Thermoplan hybrid thermal airships

Peter Lobner, 3 April 2021

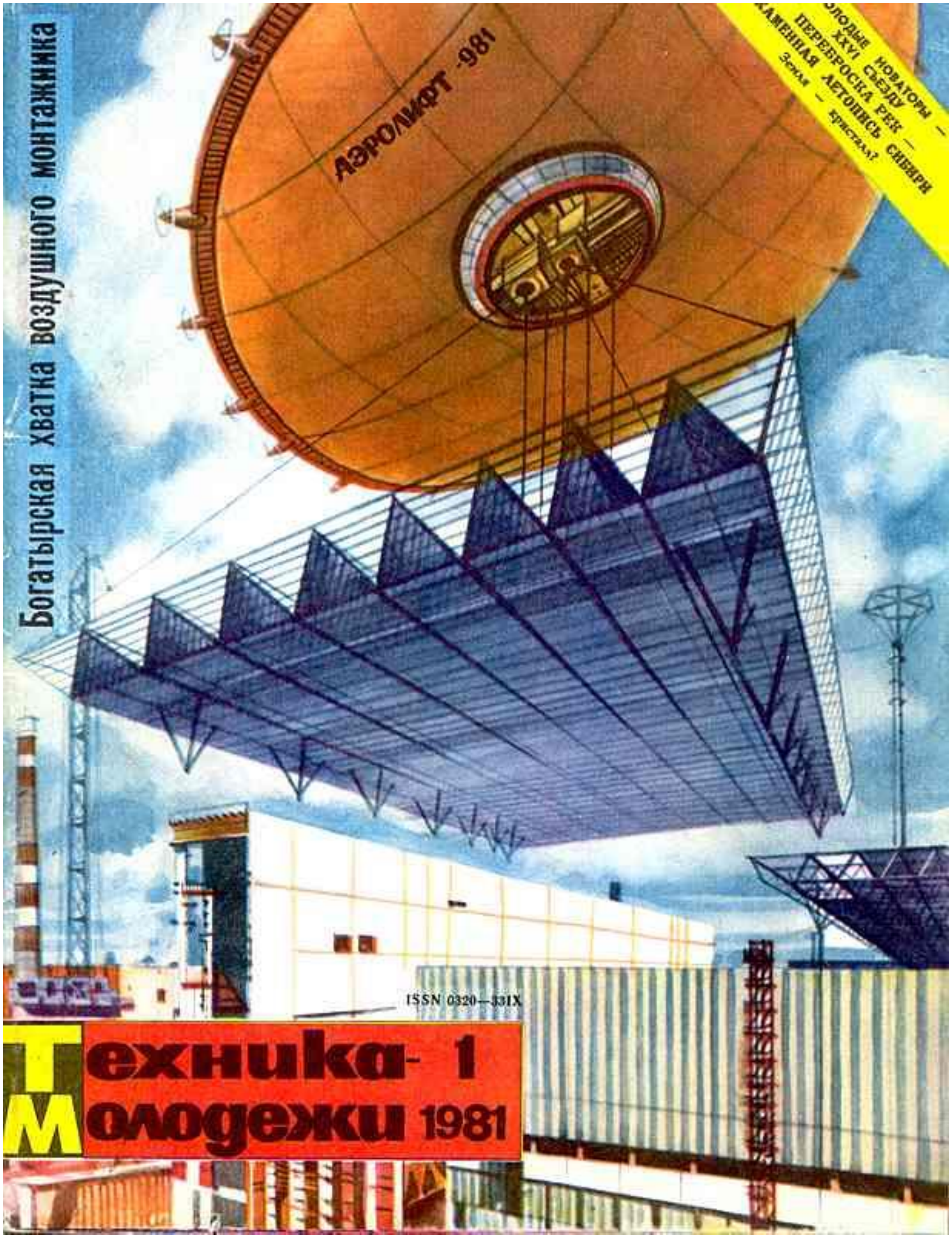
1. Introduction

The Thermoplane was a lenticular, heavy-lift, hybrid airship that generated its aerostatic lift from the combined effects of helium lift gas and hot air. With helium alone the airship was semi-buoyant (heavier-than-air). Buoyancy was managed by controlling the heating and cooling of air in a "thermal volume" within the broad, rigid, saucer-shaped hull, which was nicknamed the "Soviet UFO."

