Land monitoring and cartographic surveys using aeronautical aids

E A Lukyanova¹, K Yu Zhigalov², M S-U Khaliev³

¹Irktuk National Research Technical University, 83, Lermontov str., Irkutsk, 664074, Russian Federation
²V. A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, 65, Profsoyuznaya Street, Moscow, 117997, Russia
³Chechen State University, 17а, Dudaev Boulevard, Groznyy, 364015, Russia

E-mail: lukirgtu@yandex.ru

Abstract. Nowadays there are many tasks, the implementation of which can be fully or partially assigned to aerostatic balloons, as to air laboratories. This paper analyzes the existing types of balloons and possible tasks for their use. The possibilities of using this technique for monitoring lands and for carrying out cartographic research are shown. During the course of the research of the material of this paper, the disadvantages of the use of aerostatic balloons were also found. They are also described in this paper, and possible options to overcome them are given. This article shows potential ways to eliminate the shortcomings of the described air technology when conducting cartographic research and solving monitoring problems.

1. Introduction
Aerostatic balloons were the first devices that allowed a person to travel in the air and subsequently reach the stratosphere. However, their use has declined dramatically in recent years.

Today science is quite strongly commercialized and the costs of laboratories and their maintenance are quite limited. At the same time, there are a number of tasks that require lifting a set of equipment to a height both for single tests and for periodic use [1, 2, 7]. In this context, there is a reasonable proposal to use the cheapest methods of delivery and hold the useful load at a certain height for some time. This, among other things, solves the problem of emissions of harmful substances in transport [9, 10].

2. Modern state of the industry
Today, the main developers and consumers of balloons are military organizations and meteorological services. At the same time, meteorological services mainly use non-reusable balloons and military experiments are usually classified. Moreover, in Russia, strato-laboratories have already begun to appear. They are engaged in research at high altitudes [3, 8].

Nevertheless, today balloons can be successfully used for:
- meteorological services to perform experiments and obtain data on the state of the stratosphere using expensive equipment;
- initial experiments on the behavior of substances in space (without orbital launching using launch vehicles);
- Experiments on launching small satellites from the stratosphere;
- Aerial photography for the creation of various kinds of GIS [4];
- Works on signal retransmission;
- Refueling stations.

According to our experiments, we can conclude on the following achieved characteristics of balloons:
- maximum lifting height is up to 45 kilometers;
- maximum altitude hold time is up to 5 hours
- useful lifting load is up to 300 kg at an altitude of 45 km and 2000 kg at an altitude of 36 km;
- partial possibility of remote control is up to an altitude of 45 km.

More detailed variants are presented in Table 1.

Table 1. Variants of the relation between the main characteristics of balloons

| Envelope volume (m³) | Balloon mass (kg) | Mass of useful load (kg) | Total mass (kg) | Flight height (km) |
|---------------------|-------------------|--------------------------|-----------------|-------------------|
| 2200                | 21                | 7                        | 28              | 30                |
| 5200                | 130               | 1800                     | 1930            | 10                |
| 10000               | 67                | 50                       | 117             | 35                |
| 16000               | 93                | 100                      | 193             | 35                |
| 20000               | 65                | 60                       | 125             | 36                |
| 30000               | 185               | 700                      | 885             | 30                |
| 34000               | 98                | 120                      | 218             | 36                |
| 130000              | 750               | 1400                     | 2150            | 30                |
| 170000              | 280               | 120                      | 400             | 43                |
| 180000              | 650               | 2000                     | 2650            | 36                |
| 309000              | 320               | 210                      | 530             | 45                |
| 600000              | 820               | 300                      | 1120            | 45                |

Let us consider various cases of use in detail.

In order to perform experiments and obtain data on the state of the stratosphere with the help of expensive equipment, we use balloons capable of flying to an altitude of more than 35 km. To increase the time a balloon stays at altitude and to optimize useful load, the descent is carried out by parachute. This allows lifting equipment to the altitude of 36–45 km and taking measurements for 24 hours, after which a balloon rises above the planned one, an outer balloon collapses and a balloon descends by parachute. The equipment is protected from damage by a dome-type parachute. Then the direction finding device is turned on to search for equipment using GLONASS / GPS signals [5]. We are developing a system that can automatically return equipment due to the use of a hexocopter on board, which minimizes the factor of its theft or getting into water / trees.

