

# Creation of a digital map for Sochi city masterplan development in the modern geoinformation system ArcGIS

*Dmitry Gura*<sup>1\*</sup>, *Irina Gribkova*<sup>1</sup>, *Elizaveta Berkova*<sup>1</sup>, *Anastasia Panyutischeva*<sup>1</sup>, and *Gennadiy Turk*<sup>1,2</sup>

<sup>1</sup>Kuban State Technological University, 2, Moskovskaya str., 350072, Krasnodar, Russian

<sup>2</sup>Kuban State Agrarian University named after I.T. Trubilin, 13 Kalinina St., Krasnodar, 350044, Russia

**Abstract.** Today, taking into account the development of modern geodetic and cartographic technologies, it is impossible to solve the tasks of territorial planning without using modern geographic information systems. The main tasks of GIS are the search for solutions in the field of rational use of natural resources, territorial sectoral planning, and management of the location of industry, transport, agriculture, energy, and finance. In addition, GIS systems provide control of living conditions of the population, as well as regulate the issues of mapping. The article discusses the application of modern GIS as methods of creating topographic plans. For work on creation of digital terrain models space images are used, which should be accompanied by data of territory interpretation. This allows to make sure the accuracy of information contained in cartographic open databases and to compare it with the current situation on the projected territory. To build a GIS it is necessary to use special integrated programs that allow to create, analyse, edit and present spatial data. The paper examines the process of creating a GIS using ArcGIS programme. The purpose of this paper is to study the process of creating a digital map and database with all the information of common attributes. The developed digital map is the basis for the formation of the master plan of the city. The master plan consists of an explanatory note and a set of drawings. The drawings should be made on a certain scale (1:200 - 1:2000). It is necessary to take into account natural conditions, wind rose, and other data. All objects on the drawings shall be designated with the help of conventional signs established by the relevant regulatory documents. The general plan of the city shall comply with the territorial planning documentation.

## 1 Introduction

This article considers the process of development and creation of a topographic plan of the city using modern geographic information systems, as well as the formation of the general

---

\* Corresponding author: [gurada@kubstu.ru](mailto:gurada@kubstu.ru) , [gda-kuban@mail.ru](mailto:gda-kuban@mail.ru)

plan of the city taking into account the data of spatial planning and characteristics of the objects of the topographic plan [1-13].

The general plan is a document that not only determines the spatial organisation, but also regulates the use of land in a certain settlement. The efficiency of the use of these lands determines the development prospect of a given locality [6, 14-16].

The general plan contains information on the location of territories of local importance, functional zones, boundaries and territorial planning of a settlement [14]. It is territorial planning that determines the development of urban environment territories and establishes functional zones and zones of capital construction objects' location taking into account social, economic and environmental factors. According to the above factors, various types of urban development of the territory are carried out, including its development and reconstruction of buildings [4, 7].

In addition to the main drawing, the master plan of the city includes maps of the settlement boundaries, placement of linear objects of transport infrastructure of local significance, placement of electric transport of local significance, placement of social infrastructure objects of local, regional and federal significance, as well as a map of the natural and recreational complex of the urban district [1]. The main part of the general plan consists of a scale image obtained by creating topographic plans as a result of graphic superimposition of drawings of separate parts of the territory of the settlement. Maps of the substantiating part of the general plan project within the boundaries of a settlement, urban district can be made on a scale of 1:50000; 1:25000, 1:10000, 1:5000, and within the boundaries of settlements - on a scale of 1:10000; 1:5000; 1:2000 depending on the population and the size of the territory of settlements, urban districts, taking into account the visibility of graphic materials in accordance with the design assignment (urban planning assignment) or by agreement with the customer in the design process. Various engineering and geodetic works are performed for their creation. Topographic survey is carried out on the territories of settlements (survey scale varies from 1:500 to 1:5000), as well as field interpretation of images obtained as a result of this survey. As a result of field interpretation, all necessary objects are identified and their characteristics are determined. Then digitisation and creation of topographic maps is carried out [2].

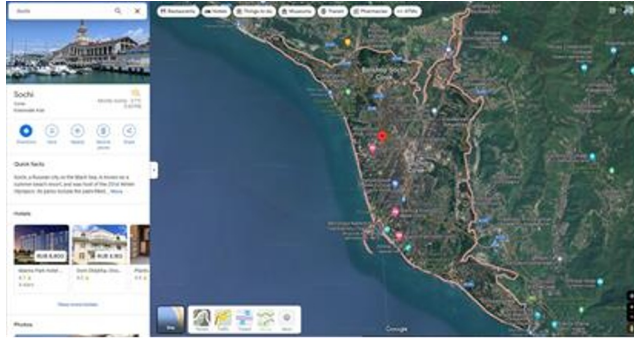
All engineering and geodetic works are carried out using geographic information systems. GIS allows to search, study, analyse and edit not only digital maps, but also additional information about the characteristics of various objects [8, 12].

