

Conceptual principles of geospatial data geoinformation integration for administrative and economic management of transport infrastructure facilities

Olena Boyko¹, Dmitry Prusov², Borys Chetverikov³, Maria Malanchuk^{3*}

¹National Aviation University, Kyiv, Ukraine

e-mail: boyko_lena@ukr.net; ORCID: <http://orcid.org/0000-0001-8654-9392>

²Kyiv National University of Construction and Architecture, Kyiv, Ukraine

e-mail: d.e.prusov@gmail.com; ORCID: <http://orcid.org/0000-0002-1720-2798>

³Lviv Polytechnic National University, Lviv, Ukraine

e-mail: chetverikov@email.uagmail.com; ORCID: <http://orcid.org/0000-0001-5187-008X>

e-mail: malanchuk.mari@gmail.com; ORCID: <http://orcid.org/0000-0003-0819-6573>

*Corresponding author: Maria Malanchuk, e-mail: malanchuk.mari@gmail.com

Received: 2021-04-13 / Accepted: 2021-12-22

Abstract: In the article publications have been analyzed and summarized on this topic: studied the experience of implementing building information models and geographic information models for administrative and economic management of transport infrastructure facilities on the example of the regional airport activity. After the stage of collecting geospatial data from various sources and sensors, the data is imported into CAD-systems or GIS-systems. Different software products are used to work with both of these models. The processes of data organization in the process of creating building information models and geographic information models differ to some extent. The issues of integration of such models are not yet fully addressed and need to be addressed. In the process of integration of spatial data, solutions to the integration of semantics, topology, formats and standards of geospatial data are needed. An important task is to develop and study the experience of creating software modules that allow you to integrate BIM-models into geographic information systems. Based on the research, it is established that the current area of research is the development of technologies that allow the generation of information from BIM and GIS to create a more interconnected infrastructure. The integration of BIM and GIS information to create a spatial data infrastructure (SDI) is a perspective direction.

Keywords: geospatial data, geoinformation system, transport infrastructure, regional airport, administrative and economic management



The Author(s). 2022 Open Access. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

1. Introduction

The technology of Building Information Modeling (BIM) and data integration building models are actively developing in recent years, and Geographic Information Systems (GIS) opens new possibilities for the construction, maintenance, renovation, modernization of significant infrastructure projects, such as airport facilities, and GIS technology is being used in many areas of society for the collection, storage and processing, spatial planning of the territory, inventory management and geospatial data infrastructure, monitoring and forecasting, asset management and management decisions, etc. This article explores the problem of transformation and developing a GIS for administrative and economic management of transport infrastructure facilities on the example of the regional airport activity, considering the requirements of state standards and modern technologies of geospatial data collection. Airports are complex spatial objects with developed infrastructure, the economic complex of which is a set of land, buildings, structures, utilities, passages, runways, aeronautical equipment, lighting, vehicles, etc.

The relevance of the study is explained by the fact that in many countries of Eastern Europe and the post-Soviet space a number of regional airport development programs have been adopted, in particular, in 2019 have been published The Analytical Report on the state of airport infrastructure, aerodrome equipment, air navigation and radio technical support for aircraft flights of the Eurasian Economic Union Member States on the development programs of the airports of Armenia, Belarus, Kazakhstan, the Kyrgyz Republic, Russia ([Eurasian Economic Union Member States, 2019](#)). In 2016 the Ukrainian State Targeted Airport Development Program for 2023 was adopted, according to which 17 out of 20 operating airports are subject to reconstruction and modernization ([Resolution of Cabinet of Ministers of Ukraine, 2016](#)). Many of the airports, which included in the program are in a state of disrepair. There is no up-to-date mapping, and topographic-geodetic data of the territory, the material and technical base is outdated, the runway and the premises need updating and modernization, no effective monitoring and control system is using modern technologies.

An example of successful implementation of GIS systems in the main and largest international airport of Ukraine – Boryspil, the only airport in Ukraine that has transcontinental status, is Geoportal of Boryspil, which is designed to maintain and manage information resources in order to improve the efficiency and safety of all life processes of the airport ([Geoportal of Boryspil International Airport, 2021](#)). Millions of decisions made every day are based on the findings of a large number of types of information related to the spatial location of objects. Thus, the concept of creating a geographic information system was developed at the Boryspil State Enterprise, which will allow to make management decisions quickly and will allow to optimize the work of the airport. Implementation of the Geoinformation System (GIS) of Boryspil International Airport started in 2018. The system is designed to collect, store, analyze and visualize (issue) spatial infrastructure of the airport to create a single database, which includes a cartographic basis, distribution of land resources, buildings and structures, utilities and telecommunications networks, transport infrastructure. GIS allows airport services to visualize all their assets - terminal buildings, leases, lighting, ground, underground and aboveground

engineering networks. By showing these assets, the GIS displays an overall operational picture of the status of all facilities, helping to effectively monitor the operation of the airport and its services.

