Creating a Municipal Information System of a City using GIS Technology

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Abstract: The article considers the essence and identifies the main components of the formation of a municipal information system. The theoretical aspects of GIS (geographic information system) technology usage in creating a city information system are studied. Conceptual frameworks and architectures of the city GIS are developed. The possibilities for rationalization of the process of preparing solutions for managerial tasks using the city GIS are characterized. The functional requirements for municipal information systems based on GIS technology are presented.

Index Terms: city, geobank, geobase, geographic information system, geospatial data, GIS technology, information system, municipal structure.

I. INTRODUCTION

Today, enormous changes take place in various areas of human activity, based on the development of basic and applied sciences. A significant proportion of these changes are produced by modern geographic information technologies (GIT), for the operation of which geographic information systems (GISs) have received large-scale development and implementation. GIS provides significant development benefits in economics and politics, ecology and environmental management, media and communications, education and culture [1].The modern world is in a constant process of change and development. The same thing happens with its geographical features. Comprehensive scientifically-based planning for the development of any state today is impossible without analysis and perception of the geographic environment, the reflection of which by the aggregate means of cartography and computer technology is intended to be as complete and reliable as possible.The problems of forming city GISs and their activation for effective urban management have not lost their relevance for the past several decades. Back in the 1970s-1980s, according to Simon Marvin and Stephen Graham [2], the foundations of formalized methods for automating urban planning and managing territorial development were laid, but the effectiveness of their practical application, according to Schneider, Fischer and König, was limited by the inadequate level of computer equipment and the labor intensity of

technologies for collecting large amounts of primary information necessary for complex modeling of complex urban systems [3]. Only from the mid-1990s, according to Lisitsky, with the mass production of powerful and relatively inexpensive computer equipment and the development of the latest information technologies, the material basis for the implementation of ideas and conceptual developments in the field of informatization of urban planning and urban management was formed [4].Today, in a large number of countries, municipalities are provided with significant opportunities and, at the same time, they have responsibilities for managing land resources and real estate, maintaining infrastructure, preserving the environment and ensuring public safety [5].The city as a municipality with certain resources, in the process of implementing its mission, which consists in providing a complex of services to the population and ensuring the standards of its life, must use them effectively. To implement the rational management of the city and the efficient use of its resources, it is proposed to use GIS technology. According to the GeoBuiz-18 report, the GIS market expects growth from 66.2 billion US dollars in 2017 to 88.3 billion US dollars in 2020 with an average annual growth of 12.4%. Given that an increasing number of developing countries, such as China and India, are developing smart-city technologies, the introduction of GIS into city mapping is becoming a necessity to increase the market for GIS technologies. Moreover, under the assumption that in 2020, the GIS software market will amount to 17.9 billion US dollars, the share of services and turnkey solutions in 2020 will make 46.2 billion and 24.2 billion US dollars, respectively [6].The purpose of the study is to analyze the use of GIS technologies in the creation of a municipal information system at the city level.

II. THE THEORETICAL ASPECTS OF GIS TECHNOLOGY USAGE IN CREATING A CITY INFORMATION SYSTEM

Any urban settlement is a unity of three components: firstly, the population, which predetermines the essence of the urban settlement existence; secondly, the territory as an inseparable unity of the spatial component and the natural resources that are located thereon; thirdly, the economy as a set of economic organizational entities and the relationships among them, ensuring the vital activity of the city, meeting its diverse life needs [7].The existence and development of modern municipalities are impossible without the effective work of municipal services. At the same time, information plays an important role in managing the development of a city, due to which project planning decisions are made and, for example, the geoecological consequences of decisions made are assessed.