## **2 Materials and methods of research**

### **2.1 Analysing cartographic sources**

For drawing up the master plan of the city it is necessary to use different cartographic sources. When analysing the information, it was found that cartographic data from different services differ. Therefore, one or two sources were not sufficient for the work. In this study open systems of maps and satellite images, such as Google Maps, Yandex Maps, 2GIS city map directory, as well as the open service Public Cadastral Map were used.

Each source has its own peculiarities and disadvantages. Let us consider the Google Maps service (Fig. 1). It was used to determine the boundaries of the city. This cartographic system has satellite images in its database, which allow to determine the location of this or that object. The location of roads, pavements and forest belts was determined using the "panorama" function, which allows viewing streets in real time. This method is the most efficient as every intersection and all objects located on roads, pavements and behind trees are visible.



**Fig. 1.** Image of the city of Sochi on Google Maps.

However, when using this service, some shortcomings were identified. One of them is incomplete viewing of streets due to the lack of panorama on minor streets. Figure 2 shows an area where the majority of the area is not available for viewing. This creates difficulties for further work as information about houses, vegetation and streets in this area is private.



**Fig. 2.** Panorama of the city of Sochi.

Another disadvantage is the inaccurate location of buildings and structures on the map. A large number of houses have a size and shape that are different from reality. Some houses are missing on the Google digital map (Fig. 3).



**Fig. 3.** Location scheme of houses on the satellite image and on the map.

Taking into account all the above-mentioned disadvantages of the Google Maps service, in order to obtain additional spatial information, the Yandex Maps resource was used.

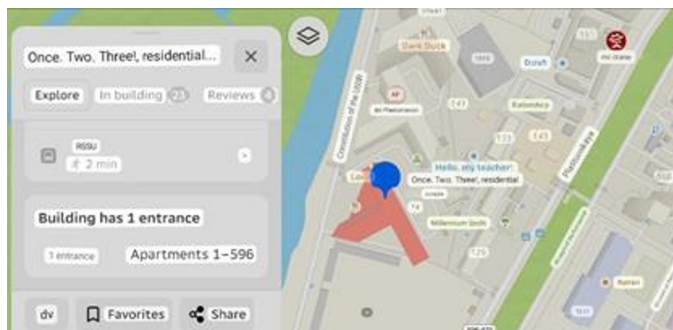
Unlike the previous service, Yandex Maps has better quality of satellite images (Fig. 4). Each object is clearly visible, even at a great distance. Almost all buildings and structures are located on the map, which have the correct shape and size. It is also possible to view objects in 3D mode.

The problem of this service was inaccuracy in the location of objects. The addresses in the database differ from the real ones, which makes it difficult to compile attributes of buildings.



**Fig. 4.** Sochi city image on Yandex Maps.

To further analyse the available GIS with cartographic information about the territories, the 2GIS electronic gazetteer was investigated, which allowed to accurately describe each building and structure. The database contains information on storeys, wall material, building purpose, as well as information on the dates of commissioning of facilities (Fig. 5). This made it possible to accurately describe each object on the territory of the city. A clear disadvantage of 2GIS is the lack of panorama and satellite images.



**Fig. 5.** Description of the object in the 2GIS map directory.

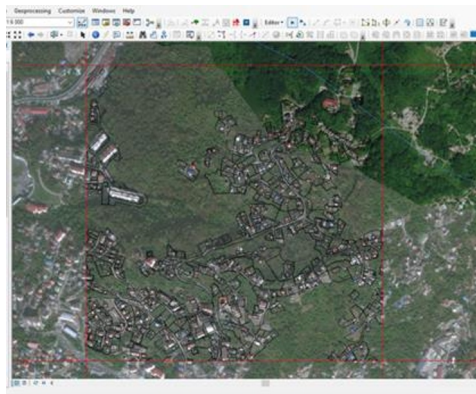
## 2.2 Working with material in the programme ArcGIS

After studying all software products and sources of cartographic information, raster images and already ready database with necessary layers were loaded into ArcGIS programme (Fig. 6).



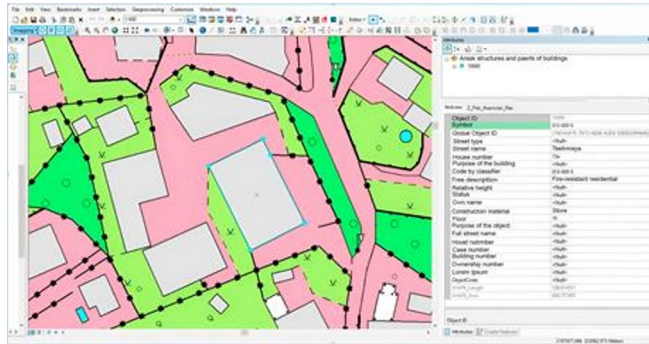
**Fig. 6.** Layers in ArcGIS for territory digitisation.