This example proves the need for additional research based on modern world and national experience, the possibilities of modern technologies for collecting and processing geospatial data, international and national standards, because the development of a conceptual GIS model specifically for regional airports, and methods of implementing integrated geographic information technologies will allow to effectively manage and develop regional airports. The analysis of existing research, both foreign and domestic, has been carried through several directions: creation of GIS and integration of data between building information models and geoinformation systems; and development and implementation of GIS for administrative and economic management of airports.

The research in the field of geoinformatics is devoted to the articles of many foreign scientists and specialists (Mitchell, 2000; Harrie et al., 2019). In particular, recent publications have focused on the integration of data between building information models (BIM) and GIS, which opens new opportunities for the design of objects and structures, their construction, reconstruction, operation (Prusov, 2012; Kuehne and Andrews, 2016; Dasgupta, 2018; Andrews, 2019). The experience of using geospatial data to support the activities of airports has outlined in (Parrish, and Nowak, 2009; Chen et al., 2012). The practical experience of using GIS in airports could be found in the materials of the magazine ArcReview, which covers the development and implementation of geoinformation systems based on software ArcGIS since 1997 (Gokhman and Glebov, 2013; Vladimirov, 2016). Examples of GIS for managing the property complex of the airports of Houston, USA, Atlanta, USA (Hartsfield-Jackson Airport Representatives, 2016), Los Angeles, USA (LAX Development Program Materials, 2019), Geneva, Switzerland (Peters, 2018), Perth, Australia (Esri and Perth Airport Website, 2016) and others. In addition, the processes of design, construction and operation of modern transport infrastructure should be considered taking into account the principles of urban and spatial planning of urban areas for scientific and technical support of all reconstruction processes and develop recommendations for safe and balanced development of built-up areas, and more efficient use of areas in modern socio-economic conditions (Prusov, 2014).

There are many examples of successful implementation of geoinformation technologies both in Eastern Europe and in Ukraine, which have been implemented for major airports through the collaboration of scientists and practitioners: systems of urban cadaster of settlements, geoportals (political and administrative system, regulatory, monetary valuation of agricultural land, settlements, nature reserve fund, water fund, etc.), geoinformation systems of different levels and purpose (transportation GIS, GIS for the united territorial communities, GIS for housing and communal services, the conception of GIS for regional development, etc.).

Thus, analyzing the available scientific and practical materials, we can conclude that the problem of introduction of geoinformation technologies to manage the administrative and economic complex of regional airports in Ukraine and the countries of the post-Soviet space is still not sufficiently studied and practically not realized. It needs additional re-

search considering the current world and national experience, the possibilities of modern technologies for collecting and processing geospatial data, implemented international and national standards. The development of the GIS conceptual model for regional airports, and methods for the introduction of complex geoinformation technologies will enable effective management and development of regional airports.

The aim of this study is to develop the concept of the airport geoinformation system structure for administrative and economic management and to define the sets of geospatial data of objects and their attribute characteristics, which constitute a single digital topographic basis of the airport, considering the national and international standards.

The objective of this study is the following:

- investigation of the general structure of the airport and its management system;
- analyzing the world and domestic experience in the development and use of administrative and business GIS at airports;
- analyzing the international and national standards using for the Geographic Information/Geomatics series to create the GIS;
- identification of the elements of a single digital topographic base of the airport;
- development of the GIS concept of administrative and economic management of the airport.

GIS analytical tools provide the ability to model and predict certain events that are encountered daily by airport staff. Location analysis and location technology gives airport staff a better understanding of how passengers interact with its facilities, systems and services. It accurately indicates the places where problems need to be resolved. It helps to monitor the operation of many facilities and subsystems of the airport, such as elevators, escalators, parking lots, security and luggage handling systems, as well as boarding exits.

The development of the concept is based on the experience of the development and implementation of similar geoinformation systems in the world's airports and the Borispol airport. The concept was developed for implementation in regional airports and adapted for solving problems that are urgent for small airports in Ukraine.

2. Materials and methods

An analysis of the airport economic complex structure and the general management system is the methodological basis of this research, as well as analysis of the master plans of open access airports; analysis of geoinformation systems implemented at airports in the world, their functions and capabilities (Boyko, 2018); an analysis of the GIS Development Concept of the Boryspil Airport of 2010, developed by the Research Institute of Geodesy and Cartography; regulatory documents on the creation of a single digital topographic base; international and national standards of the Geographic Information/Geomatics series (Cherin, 2019); research on integrating BIM/GIS-technologies (Boyko et al., 2019b). ArcGIS software from Esri (USA) (a world-leading company in the development of geographic information system development tools that meets the essential requirements of international standards) as a software to create a geoinformation system is considered.

The following is necessary for the formation of geospatial data of a single digital topographic database: Complex of standards Topographic database “Rules for encoding and digitally describing vector data” (National Standard of Ukraine 742-33739540 0012, 2010); Topographic Instruction in Scale 1:500 (Order of the Headquarters of Geodesy, Cartography and Cadastre, 1998); topographic symbols in scales 1:500 – 1:5000 (Topographical-Geodetic and Cartographic Activity: Legislative and Regulatory Acts, 2002); substantive provisions of planning and development of territories (State Building Codes of Ukraine, 2019), ICAO requirements (ICAO, 2019) regarding design and operation of aerodromes are used.

