Kamov Company – Aerolet hybrid airships

Peter Lobner, 11 February 2022

1. Introduction

In 1979, the Nizhnaya Salda design bureau, located in the Urals region of Russia, became part of the Ukhtomsk helicopter plant (named after N.I. Kamov), located about 1,860 km (1,156 miles) away in Lubersy, southeast of the Moscow city center. From 1979 to 1983, this combined project team developed design concepts for a family of hybrid airships under the leadership Lenin Prize laureate I.A. Erlikh, who named the airship family "Aerolet."

This article provides an overview of the Aerolet A-30, A-80 and A-150 designs described by Russian aeronautical engineer and author Y.S. Boyko in his 2001 book "*Aeronautics: Tethered, Free, Managed*."

2. The business case for the Aerolet

The main purpose of the Aerolet airships was to transport bulky cargo into isolated areas that lacked reliable transportation by other means because of difficult natural conditions (i.e., mountainous terrain, swamps, tundra, permafrost). The goal was to establish reliable commercial links between the isolated regions and the industrialized regions of the country.

Industries and activities in the isolated regions include:

- Timber harvesting and processing
- Oil, gas and mineral exploration
- Mining
- Mineral processing
- Oil & gas production field development and operation
- Pipeline construction
- Gas compressor and oil pumping station operation and maintenance
- Electric power transmission line installation
- Road and railway construction

These industries require large volumes of cargo, including some heavy, indivisible loads. For example:

- Construction of a drilling rig can require 1,000 to 1,500 metric tons (1,100 to 1,650 tons) of cargo, with individual items weighing up to about 20 metric tons (22 tons).
- Construction of compressor and oil pumping stations can require 50,000 metric tons (55,000 tons) of cargo, with individual items weighing 50 – 60 metric tons (55 to 66 tons).

In addition, logistical support for communities and base camps for the labor force and families in these remote regions creates additional transportation and cargo demands. Rescue and emergency services also may be required on occasion.

This target market established a strong business case for developing the Aerolet family of hybrid airships.

3. Aerolet design

<u>Design criteria</u>

Based on the business case, the design criteria for the Aerolet airships included the following:

- Must be "ballastless" (i.e., Must be able to take off, land and exchange cargo without having to take on or discharge passive ballast such as sand or water).
- Must be made only of domestic materials and equipped with domestic engines and equipment.
- Must have a higher economic efficiency relative other types of aviation technology (i.e., helicopters, fixed-wing aircraft).
- Must be able to operate from unprepared sites.
- Flight range must be at least 2,000 km (1,243 miles).
- Airspeed speed must be at least 130 kph (80.1 mph).
- Must be able to operate with a large sling load, making load pickups and deliveries from a hover.

- Must have maneuverability sufficient for operating as a flying crane in a near-ground turbulent layer of air.
    - Hover over a designated point in windy conditions.
    - Provide positional accuracy of 0.2 to 1.5 m (0.7 to 4.9 ft).

Rigid airframe

Aerolets were rigid airships with a conventional airframe structure consisting of transverse frames and longitudinal stringers reinforced with braces. A load-bearing service passage ran along the keel of the hull from the bow lateral control unit, through the crew cabin area and the cargo compartment, all the way to the aft power plant in the tail section. This passageway through the keel provided access to airship systems and cargo during flight.

Two large transverse rigid beams passed through the center section of the hull to support the "lifting-lowering" rotors, vertical control rotors and their engines. Passageways through these beams provided in-flight access to the engines, gearboxes and other related equipment.

The airframe had a conventional cruciform tail with hydraulically operated rudders and elevators. The rigid airframe and tail surfaces were covered with a durable fabric outer skin that gave the airship its smooth aerodynamic contours.

The crew cabin was installed under the nose of the airship. The cabin accommodated six crewmembers and contained the airship control systems and communications, electrical and navigation equipment.

The mooring unit used to engage a mooring mast was installed under the nose of the airship, forward of the crew cabin. Fuel filling, ballast fluid injection, lifting gas filling, electrical, hydraulic and other systems were connected to ground-based systems through the mooring mast.

The three-point landing gear, consisting of a single nose gear behind the cockpit and two main landing gear aft of the center-of-gravity, transferred static and dynamic landing loads directly into the rigid airframe. In addition, there was a single support strut at the tip of the ventral tail fin.

Propulsion and control systems

The Aerolet hybrid airships were lighter-than-air when empty and required water ballast when parked between missions.

In operation, aerostatic lift provided between 77 to 80% of the lift needed when the Aerolet was loaded to its takeoff weight. The principle of “ballastlessness” was implemented with powerful rotor systems that provided the control and dynamic thrust needed to compensate for the mass of the cargo loaded (i.e., making the airship heavier-than-air) or removed (i.e., making the airship lighter-than-air) during a mission. With this range of dynamic thrust, the Aerolet did not require a ballast exchange during a mission.

