Application of laser scanning technologies in territorial planning in Russia

D A Gura¹, J A Doumit², N A Dyakova³, P S Malimonenko¹ and D A Lipilin³⁴⁵

¹Kuban State Technological University, 2, Moskovskay str., Krasnodar, 350072, Russia
²Lebanese University, Faculty of Letters and Human Sciences branch 2, Geospatial Lab
³Kuban State University, 149, Stavropol'skaya str., Krasnodar, 350040, Russia
⁴Kuban State Agrarian University, 13, Kalinina str., Krasnodar, 350044, Russia
⁵Russian State Hydrometeorological University, Tuapse Branch, 7, Morskaya str., Tuapse, Krasnodarskiy Kray, Russia

E-mail: gurada@kubstu.ru

Abstract. Spatial planning affects all aspects of human activities. Spatial planning has a rich history; not all urban plans were correctly designed. Improper urban planning has led to various negative consequences. It is difficult to correct this situation at this stage, but design errors could have been prevented at the territory planning stage, using airborne laser scanning technology and predicting urban development trends. This method has appeared recently but proved to be efficient. Airborne laser scanning is effective as it simplifies work, reduces shooting time and costs. Besides, the method of airborne laser scanning makes it possible to survey hard-to-reach regions where terrestrial laser scanning is impossible or requires high costs and labor intensity. Airborne laser scanning facilitates the creation of electronic maps, plans, and diagrams.

1. Introduction

The social and economic development of Russia depends on spatial planning since it contributes to the rational spatial organization and consistent transformation of the sectoral structure of the national economy. The spatial organization determines the sectoral affiliation of districts and regions, and the structure of the national economy. The correct spatial planning ensures the observance of rights to the safe living environment, social and economic rights, and freedoms.

Nowadays, spatial planning is less active than in the USSR. From 1920 to 1941, construction works aimed to create territorial-production complexes and resort areas were being performed. This period was characterized by the search for a solution to the problems of development of new territories, placement of industrial facilities, settlements, service institutions, using architectural, planning, and engineering approaches. From 1940 to 1960, a program to construct the largest hydroelectric power plants and various plants and enterprises was being implemented. By the end of this period, developing the largest region of the oil and gas industry began. In the next decade, developing basic concepts for developing general schemes began, an attempt of the integrated development and distribution of productive forces was made. However, after the collapse of the USSR, the unified territorial planning system was abandoned. Despite this, the main provisions of the urban planning policy remained relevant, but it was impossible to transform the existing system during the transition period. Thus, by the end of the 20th century, the old methods no longer worked, and the new ones were not developed.
2. Materials and methods
In modern society, the role of urban regulation has increased due to market reforms [1]. The transformations have affected urban planning: new scales of territorial systems, organization of resettlement in territorial and administrative transformations, and economic relations. The social development has created a need for the comprehensive analysis of the territorial structure of the country; the importance of the economic approach in the territorial placement of urban planning objects increases, this leads to an increase in specific requirements for design objects, new professional tasks, and methods of data collection.

Spatial planning documents are divided into three groups depending on the territorial division: the Russian Federation, municipalities, or regions of the Russian Federation. One of the main documents of territorial planning is a territorial planning scheme; during its development, information is collected and systematized; all aspects of economic activities of territorial divisions are analyzed.

Territorial planning activities will depend on the quality of information; therefore, information support requires the use of special tools [2]. One of the most effective ways to solve the problem of developing territories in developing photographic plans, digital terrain models, digital models of overhead objects, airborne laser scanning (VLS) [3-4], and other activities used for monitoring [5] and development of the territory.

3. Results and discussion
The experiment revealed territorial planning errors associated with improper space organization. For example, incorrect planning in multi-story buildings has created daily traffic jams and no parking spaces. Design errors in urban areas have caused problems with aeration and correct insolation. Incorrect location of engineering networks has aggravated the problem of illumination of residential and other premises and caused an overload of the storm system. One problem is the location of industrial complexes on the territory of modern cities. The location of airports, which restrict the development of aerodrome areas, harms the layout. Functional zones complicate the movement of people from places of residence to places of work. Another mistake is improper planning of green areas, which decreases the level of recreation inside the city.

Thus, improper planning leads to the irrational use of land, rapid depletion of natural resources [6], environmental degradation, and other concomitant negative consequences [7].

However, many problems can be solved by using the method of laser scanning (LS) to predict these errors when planning the territory. Within territorial planning, drug technologies are in demand; they began to be used in the second half of the 20th century [8]. Different shooting methods are used. When it is necessary to scan small objects, ground-based laser scanning (LLS) is used to achieve the highest possible accuracy. If it is necessary to cover a large territory or an extended object, an overhead line is used combined with digital aerial photography [9]. Thus, when using airborne laser scanning, it is possible to shoot up to 100-150 km² per hour, which saves time. Besides, the VLS allows you to survey hard-to-reach regions where the NLS is impossible or requires large costs [10].

VLAN technologies solve many urban planning problems. To solve the problem of daily traffic jams, an analysis of road transport networks and traffic intensity of vehicles is carried out using the VLAN, additional approaches to the districts are designed. Applying modern technologies of artificial intelligence and decision support systems with three-dimensional digital models, it is possible to solve any spatial problem.

The problem of parking spaces is solved using engineering, geological and geodetic surveys with modern innovative measurement and control tools. Using the VLS method, it is possible to determine territories suitable for placing certain infrastructure objects [11].