In accordance with the State Aviation Service of Ukraine, as of 2019, there are twenty operating airports in Ukraine (Geoportal of the State Aviation Service of Ukraine, 2020). To solve the issue of modernization and reconstruction of regional airports, and bringing its infrastructure in line to the requirements of the International Civil Aviation Organization (International Civil Aviation Organization, ICAO) and modern safety requirements and passenger services, a program at the state level designed and implemented. This program will be done in the 17 regional airports to take a prominent place in transport infrastructure. The structure of the airport is quite complex and includes a large number of different elements, which make up a single, clear and well-functioning complex. All airport buildings and facilities of the complex can be divided into three groups by location and functionality (Fig. 1):

- airport (terminal) – (one or more);
- an airfield that includes runway, taxiways, platforms, airplane parking areas, end and side safety lanes, overburden, deviation pad, engine launch pad, etc.;
- service and technical territory, including hangars, repair shops, fuel and lubricant stores, post and cargo terminals, on-board power supply, transformer substation, compressor station, emergency rescue building, storage facility for motor vehicle transport, vehicle transport bases, radio navigation and communication services, boiler room with reserve fuel warehouse, main mechanic’s workshop building, airfield service base, car access and road repair and construction section, warehouse logistics property, service dining room, building control airport training and the technical unit, command and dispatch station with square plot refueling.

Also, in the infrastructure of the airport are lighting and electronic devices and systems required to ensure the safety of aircraft operations, communication lines, water supply, sewage, etc.

Organizational structure and management systems of airport complexes at different airports differ, depending on the area of the territory, available economic assets, passenger traffic, etc. The system supports both daily and local data updates in the cloud environment to ensure business continuity. Moreover, a number of applications for ArcGIS, including Collector for ArcGIS, Operations Dashboard, Explorer for ArcGIS, ArcGIS Pro and others, created with the help of the Web AppBuilder constructor allow expanding the possibilities of interaction with the system of any employee in the organization at anytime, anywhere and at any device. The experience shows that taking advantage of the ArcGIS platform helps to support the successful operation of the airport and achieve its top priorities: efficiency, high quality of service and safety.

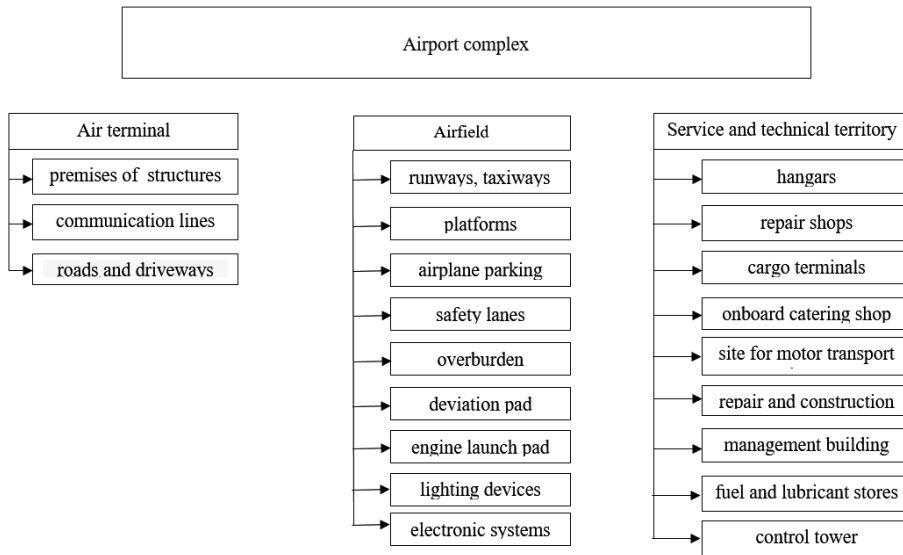


Fig. 1. The constituent structures of the airport complex divided by location and function

Analysis of world experience in the use of GIS at airports for administrative and economic management, could allow be distinguished different groups of users served by GIS: operators, planners, mobile flight crews, repairers and technical personnel for engineering communications and facilities, decision-makers, airport security, contractors, inspectors, passengers, customers and the public. Spatial planning and efficient management of airport infrastructure requires detailed information on the location and condition of their sites, regular collection and accounting of accurate spatial data, and the ability to analyze them.

A generalized scheme of directions of GIS application at airports based on GIS analysis of administrative and economic complexes of airports of the world, could be formed (Fig. 2):

- property management and rent control;
- warehouse management;
- capacity estimation and planning and passenger flow calculation;
- vehicle fleet management (equipment monitoring, cost accounting and fuel spill);
- terminal management;
- setting boundaries and checkpoints;
- reconstruction of the airfield complex;
- business services;
- ensuring the safety of the aerodrome complex;
- transit service, etc.