This buoyancy control concept was developed and applied in the 1700s in hybrid balloons designed by Jean-François Pilâtre de Rozier. Such "Rozier" balloons have separate chambers for a non-heated lift gas (hydrogen or helium) and a heated lift gas (air).

The Thermoplane was intended to carry heavy loads from bases or remote sites without a mooring mast, operating year-round, including during severe winter weather in Siberia. Candidate applications included hauling timber, oil exploration and development equipment, and other heavy industrial loads. Other applications included serving as an emergency evacuation vehicle (for sea disasters, earthquake relief etc.), a firefighting aircraft, a mobile hospital and a flying tourist hotel.

The project was started in the late 1970s at the Moscow Aviation Institute (MAI), with a small team led by chief designer Yuri Ishkov, with scientific direction from Sergey Eger. With help of MAI director Yuri Ryzhov, the team obtained support from Gazprom in the mid-1980s and formed Design Bureau "Thermoplan" at the production site of the Ulyanovsk Aviation Production Complex (later known as the Aviastar Industrial Complex) at Simbirsk, about 500 km (311 miles) east of Moscow. The designs for the production Thermoplane and a 1/5th scale prototype, the ALA-40, were finalized in 1989, near the end of *perestroika* in the Soviet Union.



This 1981 Soviet magazine illustration entitled, “The hero grip of the airship,” looks like a full-scale Thermoplane delivering a heavy construction load from a hover. Source: Soviet magazine “Technology for the Youth,” 1981, Issue 1.

2. Managing buoyancy and conducting load exchanges

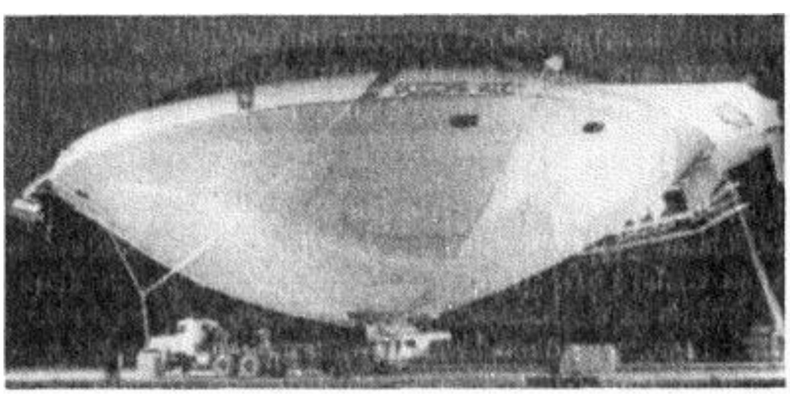
The Thermoplan is a variable buoyancy, hybrid thermal airship that generates aerostatic lift from the combined buoyancy of a fixed amount of helium lift gas and hot air at a variable temperature in separate chambers within the hull. The designers called this an "unballasted" airship (i.e., it did not need to take on or discharge external ballast during a load exchange). This also is called "thermo-ballasting." With helium alone the airship is semi-buoyant (heavier-than-air).

Load exchanges would be conducted as follows:

- To pick up a load, the neutrally buoyant airship hovers and connects to a load on the ground. Then the air in the thermal volume is rapidly heated to increase gross lift enough to establish positive buoyancy at the higher gross loaded weight. The loaded airship lifts off and proceed to the delivery site.

