Information Tools for Project Management of the Building Territory at the Stage of Urban Planning

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Abstract

The article deals with the problems of project management of the building territory at the stage of urban planning. The model of building territory planning project is presented as an integrated system, which consumes information from the environment and transmits information about its state to the environment to increase its information potential. In the study process of urban planning is carried out in four stages. The decision-making algorithm for territory planning project at the stage of urban design is developed. The study considers eight stages of the lifecycle of building territory based on BIM technology. There are conceptual BIM-models of data storage and data exchange for consolidation of information of different automated systems. Central Project Database for comprehensive information support of the territory planning project is given. The application of integrated BIM management for urban infrastructure is presented.

Keywords [1]

BIM project, IT for urban planning, common data environment, central project database

1. Introduction

Complex construction projects are becoming an important direction in the formation of sound economic decisions when assessing the possibilities of introducing innovative information technologies. An example of such an innovation is BIM technology, information support for urban planning. The idea of BIM was born in the 70s of the XX century and has been actively developing since then. BIM technologies belong to the CALS (Continuous Acquisition and Lifecycle Support) family of technologies, which are aimed at continuous information support of supply and product lifecycle. Unlike other representatives of the CALS family, BIM technologies operate with visual infographic presentation of models. An infographic model is an information model of an object or process, which is specified in terms of geometry and graphics (images of abstract space, figures and bodies of real space, etc.). Such a representation makes it possible to impose various interpretations of its functional content on the precise description of the object's shape [1].

The use of BIM-technology involves working directly with a building model from any type (plans, sections, specifications) with the ability to make automatically synchronized changes. Due to the interdependence of all elements, the model is correctly updated and allows automatically generating updated project documentation.

By creating an accurate digital information model of an object, the integrated information common data environment (CDE) enables all participants in the investment and construction process, according to the regulations, to receive the necessary information about the construction- design-modernization object at any time. At the expense of CDE, BIM technology allows the investor to

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control the use and expenditure of funds at all stages of the building project, and the combination with the life cycle of the territory allows to take into account the changes introduced by changes in the characteristics of the territory in the parameters of the building and vice versa. The territory of the building, depending on its geographical location, climate and other factors, requires additional research to ensure its safe construction and operation. The analysis of literature sources [2-9] allowed classifying the requirements for the layout of the elements of general planning and the main environmental factors that affect their location. The authors of [10, 11] propose models by which it is proposed to specify information flows to achieve consistency in all elements of the automated system. In the works of specialists [12, 13] the prospects of creating integrated and specialized data warehouses on all aspects of the municipal economy are considered. This topic was further developed in the manuscripts [14, 15], in which the infrastructure of three-dimensional spatial data includes the mechanism of accessibility, standardization, accumulation of information exchange, taking into account primarily geo data about the study area by terrain, hydrology, engineering networks and administrative boundaries. Information support of DB is formed by both primary and secondary data. The authors of [16, 17] propose information models of construction object on BIM-Based Design. The accuracy of the primary data determines the resolution parameter when conducting photo fixation, probing, scanning and other types of measurements [18-30].

The purpose of the article is to develop of information tools for project management of the building territory at the stage of urban planning based on BIM technologies.

2. Theoretical Studies

Building territory should be considered as a complex open system. For a system to operate and interact with the external environment, it must consume information from the environment and transmit information about its state to the environment to increase its information potential. The scheme of the interaction of the building territory with the external environment is shown in Fig. 2.