Problems with aeration and the correct insolation regime can also be solved using an overhead line. Applying a complex of environmental [12], meteorological and geodetic surveys, based on the results of which measures are developed to change the insolation regime and prevent problems with aeration.

The problem of illumination of residential and other premises, and the congestion of stormwater systems, is associated with the incorrect laying of engineering networks. Helped by the VLAN, one can
discover outlines of road networks and develop measures suitable for the territory using methods for creating engineering networks [13].

With the VLS, a point cloud and a set of data (intensity of the reflected signal of surveyed objects (Figure 1) and initial colors from aerial photography) can be built [14]. After classifying the point clouds, they can be divided into several classes. Depending on the class, the point cloud is assigned a certain color: ground - purple, high-rise objects - yellow, and roofs – green (Figure 1).

![Figure 1. A point cloud with the intensity of reflected signals of shooting objects.](image)

Figure 1 shows a point cloud, the displayed intensity of the reflected signals of the surveyed objects, the campus of the Kuban State Technological University, Krasnodar, Russian Federation.

![Figure 2. A classified point clouds.](image)
Figure 2 shows the classified point cloud of the campus of the Kuban State Technological University, Krasnodar, Russian Federation.

4. Conclusion
When using the VLS method, based on the collected data, it is possible to create high-resolution terrain maps, digital elevation models, 3D object models, and virtual terrain models, high-precision topographic maps, and plans. The data will allow for updating outdated master plans of cities and thematic maps in a digital form, developing technical solutions and options for the optimal location of objects, monitoring [5], and creating a geographic information system (GIS) for territory management [15].

References
[1] Smita Srinivas 2008 Urban labour markets in the 21st century: Dualism, regulation and the role(s) of the State Habitat International 32(2) 141-159
[2] Billaud O, Soubeyrand M, Luque S and Lenormand M 2020 Comprehensive decision-strategy space exploration for efficient territorial planning strategies Computers, Environment and Urban Systems 83 101516
[3] Brede B, Calders K, Lau A, Raumonen P, Bartholomeus H M, Herold M, and Kooistra L 2019 Non-destructive tree volume estimation through quantitative structure modelling: Comparing UAV laser scanning with terrestrial LIDAR Remote Sensing of Environment 233. DOI: 10.1016/j.rse.2019.111355
[4] Shishkina V, Gura D, Gribkova I and Bykova M 2019 Integration of GIS and a complex of three-dimensional laser scanning IOP Conference Series: Materials Science and Engineering 698(6) 066016. DOI: 10.1088/1757-899X/698/6/066016
[5] Dubenko Y V, Gura D A and Dyshkant E E 2019 Monitoring Complex Infrastructure Facilities State Using Mobile Robots: Problem Analysis Int. Multi-Conf. on Industrial Engineering and Modern Technologies, FarEastCon 2019, 8934179. DOI: 10.1109/FarEastCon.2019.8934179
[6] Poorazimy M, Shataee Sh, McRoberts R E and Mohammadi J 2020 Integrating airborne laser scanning data, space-borne radar data and digital aerial imagery to estimate aboveground carbon stock in Hycarian forests, Iran Remote Sensing of Environment 240 111669
[7] Weifeng Qiao, Yi Hu, Kaiyang Jia, Tianqi He and Yahua Wang 2020 Dynamic modes and ecological effects of salt field utilization in the Weifang coastal area, China: Implications for territorial spatial planning Land Use Policy 99 104952
[8] Kuzyakina M, Gura D, Sekisov A and Granik N 2019 Assessment of Potential Forest Biomass Resource on the Basis of Data of Air Laser Scanning Advances in Intelligent Systems and Computing 983 403-416. DOI: 10.1007/978-3-030-19868-8_41
[9] Rishol B, Briese Ch, Doneus M and Nesbakken A 2015 Monitoring cultural heritage by comparing DEMs derived from historical aerial photographs and airborne laser scanning Journal of Cultural Heritage 16(2) 202-209
[10] Navarro J A, Tome J L, Marino E, Guillem-Climent M L and Fernandez-Landa A 2020 Assessing the transferability of airborne laser scanning and digital photogrammetry derived growing stock volume models International Journal of Applied Earth Observation and Geoinformation 91 102135
[11] Pengfei Zhao, Hongzhi Guan, Heng Wei and Shixu Liu 2021 Mathematical modeling and heuristic approaches to optimize shared parking resources: A case study of Beijing, China Transportation Research Interdisciplinary Perspectives 9 100317
[12] Stojakovic V, Bajsanski I, Savic S, Milosevic D and Tepavcevic B 2020 The influence of changing location of trees in urban green spaces on insolation mitigation Urban Forestry & Urban Greening 53 126721
[13] Yiyang Zhang, Zhigang Jin and Ye Chen 2020 Hybrid teaching-learning-based optimization and neural network algorithm for engineering design optimization problems Knowledge-Based Systems 187 104836
[14] Anh Vu Vo, Debra F Laefer, Aljosa Smolic and S M Iman Zolanvari 2019 Per-point processing for detailed urban solar estimation with aerial laser scanning and distributed computing *ISPRS Journal of Photogrammetry and Remote Sensing* **155** 119-135

[15] Inmaculada Marques-Perez, Inmaculada Guaita-Pradas, Aurea Gallego and Baldomero Segura 2020 Territorial planning for photovoltaic power plants using an outranking approach and GIS *Journal of Cleaner Production* **257** 120602