For the main areas of GIS using, the following can be distinguished:

- general management of the airport complex, management of assets and resources of the airport, operation, monitoring, spatial planning, reconstruction and construction;

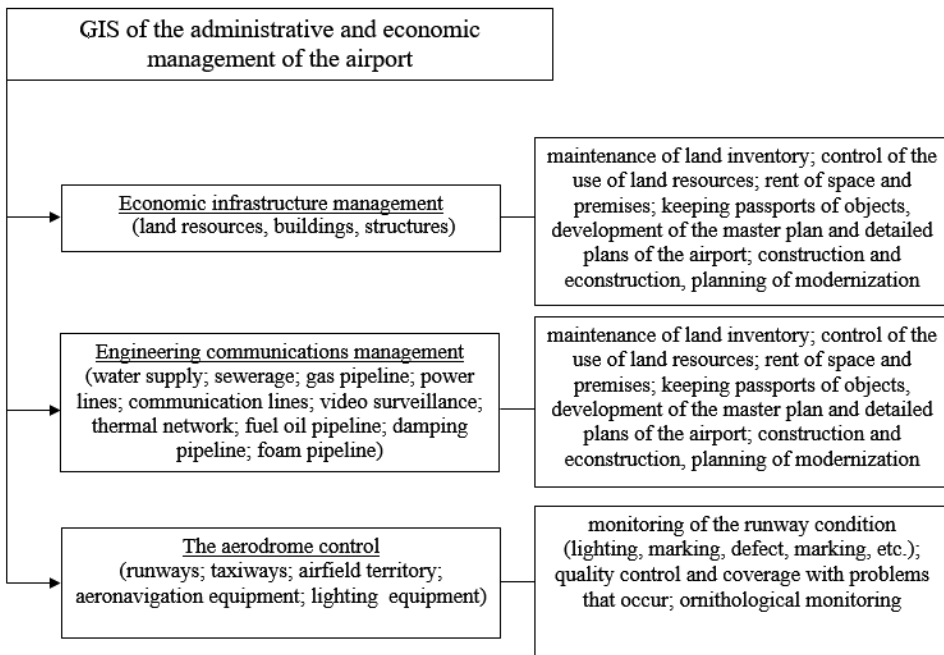


Fig. 2. Generalized scheme of directions of GIS application at airports

- management of the airfield as a component in the structure of the airport complex;
- management of business infrastructure that includes real estate and engineering communications.

Collection, processing, analysis and provision of necessary data from a typical array of geospatial data is possible through the introduction of geographic information systems that provide a single information space that operates on the basis of general principles and general rules. The use of uniform requirements and standards ensures the interaction of all subjects of the management system, as well as meeting its needs; promotes topological, communication and interoperability of information systems and registers at the airport; eliminates duplication of work on the formation and support of information resources and cost savings.

The development of the airport geo-information system concept should be implemented in accordance with international and national standards, as well as the European geospatial data infrastructure (INSPIRE), which aims at creating a European Union spatial data infrastructure for EU environmental policy. According to the INSPIRE Directive, regulations should be implemented by the INSPIRE Implementing Rules in the following areas: metadata, data specification, interoperability of data and services, network services, monitoring and reporting. Integration of information about objects collected from different sources is ensured by the use of unified object catalogues and classifiers, unified object identifiers, unified address links using unified registers, a single digital topographic basis of the territory (Cherin, 2019).

Meeting international standards ISO 19100 “Geographic information/Geomatics” provides data usage through international projects, access to open data, services and applications that can be easily integrated without the need for refinement and based on common standards and concepts of modern information technology. Compliance with Ukrainian standards “Geographic Information. Reference Model”, “Geospatial Data Modeling Rules”, standards system “Topographic Database” provides the creation, integration and accumulation of data across different units and organizations, allows to use the accumulated data and integrate it into a single information array; provides information and interoperability of system components within the National Geospatial Data Infrastructure based on a unified structure, unified system for classification and coding of topographic objects and their attributes, rules for the digital description of vector data and digital terrain models, metadata for topographic objects and topographic data sets, export/import formats of topographic data in the process of information components interaction in the system environment and with other systems.

The basis of the geoinformation system of the administrative and economic management of the airport is the Unified digital topographic basis of the territory and adjacent areas, which is formed as a geodatabase and includes basic and thematic datasets of spatial objects with attribute information, search, filtering, sorting, scaling and viewing geospatial data tools. Today, there is a wide range of geospatial data collection technologies using modern technologies: GNSS observations, total station surveying, according to aerial photography, laser and lidar scanning, georadar shooting, etc. When choosing the technology for collecting location data, it is necessary to consider the area of the territory, the intensity of the airport, traffic levels of the runways (Boyko et al., 2019a). The base set of geospatial data forms the core of geographic information resources through which all other geospatial data (attribute, profile, case) are spatially and thematically united. Base kits should be stored in an integrated repository that collects, updates, and provides general-purpose geospatial information. Raw data sets of the geospatial data of the airport include information resources of the Uniform Digital Topographic Basis: mathematical and geodetic foundations; digital topographic base ground and underground parts of the airport (digital bitmap and vector models of topographic plans of the territory in scale 1:2000 and 1:500); digital orthophoto maps; aerial and satellite imagery, lidar data capture; digital relief model (DRM) and digital terrain model (DTM); terrestrial laser scanning data.