In the context of initial experiments on the behavior of substances in space, balloons allow lifting equipment to a height and holding them there for 24 hours. Simultaneously the experiments are carried out remotely in a specially prepared laboratory under conditions of lower gravitation and low atmospheric density.

Aerostatic balloons are also used to carry out the experiments to launch small satellites from the stratosphere. It is necessary to note, launches from the stratosphere are possible theoretically, for example, the project of Elon Musk on suborbital flights. We propose to carry the carrier-vehicle to the maximum altitude with the help of balloons and carry out launches there. The orbital launch of large heavy vehicles is practically impossible this way, but it is theoretically possible to launch small ones. For these purposes, we have created a specialized complex for lifting solid-propellant vehicles weighing up to 270 kg. Today, this allows low orbital launching of a useful mass of up to 50 kg. Today, the main obstacle to the increase of the mass of a vehicle is the need to create a nozzle.
temperature of more than 1000 degrees to start the engine. Today design developments are being carried out in the direction of self-heating solid-propellant engines for missiles.

Aerostatic balloons can be used in aerial photography for the creation of various kinds of GIS. It is known that it is rather difficult to obtain satellite images in the required resolution for some territories, it is expensive and there is no required optical resolution [6]. As a result, the images taken at an altitude of 45 km can replace them. To carry out this, we built and tested the complex of aerial photography.

3. Difficulties in the operation of laboratories based on balloons
During the operation of laboratories, the following challenges occur:
- It is difficult to change flight altitude quickly;
- High dependence on weather conditions.

It is enough difficult to overcome the second problem, however the influence of the first problem can be minimized by integrating quadrocopters. The speed of their movement and maneuverability is several times higher than the speed of movement and maneuverability of balloons, using special automated docks, it is possible to organize the movement of relatively small weight blocks from the ground to balloons and vice versa. In addition, it is possible to use various types of balloons simultaneously with the communication of equipment between them.

4. Using of controlled balloons as platforms for collecting remote sensing data
Despite their limited use, balloons are used as platforms carrying payloads of equipment for obtaining remote sensing data. Devices of this type are usually equipped with a wide variety of equipment, for example, sensors for electromagnetic sounding of the subsoil or relatively heavy aerial cameras that provide high-quality data.

Aircraft of this type are one of the most effective tools for high-precision environmental monitoring. With their help, one can quickly receive a full range of data on the state of the territories of interest for solving a wide range of tasks, including urban planning. Moreover, in terms of such parameters as flight range, low energy consumption, the ability to conduct high-precision geodetic surveying, aerial photography and terrain mapping, the capabilities of balloons significantly exceed that of other types of aviation.

5. Using of controlled balloons for land monitoring
The relevance of monitoring studies of erosion processes, forecasting yields, controlling plant growth phases, identifying unused and irrationally used lands is now beyond doubt. Also, the area of sown fields requires constant monitoring.

However, from the plane, there is often no opportunity to assess the full scale of the situation in the fields. The solving of this issue is the use of aerial photography. Traditionally, small aircraft are used for this, although their use is expensive for small agricultural enterprises. The solution may be the widespread use of balloons, the cost of which, like the cost of operation, is ten times cheaper than that of any manned vehicle.

Constant monitoring using balloons allows one to control the quality of the crop, detect cases of damage and theft of crops, and accurately and quickly assess the area of agricultural land. Thanks to this data, it is possible to increase the efficiency of farming by promptly responding to changes in the state of crops and making timely decisions. In addition, aerial photography is one of the most important sources of information during land works.

6. Conclusion
In conclusion, it is necessary to note that balloons are still a relatively cheap option for research and study of the near-earth environment. The need for this kind of experiments is still present and increasing day by day. The constant increase of such launches can be explained by the opportunity to conduct the experiments under reduced pressure, rarefied atmosphere, low temperature and radiation.
In addition, stratospheric platforms will make it possible to launch small cubic satellites at a much cheaper rate than using traditional methods (using vehicles).

It is obvious that stratospheric platforms can not fully replace vehicles for the orbital delivery of various kinds of cargo. Nevertheless there is a certain scientific and practical sphere for them.

In this regard, it seems possible to use new types of materials and automation systems for the development of this direction.

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