The Aerolet A-30, A-80 and A-150 airships had six to eight turboshaft engines installed in three blocks: “front,” “middle” and “aft.” All Aerolet models used Kilmov TVZ-117VK turboshaft engines in the front and aft blocks. The A-80 and A-150 substituted the more powerful Ivchenko D-136 turboshaft engine for the TVZ-117VK in the middle block of engines.

An Aerolet had four propeller / rotor systems:

- **Main propulsion propellers:** Reversible pitch, tail-mounted coaxial propellers provided longitudinal thrust for propulsion in forward flight and for fore / aft control during slow-speed maneuvering and hover.
- **Lateral control propellers**: Two reversible pitch shrouded propellers, one installed at the nose and the other in the ventral tail fin, provided yaw (left / right) control by generating a turning moment about the vertical axis of the airship during slow speed maneuvering and hover, when aerodynamic controls are not effective.
- **Vertical control rotors:** Two reversible pitch rotors installed amidships, aft of the center-of-buoyancy and in the plane of the horizontal stabilizer (tail fin), provided pitch control by generating a moments about the transverse axis of the airship during slow-speed maneuvering and hover.
- **“Lifting-lowering” rotors:** Two large, vertical, reversible pitch rotors installed amidships, near the center-of-buoyancy, created

the dynamic vertical force (up / down) needed to operate the airship in a light or heavy condition.

- In a heavy condition, the lifting-lowering rotors provided dynamic lift during takeoff, ascent, descent and landing. After transitioning to forward flight, aerodynamic lift would partially or completely unload the lifting-lowering rotors.
- In a light condition, the lifting-lowering rotors provided the dynamic downforce needed to hold the airship on the ground and to balance excess buoyancy during ascent, forward flight, descent and landing. A limit on flight speed may be needed to maintain aerodynamic lift in a range that could be managed by the lifting-lowering rotors.

The lifting-lowering rotors had swashplates, like a helicopter main rotor, to control their thrust vectors in the longitudinal and transverse directions.

Each lifting-lowering engine nacelle contained the engine, a main gearbox that transfers power from the engine to the rotor, an air start system and a fire suppression system. The two main gearboxes were connected by a synchronizing shaft, which significantly increases flight safety, since, in the event of an engine failure on one side, power would be transferred from the operating engine to drive both lifting-lowering rotors.

While hovering and in flight speeds below of 70 kph (43.5 mph), when the elevators and rudders were ineffective, lateral forces and control moments were generated by the lateral control propellers and vertical control rotors. In this operating regime, the Aerolet was expected to exhibit controllability similar to a modern helicopter. At speeds above 70 kph, the control propellers and rotors were turned off and their functions were performed by the conventional elevators and rudders.

The airship had a four-channel fly-by-wire flight control system with 3-out-of-4 control logic. Flight controls were executed by electro-hydraulic actuators on the rotors / propellers and the aerodynamic flight control surfaces (rudders and elevators) on the tail. The hydraulic systems that supplied power to the actuators were double redundant.

Cargo handling systems

Aerolet hybrid airships could carry cargo in an internal cargo compartment located under the center-of-buoyancy, at the bottom of the airship. Loading was done through a large access hatch. To facilitate loading, roller tables were mounted on the floor of the cargo compartment.

Rails for crane equipment were installed along the ceiling of the cargo compartment, supported from the rigid keel structure. A hatch in the central part of the cargo compartment floor allowed the load suspension cable to be extended to an external sling load, which was engaged by a semi-automatic sling load gripping device and stabilized and oriented with additional external cargo handling devices.

The Aerolet was capable of depositing its suspended load at a destination with a maximum landing speed of 0.3 to 0.9 m / s (1.0 to 3.0 ft/sec).

Anti-icing systems

To permit operation in icing conditions, particularly in Arctic winter conditions, the Aerolet airships were equipped with the following anti-icing systems:

- An air-thermal system for the nose fairing, lifting-lowering rotors and the tail fins. Hot air taken from the engine compressors was directed into channels under the surfaces being protected from icing.
- An electro-thermal system for the lateral and vertical control propellers / rotors and the stern propellers. Electric heating elements were embedded under the surfaces being protected from icing. The source of electricity was the on-board 220 V /115 V AC power system operating at a frequency of 400 Hz.
- Electrically heated glazing was installed in the crew cabin windows.