Geospatial datasets include all types of geographic data that are created using basic datasets and meet the requirements of standards of geographic information and metadata placed in the information environment in accordance with the principles and rules of access and use of geographic information resources. Thematic geospatial data sets of the airport include:

- land boundaries with cadastral numbers, owners and operational data;
- geospatial data of all engineering networks and structures with characteristics;
- registers of artificial coverings;
- register of buildings and structures with characteristics;
- geospatial models of all thematic zones at the airport territory;
- register of high-altitude objects and obstacles;

- geospatial object models of all registers created and maintained by major GIS core entities with attributes of identification, address binding, purpose and functional use.

Geospatial profile sets could also be generated by extending the attributes of the underlying set objects while maintaining coordinate-spatial and topological compatibility. Figure 3 presents the generalized scheme of the database composition of the Unified digital topographic airport base, basic and profile geoinformation resources, that developed as a result of the research.

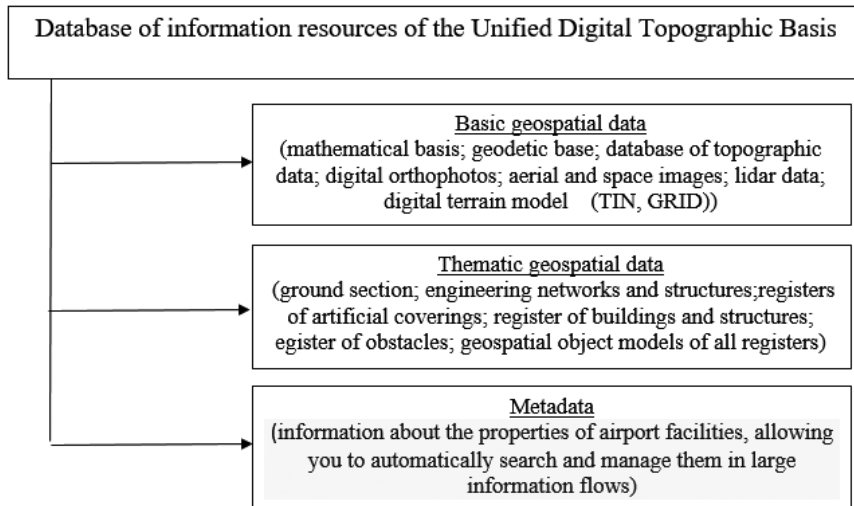


Fig. 3. The database scheme of the Unified digital topographic airport base

Spatial binding of individual objects could also be performed using the following source materials:

- the master plan of the airport;
- digital base plan of the airport;
- land inventory materials;
- materials of land plots allotment of the past years;
- executive shoot materials.

It is necessary to monitor the spatial and topological consistency, with the geometry of the objects contained in the Uniform Digital Topographic Base during registering the spatial location of new objects and their spatial referencing using a digital topographic plan.

3. Results

As a result of the performed research, it has been established the following:

- all structures and objects of the airport complex have been structured, thematic blocks have been identified, and components have been allocated by location and

functional purpose for the development of the conceptual model of GIS administrative and economic complex: business infrastructure block, utility network and communications block, airfield control unit;

- application tasks and a set of functions for GIS of administrative and economic management of the airport have been established;
- a generalized scheme of directions of GIS application in airports has been developed;
- the list of standards, as requirements in the development of GIS for the administrative and economical airport management has been identified, as well as the necessity of using international and national standards of the series “Geographic Information/Geomatics” in creating the GIS of the airport has been established;
- the list of basic and profile sets of geospatial data of the digital topographic basis of the airport has been formed, and a generic scheme for the composition of the database of the Unified Digital Topographic Base of the Airport has been developed;
- the conceptual model of the structure and functional purpose of GIS for administrative and economical airport management has been suggested and developed.

In recent years the application of the proposed conceptual model is the scientific basis for the development and implementation of GIS for the management of the regional airports economic complex, which has improve its infrastructure and management system at Eastern Europe countries. World experience shows that the implementation of such geo-information systems increases the efficiency of available assets and resources using, provides control over the operation of airport infrastructure facilities, and flight safety by monitoring the runway, etc.

The proposed conceptual model would optimize and increase the efficiency of the airport and its services, reduce the time of design and operational work, improving the quality of data collection, processing and systematization. In further works on the basis of realization of the developed scientific and methodical conceptual model of structure and functional purpose will allow:

- provide opportunities for monitoring of all property assets (from buildings, structures, utilities to the runway conditions);
- expand opportunities for access to geospatial data and its analysis for representatives of all interested airport services;
- provide opportunities for improving the property management efficiency;
- promote the development of air transportation, accounting and forecasting of passenger flows;
- have a positive economic effect on the development of regional airports;
- support and provide the system of designing and planning the development of regional infrastructure with the development of new regulations for solving the urgent tasks.