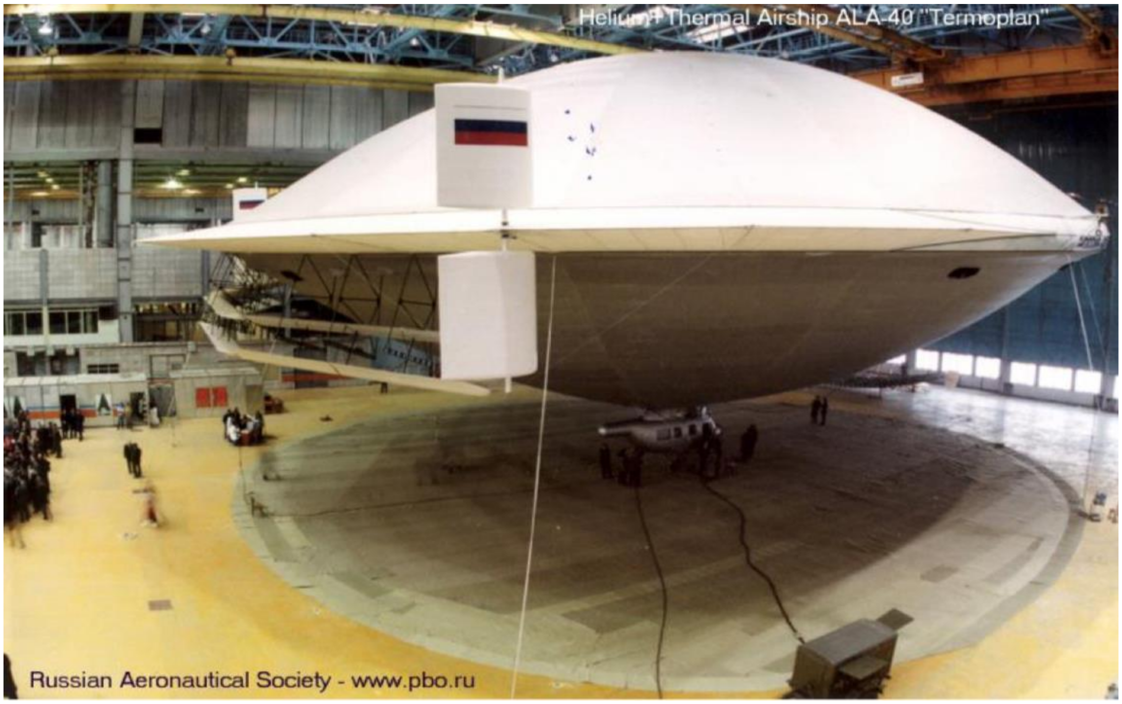
- To drop off a load, the neutrally buoyant airship establishes a hover over the delivery site and slowly descends to place the load on the ground. Hot air in the thermal volume is vented and ambient cool air is introduced in the correct proportions to decrease gross lift during a hover and allow the weight of the load to be transferred to the ground. Then, the unloaded, neutrally buoyant airship can disconnect the load and proceed to its next destination.

3. The 1/5-scale prototypes, ALA-40



The first prototype, ALA-40-01, was constructed at the Ulyanovsk Complex, completed in early 1992 and rolled out on 28 August 1992.

Profile view, bow is at left. Source: Bashny.net



The ALA-40-01 rear quarter view in its hanger at the Ulyanovsk (Aviastar) Complex. Source: Russian Aeronautical Society

Close-up of ALA-40-01 aerodynamic control surfaces & extended equatorial fairing at the stern. Source: Russian Aeronautical Society

Wide-angle view of the ALA-40-01 and dignitaries posing under the stern of the airship. Note the extended equatorial fairing above the control surfaces. Source: http://topsecretairplanes.blogspot.com/

Front view of the ALA-040-01 during roll out. Source: avon-62

Stern view of the ALA-040-01 as it was rolled out of its hanger for the first time to conduct field trials. Source: YouTube screenshot


Close-up of the stern control surfaces on the ALA-040-01. Source: YouTube screenshot

The ALA-040-01 gondola was the fuselage (minus the tail) of a Mil Mi-2 helicopter. The exhaust from the 2 x Klimov GTD-350 turboshaft engines served to heat the air in the thermal volume*.*
Source: YouTube screenshot

The Vedeneyev M14P air-cooled radial engine mounted on the nose of the ALA-40-01 provided propulsion and the engine exhaust served to heat the air in the thermal volume. *Source: YouTube screenshot*

The ALA-40-01 prototype never took off. It has been reported that, during a celebration banquet after the roll-out, the prototype, "was shaking with the wind and it was beating against the hangar." Immediate efforts failed to stabilize the craft, the shell deformed and ruptured due to the effects of the wind, the helium cell was damaged and the helium released, and the airship structure collapsed over the gondola. The remains of the first prototype were stored at the Ulyanovsk Complex until 2008 when they were recycled. The damaged torus and other parts were used to build a catamaran boat.