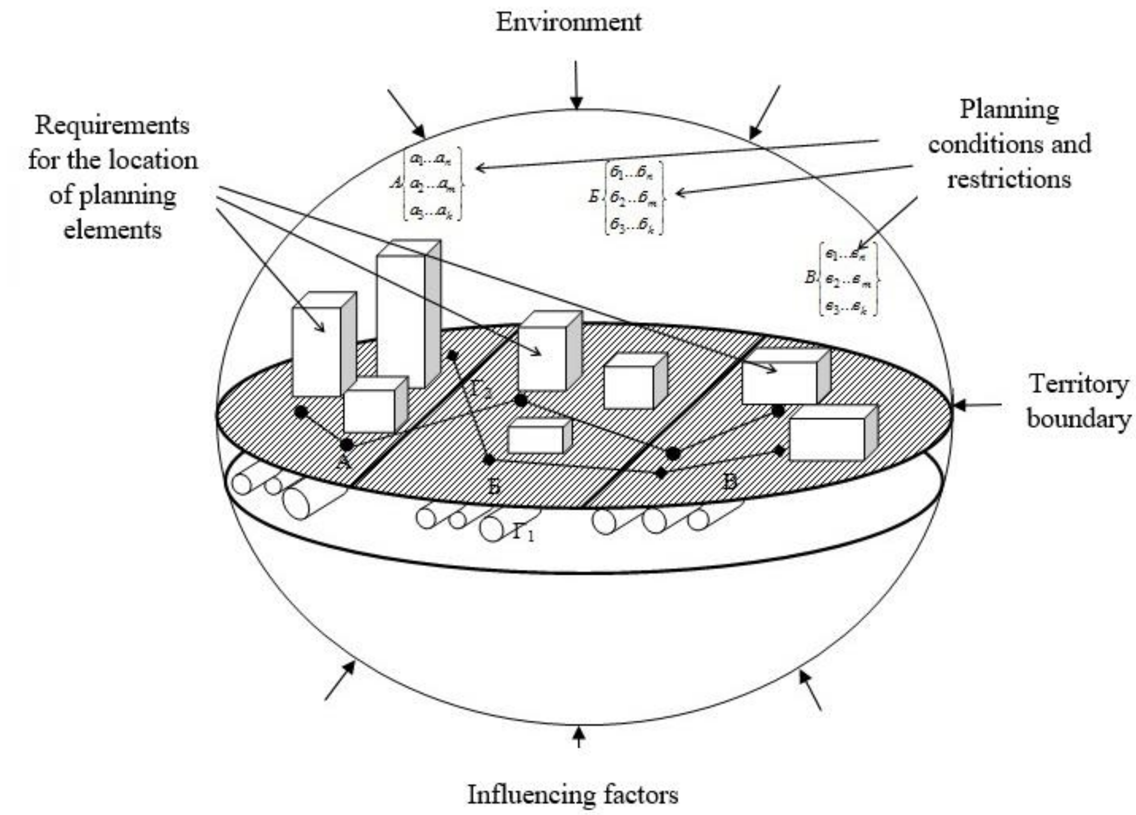


Figure 1: Scheme of interaction of the building territory with the external environment

Thus, the area intended for development is considered as a logical geospace and is a source of information about the location of planning elements. The assessment of the suitability or unsuitability of the site for development can be based on one of the factors provided in the studies, and a combination of them. Factors influencing the structure of planning restrictions on land use:

$$f\ (x_i) = f\ (x_1, x_2, x\ldots, x_n) \rightarrow \begin{Bmatrix} a_1, \ldots, a_n \\ b_1, \ldots, b_n \\ c_1, \ldots, c_n \end{Bmatrix} \quad (1)$$

where $f(x_i)$ is a function of the suitability of the building territory; $x_1, x_2, \ldots, x_n$ are factors of influence; $a_1, \ldots. a_n$, $b_1, \ldots. b_n$, $c_1, \ldots. c_n$ are planning constraints.

The study of information data to solve the problems of land planning allows us to propose a functional model of planning the territory for construction project, which is presented in Fig. 2.

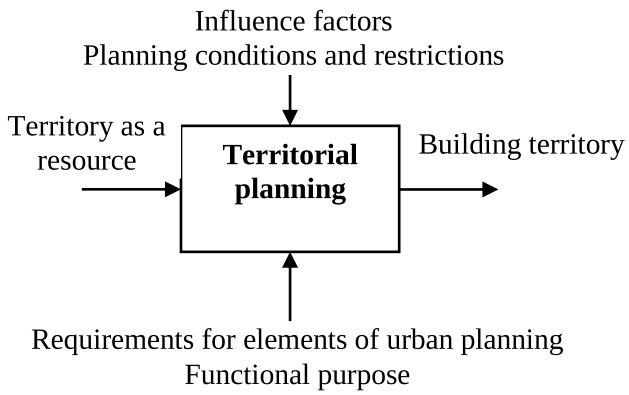


Figure 2: Functional model of the territory planning for construction project

Decision-making algorithm for territory planning project at the stage of urban design is shown in Fig. 3. Project implementation has four stages.