At the next stage of work with territory digitisation in ArcGIS software contours of area objects were created (Fig. 7). An important condition for the quality of the final result of the work was the closedness of all contours.

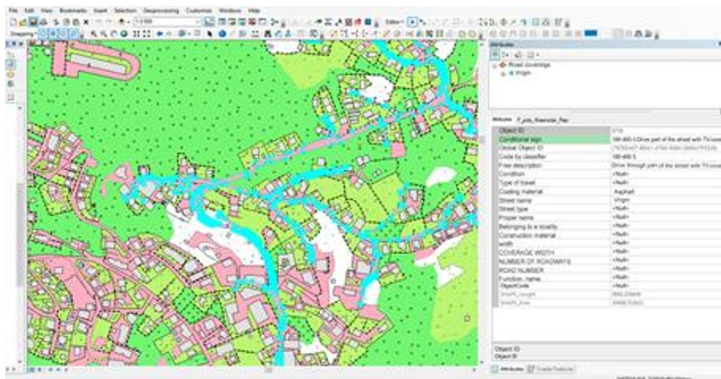


**Fig. 7.** Created contours of area objects.

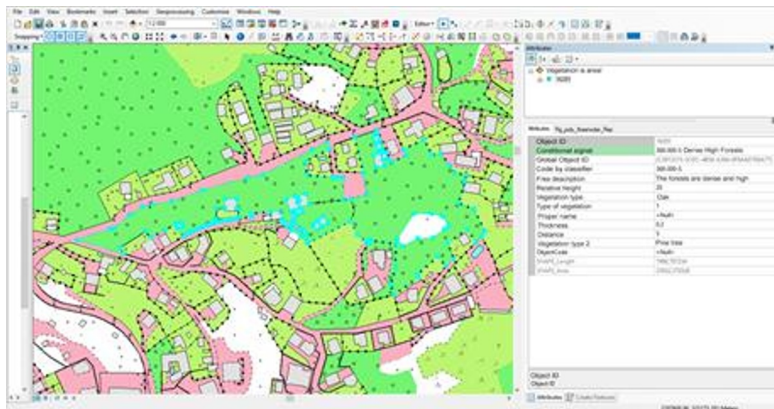
Using ArcGIS software function, the drawn contours were filled in one area layer and then distributed to other area layers according to the purpose of objects. Each layer has its own attribute table, which is populated based on information from open-source cartographic sources. The data are presented in Figures 8-10.



**Fig. 8.** Attribute database of the selected building.



**Fig. 9.** Attribute database of the selected road network.

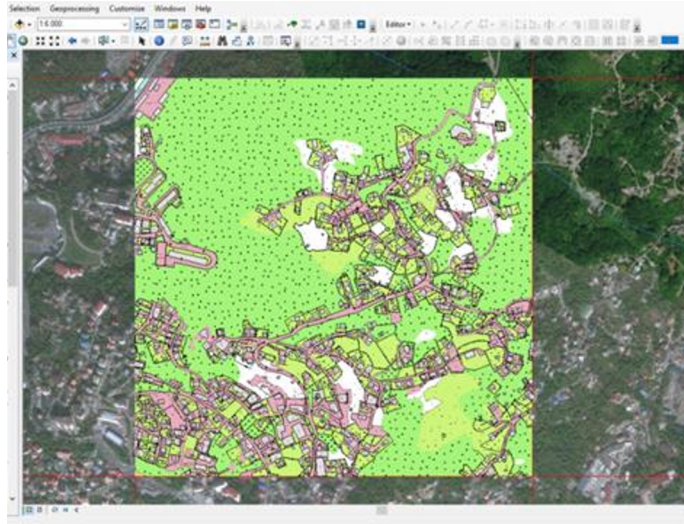


**Fig. 10.** Attribute database of the selected landscaping area.

### 3 The results of the study and their discussion

As a result of the work done, a digital map of the territory was produced, as well as an attribute table. The database includes a network of federal and local roads with different pavement types. Buildings and structures are also classified according to different attributes and purposes. Vegetation was described by vegetation type, height and width of tree trunks,

and distance between them. Among other things, objects of social importance such as kindergartens, schools and hospitals were described. The created database is the basis for further compilation of the city master plan. Figure 11 shows a part of the Sochi city master plan:



**Fig. 11.** Final version of digitisation of the Sochi city territory.

The creation of the database was carried out using satellite imagery as well as field interpretation. In the process of territory digitisation some problems were identified. The main problems were as follows: the satellite images were taken from different sources and in different time range. Due to this, the boundaries of the images did not converge, which created difficulties in digitisation of the territory. This can be clearly seen in Figure 12.