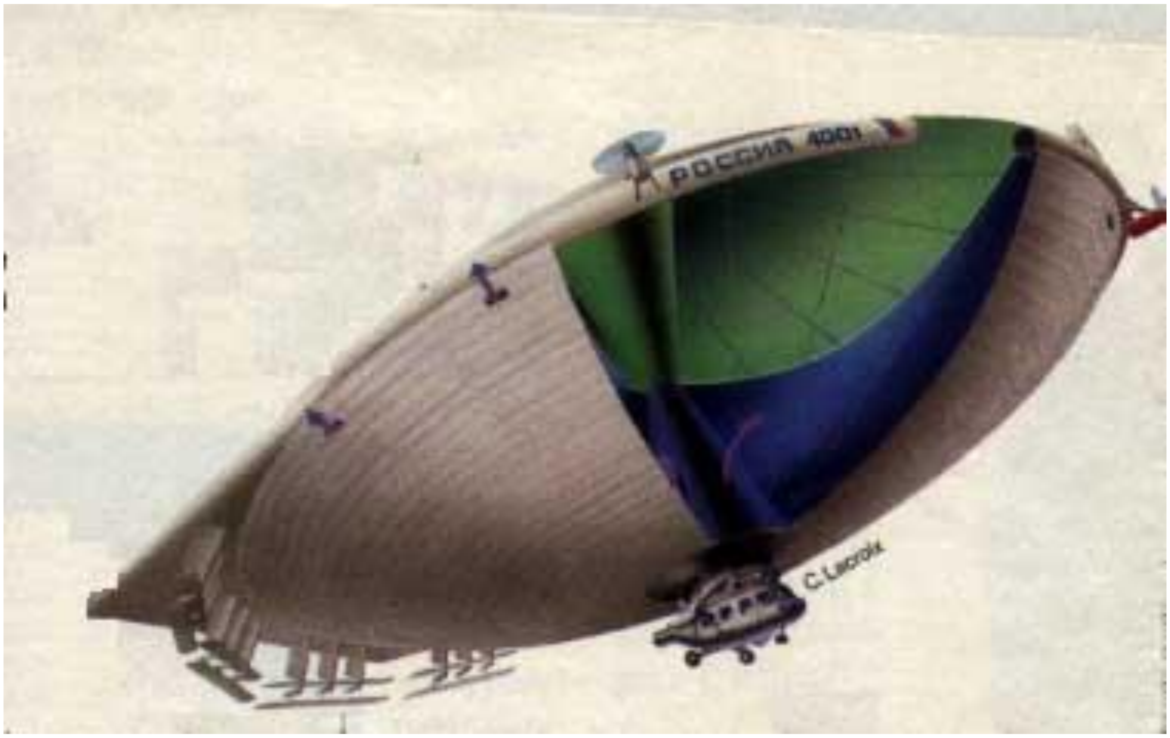
Originally, three 1/5th scale prototypes were planned. After the first prototype was destroyed, the project was placed on hold due to the economic crisis in the Russian Federation in the early 1990s. The second prototype (ALA-40-02) was started in 1995, but lack of funding stopped construction.

Basic parameters for the ALA-40-01 prototype were as follows:

- Diameter: 40 meters (131 feet)
- Envelope: Thermoplastic with carbon fiber reinforcement based on Torlon
- Volume: 10,660 cubic meters (376,450 cubic feet), containing two compartments, one for helium and one for hot air.
    - One 5,800 cubic meters (204,825 cubic feet) sealed compartment for helium at the top of the envelope
    - One 4,860 cubic meters (171,629 cubic feet) compartment at the bottom of the envelope functioned as a thermal volume (*termoobema*), containing hot air that was heated by the high temperature exhaust from the propulsion engines
- Engines:
    - 2 x Klimov GTD-350 gas turbine turboshaft engines (400 hp each) provide air heating only
    - 1 x Vedeneyev M14P air-cooled radial engine (360 hp) provides propulsion and air heating
    - 2 x EDUVT motors for vertical propulsion (50 h.p. each)
- Payload: 3 metric tons (some sources claim 5 – 6 metric tons)
- Crew / passengers: 2

The exhaust gases from the engines flowed directly into the thermal volume inside the hull. This arrangement had the potential to cause operational problems:

- Maximum exhaust gas temperature was about 700° C, creating a significant risk of damaging composite structures or burning through the shell.
- Soot from the engine exhaust deposited inside the hull and would have required regular cleaning.