Stage I is obtaining initial data.

Initial data for creating a digital terrain model (DTM) serve as the basis for making decisions on the master-planning of the building territory. They can be obtained in two ways: from open sources and based on the results of existing engineering and topographic surveys and raster images of the relief. Today there are many open sources of information on the Internet. They can be both paid and free. The files with information about the terrain mainly have the extension STRM (Shuttle Radar Topography Mission) is radar topographic survey of most of the globe. Existing DWG data must be processed in AutoCAD Civil 3D to create a TIN surface. Here it is necessary to analyse what objects the terrain survey consists of and what attributes these objects have. Data presented in the form of raster images must first be processed in AutoCAD Raster Design, resulting in objects with the necessary attributes, and then, with the AutoCAD Civil 3D tools, to obtain a TIN surface.

Thus, the result of stage I is to obtain a TIN surface for preliminary modelling of building territory.

Stage II is assessment and analysis of the resulting DTM.

After obtaining the TIN surface, it is necessary to analyse it for elevation differences, the nature of the relief and the type of terrain. To determine the preliminary mark of Master-planning, it is mainly necessary to be guided by the balance of earth masses. As a rule, at this stage there is no data from engineering-geodetic and engineering-geological surveys. After receiving data on complex engineering surveys, the elevation of the master planning can be adjusted.

Stage II should result in a clear understanding of the complexity of the terrain, preliminary marking of master planning, preliminary volumes of earthworks, solutions for strengthening slopes in vertical planning, as well as preliminary solutions for the engineering arrangement of the Building territory.

Stage III is clarification of the mark of the master planning according to the results of obtaining topographic surveys.

After receiving the engineering survey data, it is necessary to correct the existing TIN surface obtained in stage I. The data is processed in AutoCAD Civil 3D and loaded into the existing surface. After that, it is necessary to adjust the mark of the master planning, based on the conditions that were described above. Stage III should result in a corrected TIN surface, as well as the amount of earthwork.

Stage IV is the correction of the model based on geological data.

Geological data can have a significant impact on the choice of the building territory master plan elevation. Buildings and structures cannot be placed on "weak" soils without appropriate measures concerning the foundation and the soil itself. Therefore, for further design stages (Design Documentation and Working Documentation), it is necessary to obtain geological information on the types and characteristics of soils. In this regard, it is necessary to create a working geological 3D model of the Building territory. For this, it is recommended to use the Geotechnical Module software product. With its help, layer-by-layer TIN surfaces are obtained for each soil. After creating a geological 3D model, it is necessary to adjust the master level elevation again, taking into account the working geological model.

