envelope	248.5 m (815.3 ft)
Diameter, max	50 m (164 ft)
Height, overall	53 m (173.9 ft)
Envelope fineness ration (L/D)	5.0
Envelope volume	350,000 m^3 (12,360,000 ft^3) in 13 gas cells
Propulsion	• 1 x stern electric motor-driven main propulsion propeller • Fore and aft pairs of electric motor-driven thrusters • Mid-ships pair of gas turbine-driven auxiliary thrusters
Payload	1,000 kg (2,205 lb)
Power consumed by payload	No less than 1 kW
Operating altitude	19 – 21 km (62,336 – 68,898 ft)
Speed, max	• 30 m/s @ 20 km (108 kph / 67 mph) • 25 m/s near the ground (90 kph / 56 mph)
Mission duration	30 days
Range of remote airship control	150 km (93.5 miles)

10. For more information

- Robert Recks, "A Practical Guide to Building Small Gas Blimps," CreateSpace, ISBN 0-937568-28-7, Revised 1997
- Yu.S. Boyko, "Aeronautics: Tethered, Free, Managed," pp. 397 – 399 (in Russian), ISBN 5.8122-0233-8, Publishing house MGUP, Moscow, Russia, 2001
- Arnold Nayler, "Airships Today – 2004," Airship Association, Ltd.: http://www.aerall.org/docs-colloque2004/intervention_Arnold-NAYLER.pdf
- V.I. Kishko & V.F. Matyukhin, "Principles of Designing Adaptive Relay Systems for Stratospheric Power Transmission," Optoelectronics, Instrumentation and Data Processing, Vol. 48, No. 2, 2012: https://vdocuments.net/principles-of-designing-adaptive-relay-systems-for-stratospheric-power-transmission.html
- Aleksandr Kirilin, "Do new Generation Airships Change a Paradigm in Transport Logistics?," Aeronautical Enterprise "Aerostatica," paper presented at the 10th International Airship Convention, Friedrichshafen, Germany, Document ID: 380017, 2015: http://www.dglr.de/publikationen/2015/380017.pdf
- Aleksandr Kirilin, et al., "Thermal Calculation of Airship Hull Protection from Snow," Global Journal of Pure and Applied Mathematics, Volume 12, Number 1, ISSN 0973-1768, pp. 603-615, 2016: https://www.ripublication.com/gjpam16/gjpamv12n1_56.pdf
- "Modern Russian Aircraft: Part 1," avon-62: https://avon-62.ru/en/finansy/dirizhabl-v-nashe-vremya-boevye-dirizhabli-prikroyut-rossiyu-ot-raketnogo/
- "The history of the invention and the principle of operation of airships. How to build an airship? What is an airship? Are they needed in the modern world?" Airship Komsomolskaya Pravda, Ukuytdom-NN: https://ukuytdom-nn.ru/en/istoriya-izobreteniya-i-princip-deistviya-dirizhablei-kak-postroit-dirizhabl/
- Alastair Reid, "Russian Airships – An Illustrated History in English," 2016, self-published and available thru Lulu: https://www.lulu.com/it/it/shop/alastair-reid/russian-airships/paperback/product-1km4n9zw.html?page=1&pageSize=4

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
  - Augur RosAeroSystems
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/