Rendering of the ALA-40 in flight. Source: jb.aeronef

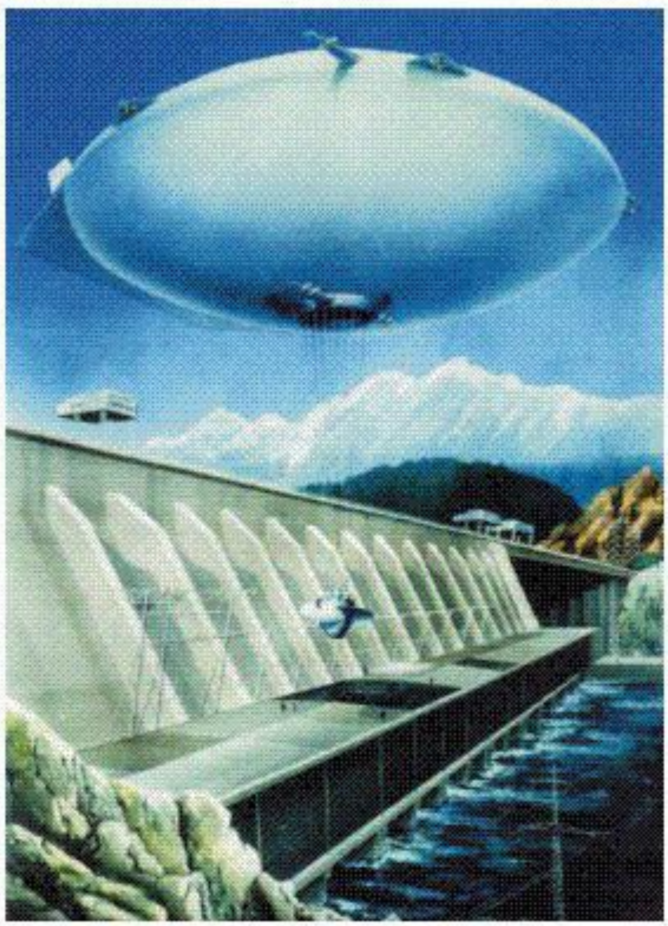
4. Plans for production versions of the Thermoplane

After the design had been validated with the subscale prototypes, the original plan was to build the first production model, known variously as the ALA-200 and the ALA-600, with the following basic characteristics:

- Diameter: 200 meters (656 feet)
- Payload: 600 metric ton (660 ton) cargo or up to 1,500 passengers
- Range: 5,000 km (3,107 miles)
- Cruise speed of 140 kph (87 mph).

The heating of an air volume equivalent to 40% of the total volume of the envelope is done by recovering the exhaust gases from the turboprop engines used for propulsion.

Rendering of the ALA-200 & ALA-40, with the fuselage of an An-124 transport aircraft as the ALA-200's gondola. Source: jb.aeronef



Concept drawing of a heavy-lift Thermoplane delivering a large component at a hydroelectric dam site. Source: Bashny.net

The original target date for ALA-200/600 first flight was 1995. After the ALA-200/600, the designers intended to develop a whole family of lenticular Thermoplanes with different carrying capacities, for example, 100, 300, 600 and 1,500 metric tons of cargo (or 500, 800, 1,200 and 2,000 passengers, respectively), and cruise speeds up to 200 kph (124 mph). A full-scale Thermoplane was not built.

5. Thermoplane legacy

Thermoplane led to the development in Russia of two other hybrid thermal airships with similar operating principles and lenticular designs, the LocomoSkyner developed by the firm LokomoSky in Ulyanovsk and the Aerosmena developed by Russian engineer Orpheus (Orfey) Kozlov.

These Russian airships are addressed in separate articles.

6. For more information

- "Modern Russian Aircraft: Part 1," avon-62: https://avon-62.ru/en/finansy/dirizhabl-v-nashe-vremya-boevye-dirizhabli-prikroyut-rossiyu-ot-raketnogo/
- L. P. Ponyaav, et al., "New Arctic air transportation with hybrid electrical disc-shaped airship and body plane aircraft innovation," 2020 IOP Conference Series: Earth Environmental Science, 539 012134: https://iopscience.iop.org/article/10.1088/1755-1315/539/1/012134/pdf

7. Videos

- "ALA-40 Thermoplane - 'Flying Saucer' Airship," (0:56 min): https://www.youtube.com/watch?v=szasukfWXTU
- "Russian UFO ALA-40 (1992)," (0:54 min, silent): https://youtu.be/Oruen8Zt7_c
- "UFO from Russia," (8:01 min, Termoplan starts at about 1:35 min), Russia Today: https://youtu.be/BbNv8PJ5SdI