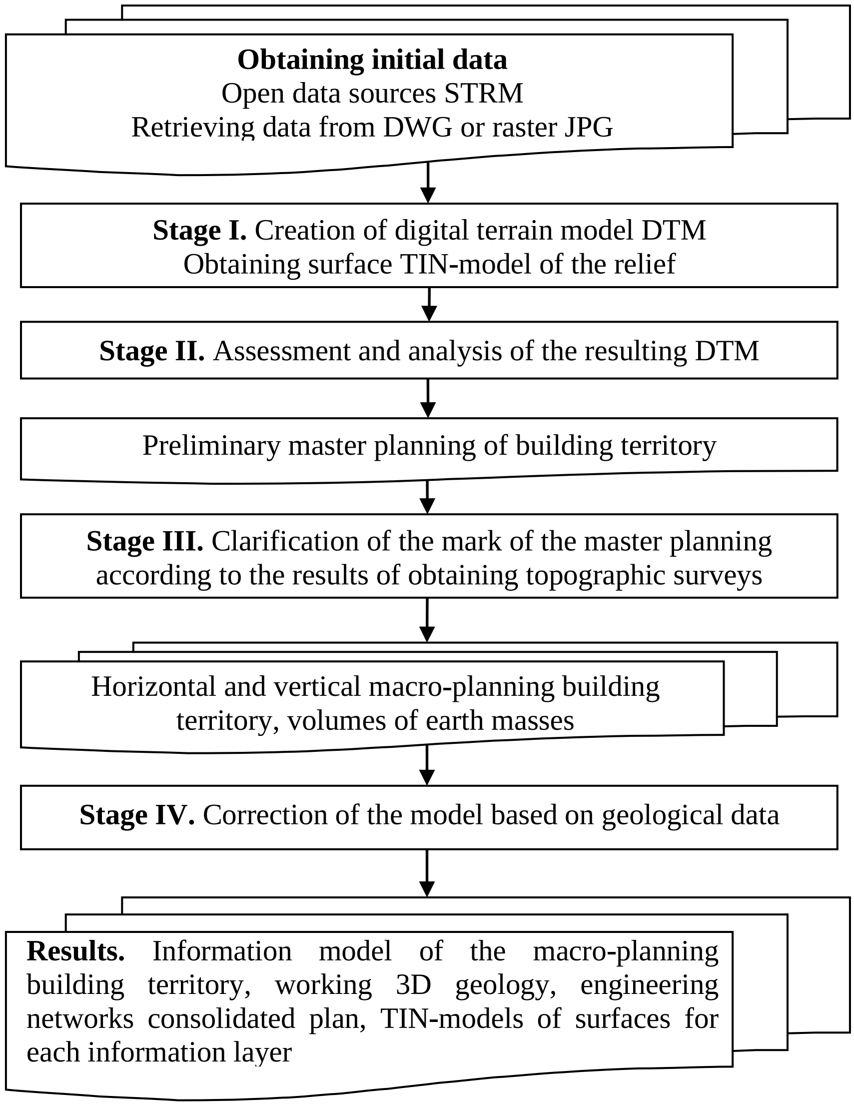
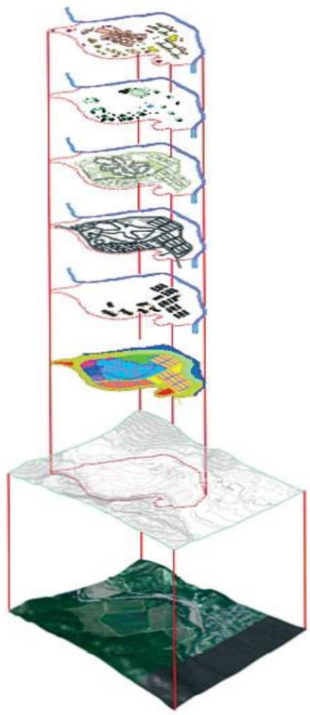


Figure 3: Decision-making algorithm for territory planning project at the stage of urban design Decision-making algorithm for territory planning project at the stage of urban design

3. Information model of the territory planning project at the stage of urban design

The data system required for the formation of the territory of urban planning design is shown in the table 1. The introduction of such a model of the territory with the objects to be placed and the accompanying infrastructure allows expanding the capabilities of BIM technology and increasing the efficiency of the design and construction process.

Table 1
Information model of the territory planning project at the stage of urban design

Information content of the territory planning project		Information layers of spatial data
Stage 1. Assessment of the current situation and prerequisites for the development of the territory	Existing use of the territory and prerequisites for its development	
	The current state and prerequisites for the development of transport services for the territory	
	The current state and prerequisites for engineering support of the territory	
	Functional planning organization of the planning territory	
Stage 2. Urban planning documentation (project proposals)	Plan of architectural and planning organization of the planning territory	
	Transport service of the planning territory	
	Engineering support of the planning territory	
	Architectural planning solution	
	Proposals for the preservation, development and limitation of the use of land plots in zones with special conditions of use	

This model in the table 1 makes it possible to establish relations between the design stages: pre-design, design and the stage of working documentation, which makes it possible to manage the quality of territory planning project. In the course of studying the possibilities of using BIM-technology in master planning, the software AutoCAD Civil 3D was used in the implementation of the project for planning the territory.

At the same time, the possibilities of the software package were studied for solving problems of developing urban planning documentation, such as:

- formation of a package of documentation for a territory planning project in a single file with the integration of various information layers according to the relevant sections;
- binding the planning solution to the geo-digital terrain model;
- development of interrelated materials to justify the spatial planning solution;

The functional and planning solutions of the territory, made in conjunction with a digital terrain model with data from satellite elevation survey, is shown in information model of the territorial cluster of urban planning.