The proposed conceptual principles of geospatial data geoinformation integration reflects the main production processes and needs of airports, based on the database of the Unified Digital Topographic Basis. Also it is a coherent and consistent model of the relationship between the administrative and economic needs of airports and the

functionality of modern geoinformation systems for the efficient operation of facilities, structures and engineering communications, analysis of the existing state, monitoring and management decision-making (Fig. 4), and to create three geographic information subsystem on the Unified Digital Topographic Basis in the conceptual model for effective management of the airport complex:

- 1) the management of economic infrastructure, which includes thematic data on land resources (land boundaries, their area, purpose and functional use, distribution by users, property rights, restricted zones and encumbrances, etc.), and real estate data (contours of buildings and structures with quality characteristics, areas, passport data and functional use). This subsystem aims at maintaining land cadastre, controlling land use, leasing premises, developing a master plan, planning for modernization and reconstruction, etc.;
- 2) the management of engineering communications, which includes thematic data on engineering networks (water supply, household, pressure, drainage and drainage sewerage, gas pipeline, cable sewage of telecommunication and communication lines, video surveillance system, thermal network, electrical network, fuel oil, gas pipeline, foam). This subsystem aims at monitoring, operation and reconstruction of utility networks;
- 3) the aerodrome management, which includes thematic data about runways and taxiways, cover and state, lighting and air navigation equipment, etc. This subsystem aims to monitor the state of the aerodrome and runway (lighting, marking, defect, marking, etc.), quality control of the cover with fixing problems that occur, etc.

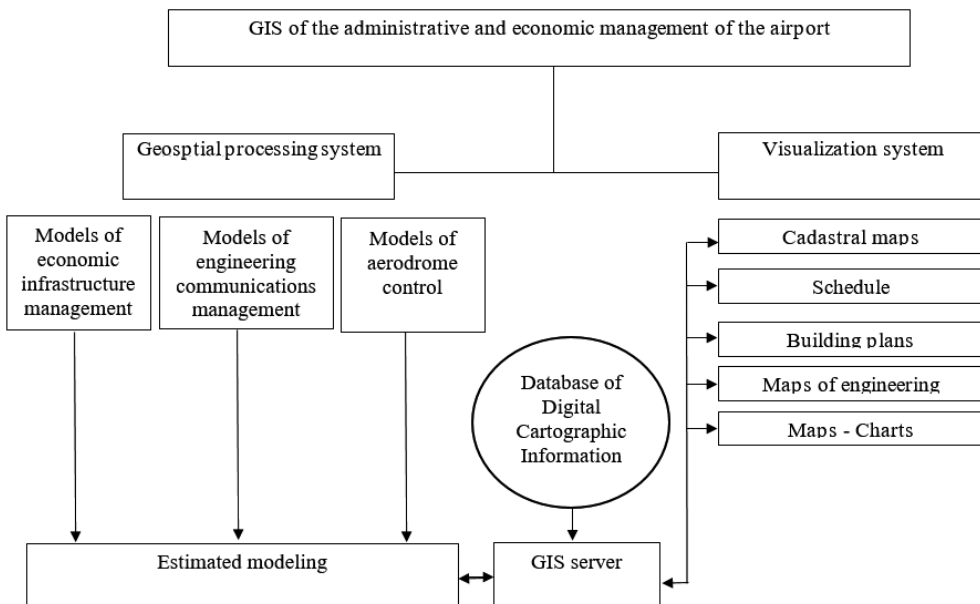


Fig. 4. Conceptual model of the structure and functional purpose of the geoinformation system for administrative and economic management of the airport

For developing the concept, the main functions and capabilities of GIS have been identified, which should be implemented for the administrative and economic management of the airport:

- management of large data sets and different types of information about objects that are subordinate to different services on the Unified digital topographic basis;
- solving tasks related to forecasting, planning and modelling;
- solving complex problems related to spatial planning, reconstruction, construction, operation of objects and structures;
- centralized storage and administration of data.

The applied tasks that are solved by the administrative and economic GIS of the airports are as follows:

- providing up-to-date information to the structural units of the airport regarding the location and condition of the engineering systems, areas of structures and other objects;
- monitoring of land use and protection;
- operation of buildings, structures, utilities and communications;
- visualization of all assets in 2D and 3D;
- integration of information modelling of buildings and structures for further operation and reconstruction.

The leading software for the creation of the geo-information system of the airport is ArcGis software by Esri Company (USA). That is world's leading company for the development of tools for the creation of geographical information system, which meets the basic requirements of international standards. The ArcGIS software enables interoperability with other airport and state geographic information systems within the National Geospatial Data Infrastructure.

Using the classifier of topographic information and the standards of the topographic data base "Rules for coding and digital description of vector data", a list of object names for classification of subsystems, classification groupings and their code designations was formed, Table 1. The rules for coding and digital description of vector data determine

Table 1. Objects of GIS classification of airport management

Object code	Classification object name	Signs that characterize object of classification
1	2	3
Economic infrastructure management subsystem		
11500000	the boundaries of the administrative-territorial structure and other territorial entities	
13000000	boundary signs – boundary pillars	the character of the location, number
40000000	buildings (ground parts of underground structures, entrances to underground parts of buildings, stairs for climbing various buildings, overhanging parts of houses, basements)	explanatory inscription, condition, building material, nature of fire resistance, number of floors, explanatory inscription, the character of the location of objects relative to the earth's surface
92000000	fences	type of fence, relative height

Table 1 [cont.]