Rendering of an Aerolet 150 in flight. Note the tail-mounted coaxial propulsion propellers, the port-side vertical control rotor amidships (aft), the "lifting – lowering" rotor amidships (forward), and the lateral control propellers in the nose and tail fin. Source: Boyko (2001)

General characteristics of the Aerolet A-30, A-80 and A-150

Parameters	**A-30**	**A-80**	**A-150**
Geometric parameters:			
Volumetric air displacement	30,000 m^3 (1,060,000 ft^3)	80,000 m^3 (2,825,000 ft^3)	150,000 m^3 (5,300,000 ft^3)
Volume, lifting gas	28,500 m^3 (1,006,500 ft^3)	76,000 m^3 (2,684,000 ft^3)	139,600 m^3 (4,930,000 ft^3)
Length	102 m (334.6 ft)	140.5 m (461.0 ft)	178 m (584.0 ft)
Height	27 m (88.6 ft)	39.5 m (129.6 ft)	44 m (144.4 ft)
Width	55 m (180.4 ft)	66 m (216.5 ft)	84 m (275.6 ft)
Diameter of coaxial stern propellers	8 m (26.2 ft)	11.7 m (38.4 ft)	17 m (55.8 ft)
Diameter of lateral control propellers	4 m (13.1 ft)	5 m (16.4 ft)	8 m (26.2 ft)
Diameter of vertical control rotors	2.5 m (8.2 ft)	3 m (9.8 ft)	4.5 m (14.7 ft)
Diameter of lifting-lowering rotors	11 m (36.1 ft)	16 m (52.5 ft)	22 m (72.2 ft)
Power plants:			
Front block: TVZ-117VK @ 1,620 kW (2,172 shp)	1	1	1
Middle block: TVZ-117VK @ 1,620 kW (2,172 shp) Middle block: D-136 @ 8,400 kW (11,265 shp)	4 0	0 2	0 4
Aft block: TVZ-117VK @ 1,620 kW (2,172 shp)	2	2	3
Weight at an altitude of 500 m (1,640 ft):			
Takeoff weight	34.3 MT (37.8 ton)	95.1 MT (104.8 ton)	172 MT (190.0 ton)
Weight of the structure	24.3 MT (26.8 ton)	51.5 MT (56.8 ton)	86.5 MT (95.3 ton)
Payload	8.7 MT (9.6 ton)	38.2 MT (43.1 ton)	83 MT (91.5 ton)
Aerostatic lift (about 77 to 80% of takeoff weight)	27.1 MT (29.9 ton)	73.4 MT (80.1 ton)	138 MT (152.1 ton)
Flight characteristics:			
Speed, max.	140 kph (87 mph)	140 kph (87 mph)	140 kph (87 mph)
Speed, cruise	130 kph (80.7 mph)	130 kph (80.7 mph)	130 kph (80.7 mph)
Range	500 km (311 mi)	2,000 km (1,243 mi)	2.200 km (1,367 mi)

Source: Boyko (2001)

4. Plans for Aerolet fleet deployment

No infrastructure existed to support deployment of Aerolet airships.

A plan was developed for establishing regional aeronautical bases in some promising remote regions of the country. Each base would include an airfield with stationary or mobile mooring masts for berthing the airships outdoors, one hangar for performing airship major maintenance and repair work, lifting gas storage with cleaning systems, ground support equipment, handling equipment, and ballast carts and tanks. The mooring mast was designed to secure an airship in winds up to 40 meters/sec (144 kph / 89.5 mph) with lateral gusts up to 8 meters/sec (28.8 kph / 18 mph).

Y.S. Boyko reported that an economic analysis of the Aerolet was performed in the early 1980s using a method approved by the USSR Provisional Scientific and Technical Commission of the State Committee for Science and Technology. This analysis estimated the technical and economic efficiencies of an Aerolet fleet relative to existing Russian transport helicopters (Mi-8T, Mi-10, Mi-26) and fixed-wing aircraft (An-12 and Il-76), and sought to determine the appropriate areas for application of these airships in the national economy. For this analysis, the following Aerolet operating parameters were assumed.

- Airship flying hours per year: 1,500 hours
- Airship service life: 30,000 hours or 15 years
- Gas envelope service life: 5 years
- Number of major indoor overhauls and engine services: 2
- Ground complex service life: 25 years
- Aircraft crew size: 6 people
- Airship fleet size: 15

The cost of the first serially-produced A-80 airship was estimated to be 6.5 million rubles ($9.1 million USD).

In spite of their impressive capabilities, no Aerolet hybrid airships were produced.

5. For more information

- Yu.S. Boyko, "Aeronautics: Tethered, Free, Managed," pp. 400 to 407 (in Russian), ISBN 5.8122-0233-8, Publishing house MGUP, Moscow, Russia, 2001

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