Binding to elevations of buildings and structures, roadways, utilities allows forming a ready-made planning solution in one file, as well as all accompanying sections for the project stage. This serves as the basis for further BIM-modeling of each of the buildings with vertical and horizontal reference to a specific territory with certain parameters. Thus, a digital model of the projected territory is created, which is the basis for the development of the planning solution itself and the materials for justification, requiring reference to elevation marks and integrated into a single constructive, engineering and technological solution.

In accordance with the developed information model in table 1, stage 2 of materials for substantiating the functional planning solution for the territory of the educational centre includes the following information layers, performed in one digital mod-el of the projected territory.

Information layer № 1 is the scheme of transport services, the development of which includes:

- routing of the road network of the projected territory in relation to the elevation marks of the buildings being placed and the existing relief with the appointment of slopes and parameters of the transverse and longitudinal profiles in accordance with the standards of urban planning;
- linking the entrances-exits from the territory to the external street network;
- automatically built longitudinal and transverse profiles, as well as vertical lay-out of the road network, output of black and red marks of trays.

Information layer №2 is the scheme of engineering support of the territory with containing:

- the scheme of the vertical planning of the territory with reference to the tracing of the road network and engineering communications;
- a summary plan of engineering networks with marks of laying relative to the red marks of the earth;
- automatically generated cartogram of earth masses.

Information layer № 3 is architectural and planning solution of the territory, which includes plans:

- 1st floor and floors located below, requiring the implementation of work under-ground or at ground level with a height reference to the red marks of the vertical lay-out of the territory;
- insolation of facades and adjustment of the placement of buildings in the absence of standard lighting times;
- typical floors, roofs, typical section, etc., giving an idea of the functional purpose of the construction object;
- isometric views of facades for visualization of design solutions.

On the example of the educational centre, work was carried out to simulate the pre-design stage of urban planning in the development of a territory planning project in accordance with the requirements of the national standard of urban planning. This experience should be considered a contribution to the development of BIM technology in urban planning and the expansion of the modeling field from a specific construction site to its location.

Summarizing the approaches used to form information support in design systems of construction, the conceptual model of spatial data storage for solving problems of territory planning project at the stage of urban design can be represented in the form of three main blocks, which are presented in Fig. 4.

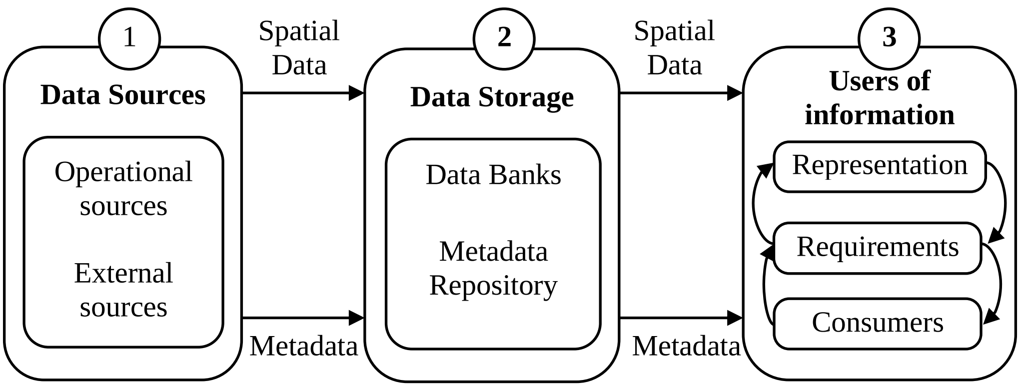


Figure 4: Conceptual BIM-model of data storage for territory planning project

Block 1 is data sources that are taken from the operating system and external sources. Block 2 is a data store, which operational and external sources supply spatial data or metadata. Block 3 is consumers of information that generate requests for data to the means of presenting information, which, in turn, generate a request sent to the data warehouse.

The main components of the data warehouse are:

- operational data sources;
- design/development tools;
- means of data transfer and transformation;
- DBMS;
- means of access and data analysis;
- means of administration.

