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Paper Authors: **Baxrinova M.X**

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Air laser systems used to ensure the maintenance of the state cadastre of real estate.

Baxrinova M.X

Samarkand State Institute of Architecture and Civil Engineering named after Mirzo Ulugbek. Samarkand. Uzbekistan.

Annotation: *This article discusses the generalization and analysis of information materials on the fields of application, principles of construction and operation of air laser systems used for topographic and geodetic support for maintaining the state cadastre of real estate. An analysis was made of the principles of construction, operation and main characteristics of air laser systems, their main advantages and disadvantages.*

Keywords: *land acquisition, aerial survey system, laser scanner, ALTM 3100, air laser scanner, RIEGL LMS-Q680.*

Introduction

A modern city is a dynamically developing system. On its territory, new houses, factories and other objects are constantly being built, old buildings are being demolished, the number of green spaces is changing, and so on. Among the many tasks associated with the management of territories, one can single out the updating of the master plan, monitoring of development and green spaces. To solve them, it is necessary to use methods and algorithms that make it possible to quickly and reliably identify changes occurring on the ground.

To achieve this goal, it is necessary to solve the following set of tasks:

- to reveal the content of geodetic support during cadastral work: its main tasks, land surveying issues, accuracy of determining the boundaries of land plots and real estate objects located on them;
- consider the main methods of obtaining topographic materials used in the cadastre: ground surveys and remote sensing of the Earth;
- to analyze the principles of construction, operation and main characteristics of airborne laser equipment;
- give the main advantages and disadvantages of airborne laser systems.

The object of research is airborne laser scanning systems. Subject of research: the use of laser systems for scanning built-up areas.

The main tasks of geodesy in cadastral works. The provision of the State Real Estate Cadastre (SREC) and the Urban Development Cadastre, land management and land monitoring is based on cartographic materials, land inventory materials, land surveying and cadastral surveys, which are used in drawing up plans for land plots attached to documents certifying the rights to these plots [4].

Geodetic works are essential for the creation of cadastres, since all information about land and real estate must be georeferenced. Such works include land surveying, which is a set of works for establishing, restoring and fixing the boundaries of a land plot on the ground, determining its location and area. There are several types of topographic and geodetic works:

- creation of a fund of cartographic and geodetic materials, including topographic maps (plans);

- catalogs of coordinates of points of the state geodetic network (SGN) of survey networks;
- catalogs of coordinates of the reference boundary network (RBN) and boundary marks;
- cadastral maps (plans);
- cadastral surveys.

Depending on the purpose of the cadastre, cadastral surveys are carried out on the same scale, in the same ways and with the same accuracy as topographic surveys. The basic scale is 1: 500, the most widely used is 1: 2000, the reference scale is 1: 100,000 and smaller [1].

On cadastral maps and plans depict:

- boundaries of land plots, possessions, agricultural and other land holdings;
- cadastral numbers and names of land plots;
- give an explication (description) of the categories of land use and other cadastral information. Cadastral maps and plans may not contain information about the terrain;
- land inventory.

In the process of land and real estate inventory, as well as complex cadastral works, the collection and analysis of available cartographic, cadastral, land management, legal and other materials is carried out, the boundaries of land plots are examined, the nature of land use is determined; determination of the areas of land plots. The areas of land plots are calculated mainly by analytical methods according to the coordinates of boundary marks. In some cases, cartographic materials are used; allotment of land plots.

Allocation of a land plot is a process of establishing territorial boundaries on the basis of an approved administrative decision on the provision for use (possession) of a plot of a given area. The boundary of a land plot is a fixed spatial object, the main function of which is to legally and technically separate the land of a given plot from the lands of adjacent territories [2].

Cadastral plans of cities should be drawn up in a unified state coordinate system [1], which allows the creation of a unified data bank and the ability to store information about objects in the form of digital data.

At present, GLONASS / GPS satellite technologies are used in combination with digital photogrammetric systems, for example, PHOTOMOD (Russia) and others [3], to collect and process information about areas with dense urban development and large tracts of adjacent lands.

Main characteristics of airborne laser systems. ALTM 3100 aerial laser mapping system.

A laser scanner is a device that performs measurements using laser radiation. Currently, the ALTM-class family of aerial laser mapping systems is used in most cases. There are many varieties of these scanners [6].

The main features of this class of scanners:

- fixing the intensity of the reflected signal

(the ability to work at night);

- fixation of up to 4 reflections of one sent pulse (the ability to separate the top of vegetation and the surface of the earth);
- the highest performance of the commercially available laser mapping systems (for example, the performance of the aviation laser locator ALTM 3100 - up to 1000 sq. Km in one working day);
- integrability with digital cameras, hyperspectral sensors, pulse waveform recorders to obtain new complex data types;
- the ability to use with GPS and GPS / GLONASS receivers from various manufacturers;

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• availability of an approved installation scheme for domestic aircraft;

• adaptation to Russian conditions;

• high economic efficiency of use in those conditions when the use of other methods is extremely difficult, impossible, or limited by seasonal factors (no reference area, solid foliage, very "flat" relief, and so on);

• high performance DASHMap laser data preprocessing software with built-in 3D viewer for visualization and output of XYZI data and so on.