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In this connection, the collection and operational processing of information, as well as the provision of processing results in a cartographic form, are a prerequisite for the effectiveness of urban management. The above concerns various types and forms of activity, in particular, environmental management, which is characterized by the distribution of activities in space, the need to take into account local geographical conditions and the imposed legal and environmental restrictions. The more complete and better the information available to the municipality is, the more efficient will be the management and distribution of resources available to the municipality, and, accordingly, the more the competence of the municipal government and the significance of its results for the population will increase. The introduction of urban GISs will ensure the creation of a single information frame that will facilitate the implementation of the diverse activities of municipal governments at a more integrated level [8].GIS technologies provide tools for displaying and understanding what is in a particular place or several places, software tools designed to simulate the use of the resource base, to determine interdependencies, risks, and threats [9].The ability of GIS to integrate spatial and nonspatial data, simultaneously with the possibilities of analyzing and modeling, allows the application of this technology as a single platform for the integration of management actions within the city government [10].According to Karpik, GISs are a complex of methodological, organizational, software, technical and information tools that should increase the efficiency of managing territorial infrastructure through the use of the latest information technologies [11].In this case, according to Tsipileva, the concept of a city GIS should not be limited to geospatial information of a single locality, but focused on the further development and extension to the following levels of management – both vertically (regional, federal, interstate levels) and horizontally (municipal and private enterprises and organizations) [12].The use of GIS in an urban settlement should lead to a significant increase in the controllability of urban development processes in order to improve the quality and standard of living for residents and lead to a gradual transformation of the social environment into an information society.It is worth noting that the mandatory use of GIS in the management of all municipalities will provide such a management tool that will enable the integration of data from all departments into a common GIS structure.Significant global experience in the use of GIS technology clearly demonstrates that reliable geographically-related information is a critical element, since the consideration of the totality of factors affecting various indicators of the quality of life of the population is largely determined by spatial location. Having knowledge of a particular territory, the manager has control over the situation, i.e. GIS marks the transition of the city administration and its executive bodies to modern computer technologies in managing the economic complex [13].

III. METHODS

The study algorithm includes the procedure for creating in each city with the help of municipal GIS a fund of geospatial city data (GSDF) – a systemically structured spatial data bank, in which user-friendly general geospatial information will be collected.When developing the conceptual foundations and architecture of a city GIS, the authors relied on the studies by Karpik [11], Kiriyenko [13], and Milyukov [14].

IV. RESULTS

The final results of the study are the development of a conceptual framework and architecture of a city GIS, which identifies the subjects and structure of a city GIS (Fig. 1).
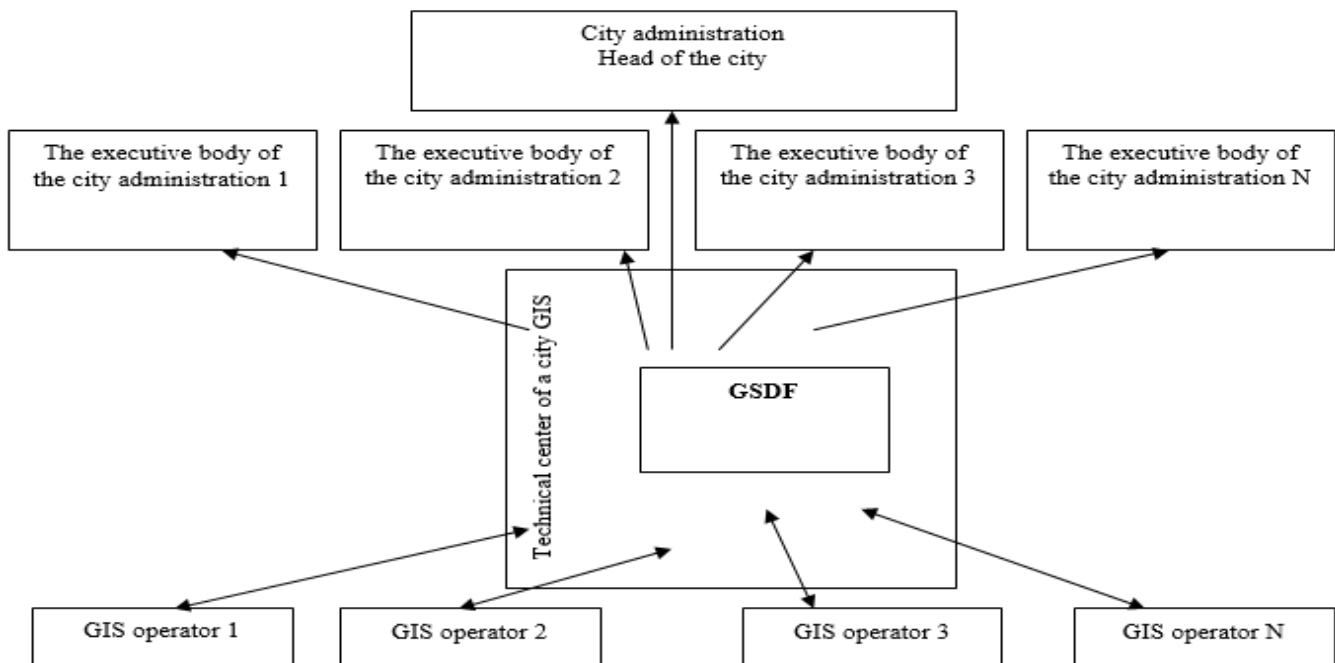