For automated systems of integrated general planning of territorial clusters, it is important to have "feedback" with the data storage , which allows to notify the user about the appearance of the required information in the repository and automatically send this information in the form converted to customer data model.

The data bank on organizational preparation of territories should generate information both for operative design decisions, and for the control over already put into operation communications. Therefore, data transfer and transformation services must only be able to receive and convert information, but also provide or automatically download the necessary data from the repository to operating systems in an understandable form and the required data format.

Fig. 5 presents a BIM-model of data exchange in territory planning project. Data stores are characterized by multidimensional presentation of information. This structure determines the set of actual and measured data. This is due to the desire to identify individual entities that facilitate business intelligence data from the required in-formation sections of the organization. In contrast to the multidimensional information model of general construction tasks, for the storage of cadastral information of architectural and construction design, the model requires a multilayer, and its main element should be a cadastral object.

The aggregated data on the object will represent an information slice for all layers relevant to the object at a certain point in time. Thus, in the system of organizational preparation for construction, the data warehouse for the subject area of the urban cadastre must meet the following requirements:

1. perceive and recognize cadastral information through procedures for extracting, converting and uploading data to the repository;
2. to ensure long-term storage of information and keeping a history of its accumulation;
3. create and store matching schemes of source operating system metadata and storage metadata;
4. provide services for automatic updating of storage data into the operating system, converting information in accordance with the client's metadata;
5. protect information from unauthorized access; have an open architecture that is easily integrated and expandable; provide access to metadata and data from analytical information systems.

Thus, the main difference between the data exchange model in Fig. 5 from the traditional storage is determined by the purpose of information accumulation: data in the database should be organized in an optimal way not for analysis, but for consolidation of information of different automated systems. Thus, a conceptual model of information support of the process of general planning of territories for complex concentrated construction has been developed. The developed conceptual model of information support of the process of general planning of territories for complex concentrated construction envisages creation of a single methodological and technological base for integrated information space with maximum use of already existing databases and available technical means.

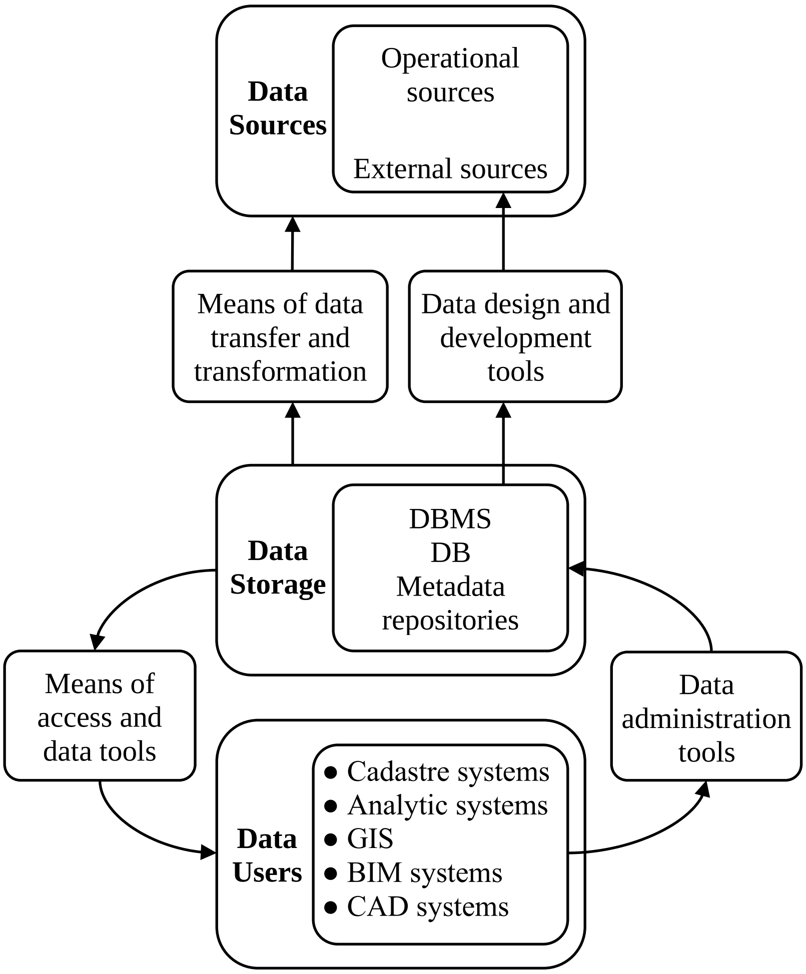


Figure 5: BIM-model of data exchange for consolidation of information of different automated systems in the territory planning project