Table 1 - Specifications of the airborne laser scanner ALTM 3100

Parameters	Value
Frequency of the probing pulse	33 kHz 50 kHz 70 kHz 100 kHz
Flight altitude during shooting	80 to 3500 m
Accuracy of scanning in height	not worse than 15 cm at 1200 m at least 25 cm at 2000 m at least 35 cm at 3000 m
Accuracy of determining the planned position of points	better than 1/2000 of the shooting height
Swath width	0 to 93% of the shooting height
Range resolution	1 cm
Number of registered laser pulse reflections	4 including the last
Intensity registration	12 bit dynamic range for each measurement
Scanning angle	0 to +250
Roll compensation	Nominally ± 50, depending on the current value of the field of view
Capture bandwidth	0 to 0.93 × Nm
Scanning frequency	0-70 Hz, dependent on scan angle
Distribution of reflections on the ground	Evenly over 96% of scan line
Used onboard navigation system	Applanix POSAV, modified
On-board GPS receiver	Trimble 750
Laser divergence	0.3 mrad or 0.8 mrad
Laser category	Class 4
Safe vision altitude	200 m @ 0.7 mrad 400 m @ 0.2 mrad
Humidity	0-95% non-condensing
Consumption	28 VAC, 24 A average, 35 A peak consumption
Operating temperature range: - scanning unit -control rack - with thermal stabilization	from -100 C to +350 C from +100 C to +350 C from - 300 C to +550 C
Dimensions / Weight: -scanning unit -control rack	26 × 19 × 57cm / 23.4kg 65 × 59 × 49cm / 53.2kg

The ALTM 3100 aerial laser mapping system is the most accurate, efficient and cost effective (in its class) laser mapping system today.

Figure 1 - Air laser scanner ALTM 3100

The operating parameters of the RIEGL LMS-Q680 can be configured to cover a wide range of applications. The extensive interface capabilities make it easy to integrate the instrument into a complete (complete) aerial scanning system. The RIEGL LMS-Q680 Airborne Laser Scanner is shown in Appendix B.

The technical characteristics of the RIEGL LMS-Q680 airborne laser scanner are presented in Table 2.

The scanner is an extremely reliable and durable device, ideally suited for installation on an aircraft. In addition, it has a compact design and low weight, sufficient for installation on single-engine airplanes, helicopters and unmanned aerial vehicles.

The device requires only a power supply and GPS synchronization signals in order to ensure operational control when registering precisely timed and digitized echo signals.

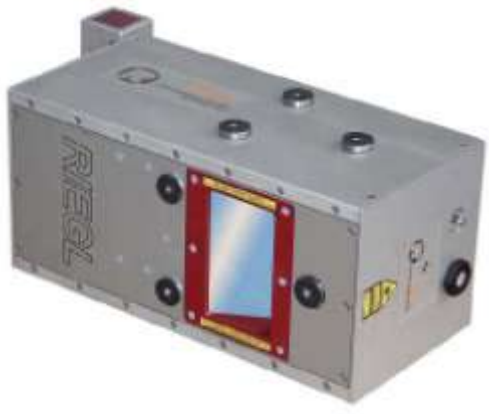

Figure 2 - Airborne laser scanner RIEGL LMS-Q680

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The RIEGL Data Recorder ensures reliable recording and data storage during measurement.

Table 2 - Technical characteristics of the airborne laser scanner RIEGL LMS-Q680

Parameter	Value
Probing pulse frequency	80 kHz 120 kHz 180 kHz 240 kHz
Flight altitude during shooting	1000 to 1600 m
Uncertainty	20 mm
Reflectance	20%
Laser wavelength	Near IR
Intensity registration	16 bit dynamic range for each measurement
canning angle	0 to +600
Roll compensation	Nominally ± 50, depending on the current value of the field of view
Scan engine	Rotating multi-faceted mirror
Scanning rate	up to 160 Hz, depends on scanning angle
Raster	Parallel scan lines
Scanning speed	10-200 scans per second
Reading angular resolution	0.0010
Laser divergence	≤0.5 mrad.
Consumption	7A at 24 VDC
Power	18-32 VDC
Dimensions / Weight:	480 x 212 x 230 mm / 17.5 kg

The principle of operation of airborne laser systems is shown in Figure 1. A semiconductor laser, usually in the near infrared range, operating in a pulsed mode is used as an emitter. In each scanning act, the slant range to the point of reflection and the value of the angle that determines the direction of propagation of the probing beam in the locator coordinate system are recorded. Depending on the type of scanning system, more than one (up to five) reflections can be recorded for each line of sight. This possibility contributes to obtaining more informative laser-location images, since in one scanning act, responses from several components of the scene can be obtained at once: the first responses will be received due to reflections from vegetation foliage, wires and power line supports, edges of buildings, and the last response usually corresponds to the ground or other solid surface, such as the roof of a building. The vehicle's trajectory is recorded by an on-board GPS receiver (GLONASS). In combination with the measured values of the slant range and scanning angle, this allows you to directly obtain the absolute geodetic coordinates of the scene elements that caused the reflection of the probe beam.

Conclusion

When writing the article, the following tasks were solved:

- disclosed the content of geodetic support during cadastral work;
- the main methods of obtaining topographic materials used in the cadastre are considered: ground surveys and remote sensing of the Earth;
- an analysis of the principles of construction, operation and main characteristics of airborne laser equipment has been carried out;
- the main advantages and disadvantages of airborne laser systems are given.

When disclosing the content of geodetic support for cadastral work, its main tasks and issues related to land surveying were considered. It has been established that the accuracy of determining the boundaries of land plots and real estate objects located on them for built-up areas should not be less than 0.20 meters.

An analysis was made of the principles of construction, operation and main characteristics of air laser systems, their main advantages and disadvantages. The main characteristics of two airborne laser systems were reviewed and presented: the ALTM 3100 aerial laser mapping system and the RIEGL LMS-Q680 airborne laser scanner.

The use of laser scanning technology allows us to offer the end user a variety of products that can be used to create geographic information systems, design, survey and analyze the state of various objects, control engineering work, conduct regression analysis, and so on.

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