**Fig. 12.** Plot of two space images with mismatched boundary.

However, this problem can be solved by replacing space images with cartographic information based on laser scanning data. Laser scanning is a survey system that allows to quickly create a digital image in the form of a cloud of points, which in turn has spatial coordinates [10, 15]. It is this type of scanning that is better suited for GIS creation because

it is compiled from a large array of points rather than discrete measurements, which allows for a more accurate reconstruction of the cartographic model of the terrain [3, 9, 17].

## 4 Conclusions

Thus, in order to create a master plan of the city, it is necessary to take into account information from territorial planning documentation and cartographic open databases.

As a result of the work done, the open cartographic sources were studied, and the disadvantages of each of them were identified. The study showed that it is impossible to find complete information about objects based on only one service. Each source complements the other, which makes it possible to collect all the data about this or that object.

After studying all the cartographic information, a special integrated ArcGIS programme was used to digitise the city territory and create a digital map of the city. The ArcGIS programme allowed not only to digitise the territory, but also to create an attributive database for each object on the territory of the settlement [5, 11].

In the course of the work, the contours were drawn and area objects were created in the programme. With the help of information about the objects taken from the provided services, buildings, structures, as well as local and federal roads were described. This made it possible to create an attributive table of the database and fill in the attributes for each object on the territory of the locality.

Problems were also identified in that the boundaries of the satellite images, which were taken from different sources, did not converge. This made it difficult to work with the territory, but this problem can be solved by replacing the satellite images with map information based on laser scanning data.

## Acknowledgment

The research was carried out with the financial support of the Kuban Scientific Foundation within the framework of the scientific and innovative project No. NIP-20.1/22.16.

## References

1. A. R. Abdullina, Evolution of the State and Law: Problems and Prospects, 63-66 (2021)
2. D. V. Vinogradov, I. A. Plastinin, Interexpo Geo-Siberia **1(2)**, 158-163 (2019) DOI: 10.33764/2618-981X-2019-1-2-158-163
3. D. A. Gura, G. G. Shevchenko, A. A. Serikova, Electronic Network Polythematic Journal "Scientific Works of KubSTU" **15**, 57-68 (2016)
4. M. G. Ishbulatov, E. I. Galeev, E.I. Experience in the use of UAVs in the creation of general plans of settlements. Ulan-Ude, Dorzhi Banzarov Buryat State University, 91-94 (2018)
5. Yu. I. Kantemirov, Geomatics **4**, 24-25 (2012)
6. E. P. Menshikova, Scientific Journal of Civil Engineering and Architecture **2 (46)**, 113-119 (2017)
7. N. A. Pogrebnaya, Purpose of territorial planning and types of territorial planning documents. Novosibirsk, Limited Liability Company "Center for the Development of Scientific Cooperation", 120-124 (2017)

8. S. G. Salnikov, N. Yu. Trukhina, *Bulletin of the Moscow Humanitarian and Economic Institute* **4**, 100-103 (2018)
9. B. A. Khakhuk, A. A. Kushu, A. M. A. Akhmetov, D. A. Fominova, *Electronic Network Polythematic Journal "Scientific Works of KubSTU"* **2**, 261-271 (2018)
10. V. Tsukanov, *Territory of Neftegaz* **6**, 44-45 (2007)
11. D. A. Chij, *ArcGIS for Land Management Zoning Purposes. Collection: Problems of conservation and transformation of agricultural landscapes*, 191-194 (2016)
12. D. Gura, V. A. Shishkina, I. S. Gribkova, M. Bykova, *The International Scientific Conference "Construction and Architecture: Theory and Practice for the innovation Development"* (2019) DOI: 10.1088|1757-899X|698|6|066016
13. A. Irmanova, N. Ospanova, *GIS and knowledge sharing: designing GIS for cultural heritage in pavlodar region. Kazakhstan, Wschodnioeuropejskie Czasopismo Naukowe*, 54-58 (2016)
14. N. I. Morozova, V. I. Tinyakova, N. F. Sivtsova, Ju. L. Rastopchina, *Revista Publicando*, 1472-1482 (2018)
15. G. Vosselman, *Scope based filtering of laser altimetry data. // International Archives of the Photogrammetry. Amsterdam: Remote Sensing and Spatial Information Sciences, V. XXXIII*, 23-27 (2000)
16. B. Wade, *American City & County*, 28 (1998)
17. M. S. Arakelov, D. A. Lipilin, A. V. Dolgova-Shkhalakhova, *Geography, Environment, Sustainability* **14(4)**, 199-204 (2021)