Fig. 1: Structure of a geospatial city data fund

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A city GIS is formed on the basis of a GSDF integrating basic and subdivision data for the operation of a city GIS.The direct executor of the work is the technical center of the city GIS (GIS TC), which is simultaneously responsible for user training, as well as the acceptance, implementation, pilot and commercial operation of new developments. The remaining subjects of the city GIS interact with the GSDF of the city only through the GIS TC.In each city GIS, there is information intended for general use and departmental information used by specific subjects. In order to eliminate duplication of general information, the following principle of the city GIS architecture is proposed:

1. Different city information systems are formed not separately from each other, but on the basis of the city's GSDF.The most important condition for the effective operation of any, especially a large, information system, is to ensure the reliability of the procedures and methods for filling it with information. For this, it is necessary to respect the following principle of the city GIS architecture.

2. The division of a single information databank into separate parts should be carried out so that only one subject (organization-operator) of a city GIS is responsible for each part of the information, which has the exclusive right to make changes to this part of the information field.

This will enable the personification of responsibility for the validity of the information, will ensure the inability to change or delete the entered information by other subjects of the city GIS.

V.DISCUSSION

The use of the city GIS information integrated with other data in combination with the data of departmental information systems makes it possible to rationalize the process of preparing solutions for managerial tasks for the development of the city in various fields of activity (Table 1) [14].

Table 1: Rationalization of the process for the preparation of administrative problem solutions

Scope of activities	Management tasks
Creation of a single urban information space	a) forming sets of geobases and data geobanks, technologies for their support and application, ITC-system networks operating on the basis of general principles and rules; b) ensuring the informational interaction of organizations and the public, including meeting their information needs; c) combining the efforts of research organizations, private and municipal structures in the creation and implementation of GIT, GIS service and support centers.
Social and economic development	a) geo-information support and support for planning, forecasting and managing the development of a city and its districts; b) operational situational assessment and prediction of social tensions in the context of urban areas and population groups.
Ecology, natural resource management	a) planning the levels of natural resource consumption; b) environmental monitoring of the environment; c) forecast and assessment of the consequences of decisions taken in the environmental field.
Transportation, communications	a) assessment of the transport network, telecommunications, and their infrastructure, preparation of projects for the development of the urban transport network.
Municipal services, civil engineering	a) assessing the state of municipal utilities (including individual districts), data collection in order to create programs for the development of the city; b) monitoring the housing stock and life support systems.
Health care, education, culture	a) determining the influence of the environment on public health, creating programs to improve the quality of the environment; b) assessing public health and forecasting the development of health services; c) considering the cultural values; d) providing education; g) tourism support.
Public order, safety	a) reflecting the criminal situation and planning the work of law enforcement agencies; b) supporting the warning system and actions in emergency situations, including the formation of a database of potentially dangerous objects of natural origin and man-made nature, assessment and forecast of the occurrence and consequences of emergency situations.

In general, the city GIS should be created using modern object-oriented GITs, functionally providing the following features:- the accumulation of information in a variable user database and cartographic grounds in the object base of the city's GSDF;- sharing data of the city's GSDF and user data while solving managerial tasks;- visualization of the accumulated data in the form of a screen cartographic image;

- data processing through different methods and interpretation of processing results in the form of various graphic images;- search for data on urban objects by referring to the available information on user requests for data of the city's GSDF with visualization of results;- computer analysis of the urban area and providing the user with the opportunity to draw conclusions and make a decision based on the analysis of the computer-mapping model;- a possibility of modeling, visual display, and detection of patterns in the processes occurring in the urban area;- printing of graphic (including cartographic) documents for informational support of the city authorities, other organizations, people;

- information support for various types of expertise (land, environmental, etc.).

VI. CONCLUSION

Summing up, the following can be noted.

The issue of designing a municipal information system of urban settlements is one of the main problems, because the degree of filling the city budget and the economic attractiveness of the city for potential investors depend on its optimal solution.The municipal information system of the city must work with data that is spatially referenced, and therefore it is necessary to use GIT to create it. As a conceptual model of a city GIS, a multilevel integrated GIS with graphical visualization and interaction with various thematic blocks is proposed, the basis of which is a city's GSDF, including various special and specialized databases. The authors have considered the advantages of using GIS in city management and proposed a structural diagram of a city's GSDF. In general, the use of city GISs will allow tracking a number of processes and solving many issues related to the accounting and management of urban resources.

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