Object code	Classification object name	Signs that characterize object of classification
1	2	3
Engineering communications management subsystem		
51310000	pipelines (plumbing, sewerage, gas pipeline, ductless district heating, special pipelines)	condition, nature of the object's location relative to the earth's (water) surface, number of transmission lines or pipes, pipe diameter, explanatory inscription, pipe material, pressure
51320000	power lines (power lines, places of transition from overhead power lines to cable underground power lines, underground electric cables, electrical cabinets, transformers on poles and pedestals, transformer booths, electrical substations)	condition, voltage, number of transmission lines, pipes cables, explanatory inscription, pipe material, building material, item number, explanatory inscription
51330000	communication lines (communication lines, transitions from overhead lines to underground cable lines, underground cable communication lines, telephone booths, telephone distribution cabinets)	condition, explanatory inscription, number of wires, cables, explanatory inscription, pipe material
51360000	buildings on pipelines (inspection wells, waste gratings, basement hatches, cable posts – gatehouses, covers, latches, plugs, inspection bunkers and booths, control and distribution booths)	absolute height (m), the character of the object location relative to the earth's (water) surface, an explanatory inscription, the mark of the hatch ring, the mark of the top of the pipe, the mark of the bottom, the hatch number, the camera, absolute height (m), an explanatory inscription, the hatch number, the camera, the character of the object location relative to the Earth's (water) surface
51370000	collectors, channels (box, collectors, channels, an impassable channels, a semi-pass channels, a pass-through channels, protective tube)	building material, explanatory inscription,
The aerodrome control subsystem		
53000000	socio-cultural facilities	
53100000	air transport facilities	type of building, condition and material of the building, proper name

the unified structure and composition of the presentation of the spatial characteristics of objects and their attributes in databases.

4. Discussions

This study has been limited to the conceptual foundation development of the regional airport geoinformation system structure for administrative and economic management and generalization of its functions. The performed research is the basis for further devel-

opment of the logical and physical model of airport GIS. The conducted research is also an integral part of the following:

- introduction of modern high-precision methods of collecting and processing geospatial data of the airport territory to create the Unified digital topographic base;
- integration of BIM/GIS models of airports buildings and structures;
- development of logical, physical and technological models of GIS-system and its subsystems;
- determination of the list of attribute data for each object;
- use of GIS-system for operation and reconstruction of the airport.

The research has a practical direction, focused on the introduction of geoinformation technologies for managing the economic complex of the airport, improving the method of engineering and geodetic surveys and the collection of geospatial data.

5. Conclusions

The proposed conceptual scheme of integration of geospatial data of the airport or any transport facility, based on a combined BIM/GIS approach can be used in engineering and geodetic surveys to collect geospatial data in spatial planning, design, construction and reconstruction that is, throughout the life cycle of the transport infrastructure.

The proposed conceptual framework can also be used in the development of master plans and detailed planning projects as the main documents that identify and solve problems of integrated spatial planning, as well as as a basis for scientific and technical justification of decisions on design, construction and operation of modern transport infrastructure. based on the creation and development of effective geographic information technologies.

In general, the proposed conceptual framework for the integration of geospatial data of transport infrastructure, including airports, is aimed at developing principles of territorial management taking into account modern urban, architectural, environmental and design requirements for the preservation and development of modern transport infrastructure and ensuring their normal and safe operation. Taking into account new conditions of land use and development of territories, with transformation of processes of design, construction and operation of modern objects of transport infrastructure on the basis of improvement of the newest digital technologies, scientific and technical substantiation of the basic stages of process of modern territorial development, efficiency and degree of realization of town-planning decisions. on the basis of creation and development of effective methods as a basis of design and planning works for the purpose of increase of quality of their development and validity of the accepted decisions.

Author contributions

Conceptualization: O.B; Methodology development: D.P; Writing – original draft: B.Ch; Writing – review and editing: M.M.

Data availability statement

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an ongoing study.

Acknowledgements

The manuscript does not have external funds.

References

- Andrews, C. (2019). Myths and Realities of BIM-GIS Integration. Resources for geoenvironment users. <https://uk.geofumadas.com/%D0%9C%D1%96%D1%84%D0%B8-5-96%D1%97-5-97-bim-gis/>.
- Boyko, O. (2018). Geoinformation Systems of ArcGIS Airport Complexes. *Urban Plan. Territor. Plan.: Sci. Tech. Proc.*, KNUCA, 68, 656–665.
- Boyko, O., Lyashenko, D. and Prusov, D. (2019a). Conceptual fundamentals of airport BIM/GIS spatial data integration received by laser scan. *Journal of Chernihiv National University of Technology*, 4(18), 238–246. (in Ukrainian).
- Boyko, O., Lyashenko, D., and Gorb, O. (2019b). Development of a conceptual model for the collection of geospatial data of airports by laser scanning methods for GIS creation. *Urban Plan. Territor. Plan.: Sci. Tech. Collect.*, KNUCA, 71, 60–71.
- Chen, W., Yuan, J., and Li, M. (2012). Application of GIS/GPS in Shanghai Airport pavement management system. *Procedia Eng.*, 29, 2322–2326. DOI: 10.1016/j.proeng.2012.01.308.
- Cherin, A. (2019). Ukrainian and international standards and specifications for the construction of modern GIS and geoportals. Retrieved 2021, from <https://softpro.ua/ua/ukraiynski-ta-mijnarodni-standarti-i-specifikacii-pobudovi-suchasnih-gis-ta-geoportaliv>.
- Dasgupta, A. (2018). Integration of BIM and geospatial systems still a distant dream. *Geospatial World Magazine*. Retrieved 2021, from <https://www.geospatialworld.net/article/integration-of-bim-and-geospatial-systems-still-a-distant-dream/>.
- Esri and Perth Airport Website (2016). Perth International Airport in Australia. Enterprise-wide access to location-based data and analytics. *ArcRev.*, 1(76).
- Eurasian Economic Union Member States (2019). The Analytical Report on the state of airport infrastructure, aerodrome equipment, air navigation and radio technical support for aircraft flights of the Eurasian Economic Union Member States. Retrieved 2021, from <https://www.eurasiancommission.org/ru/act/energetikaiinf/transport/air/Documents/Preview.pdf>.
- Geoportal of the State Aviation Service of Ukraine (2020). Retrieved 2021, from <https://avia.gov.ua>.
- Geoportal of Boryspil International Airport (2021). *ArcGIS magazine*, 1(1), 34–37. Retrieved 2021, from https://ecomm.in.ua/sites/default/files/2021-10/arc-gs-chasopis_1.pdf.
- Gokhman, V.V. and Glebov, S.E. (2013). Airports around the World rely on the Power of GIS. *ArcRev.*, 3(66).
- Harrie, L., Huang, W., Raza, S. et al. (2019). Assessment and benchmarking of spatially enabled RDF stores for the next generation of spatial data infrastructure. *ISPRS Int. J. Geo-Inf.*, 8, 310. DOI: 10.3390/ijgi800310.
- Hartsfield-Jackson Airport Representatives (2016). World's Largest Airport Flies High with GIS. *ArcRev.*, 1(76).

- ICAO (2019). Annex 14 to the convention on international civil aviation, Volume I, Design and Operation of Aerodromes. Retrieved 2021, from: https://tdmegasprom.ru/uploads/images/ikao_prilozhenie-14_tom-1_aerodromy.pdf.
- Kuehne, D. and Andrews, C. (2016). Increasing interest in the fusion of GIS and BIM. Retrieved 2021, from Arcgis Blog of Esri <https://www.esri.com/arcgis-blog/products/3d-gis/3d-gis/increasing-interest-in-the-fusion-of-gis-and-bim/>.
- LAX Development Program Materials (2019). GIS as a Strategic Component of Extensive Modernization at LAX. *ArcRev.*, 2(89).
- Mitchell, A. (2000). *GIS Analysis Guide. Part 1: Spatial models and relationships*. The Esri Guide to GIS Analysis, Second Edition.
- National Standard of Ukraine 742-33739540 0012 (2010). Complex of standards topographic database. Rules for encoding and digitally describing vector data, 2. Retrieved 2021, from <http://gki.com.ua/ua/tehnichni-komitet-103>.
- Order of the Headquarters of Geodesy, Cartography and Cadastre at the Cabinet of Ministers of Ukraine No. 56 (1998). Topographic Instruction in Scales 1:5000, 1:2000, 1:1000 and 1:500. Retrieved 2021, from <https://zakon.rada.gov.ua/laws/show/z0393-98?lang=ru>.
- Parrish, Ch., and Nowak, R. (2009). Improved Approach to Lidar Airport Obstruction Surveying Using Full-Waveform Data. *J. Surv. Eng.*, 135(2). DOI: 10.1061/(ASCE)0733-9453(2009)135:2(72).
- Peters, J. (2018). Location Intelligence Saves Geneva Airport Millions. *ArcRev.*, 3(86).
- Prusov, D. (2012). Numerical research of the retaining constructions during reconstruction of the transport structures. *Transport*, 27(4), 357–363. DOI: 10.3846/16484142.2012.750623.
- Prusov, D. (2014). The Concept of the Urban Areas Reconstruction Planning on the Basis of the Scientific and Engineering Substantiation. *Proc. Nat. Aviat. Univ.*, 60(3), 54–58. DOI: 10.18372/2306-1472.60.7565.
- Resolution of the Cabinet of Ministers of Ukraine (2016). Resolution of the Cabinet of Ministers of Ukraine, No. 126. State target program for airport development for the period up to 2023. Retrieved 2021, from <https://zakon.rada.gov.ua/laws/show/126-2016-%D0%BF>.
- State Building Codes of Ukraine (2019). DBN B.2.2-12:2019. Planning and Development of Territories. Retrieved 2021, from https://dbn.co.ua/load/normativy/dbn/b_2_2_12/1-1-0-1802.
- Topographical-Geodetic and Cartographic Activity: Legislative and Regulatory Acts (2002). Part 2. Vynytsia: Anteks 656 ps.
- Vladimirov, I. (2016). The main decisions to create a geographic information system of the airport. Retrieved 2021, Electronic Resource Esri from <https://www.slideshare.net/IevgenVladimirov/esri-60108995>.