4. Central Project Database for comprehensive information support of the territory planning project

The lifecycle of building territory using information modeling can be divided into the following stages:

- from the moment of strategic planning and preparation of the design assignment to the transfer of the facility into operation;
- stage of operation and dismantling of the building.

Basic works on information modeling of the lifecycle of building territory include eight stages. All kinds of events shown by the letter in table 2 refer to the operational stage. There can be any number of such events, depending on the object management strategy. Their example is reconstruction, repair, transfer of the building to another owner, etc.

The main works on information modeling are brought in accordance with the current stages and are summarized in the table. In addition to these works, data is transferred to the customer throughout the entire lifecycle of building territory.

All kinds of events shown by the letter in table 1 refer to the operational stage. There can be any number of such events, depending on the object management strategy. Their example is reconstruction, repair, transfer of the building to another owner, etc.

The approach to the implementation of the project with a breakdown at the stage involves the predetermination of various tasks of information modeling (BIM Uses), the interaction between the persons involved in the construction process at all stages of the life cycle of the building. Decision-making on the choice of tasks is carried out by managing the life cycle to achieve the objectives of the project and maintaining a balance between cost, risk, quality and other parameters.

To implement the principle of integrated data processing, a single information base of the system is created, and information links are made through the central service of the system and the computer centre interacts with it. The complex of interconnected means of transmission, storage, accumulation and processing of information is the technical basis of such a system, in which the central place is occupied by automation. The workplaces of the project executors are equipped with computers that meet the technical requirements of BIM, integrated into a local network.

Table 2

Basic works on information modeling of the lifecycle of building territory

Stage number	Project stage	Information modeling works
0	Strategic definition	Advising a customer on the purpose of using information modelling technology. Advising the customer on attracting a specialist who manages the information model at various stages of its life cycle.
1	Preparation and Brief	Determination of long-term rights and obligations for the information model. Development and approval of requirements for information models and the scope of their application. Establishing the scope of the assessment of the building after the start of its operation. Determining the amount of information that needs to be obtained through research.
2	Conceptual project	Pre-launch meeting on working with information modelling technology. Design variants. Use of information to determine environmental parameters and area analysis. Ensuring access of the project team to the data on the object. Coordination of work performed by a specialized subcontractor.
3	Developed Design	Exchange of information between different sections of documentation. Search for collisions. Development of project components. Use of information to clarify environmental parameters and areas. Data exchange for design coordination, technical analysis and specification.
4	Technical Design	Works similar to stage 3. Inclusion of specifications in the model. Formation and evaluation of 4D and 5D models. Data exchange and detailed analysis of the work of the general designer and subcontractors. Development of detailed models for production. Final verification and approval of the model.
5	Construction	Export of data for construction control. Providing the construction organization with access to the information model. Integration of data from the construction site into the information model. Carrying out the analysis of construction works according to the schedule (4D).
6	Handover and Close Out	Coordination of terms and volumes of works for commissioning of object. Coordination and publication of information model data at the construction stage.
7	Exploitation	Making changes to the information model during the operation of the building. Study of data about the objects of the building included in the information model.

To perform the work on the design of the consolidated plan of engineering networks, a computer is allocated, which performs the functions of a server, on which a common project directory is created, to which all project participants have access. All work on the project is carried out only in it. As a result of joint work each employee has operative data of a condition of networks of the adjacent are coordinates, diameters, marks in points of intersection. Surveys of networks are in the thematic plan of the organization of projects, are placed on the server where the software product is started, and on other computers local workplaces are opened. The structure of Central Project Database and performers for the provision of spatial information for the organizational training of the territory is presented in Fig. 6.

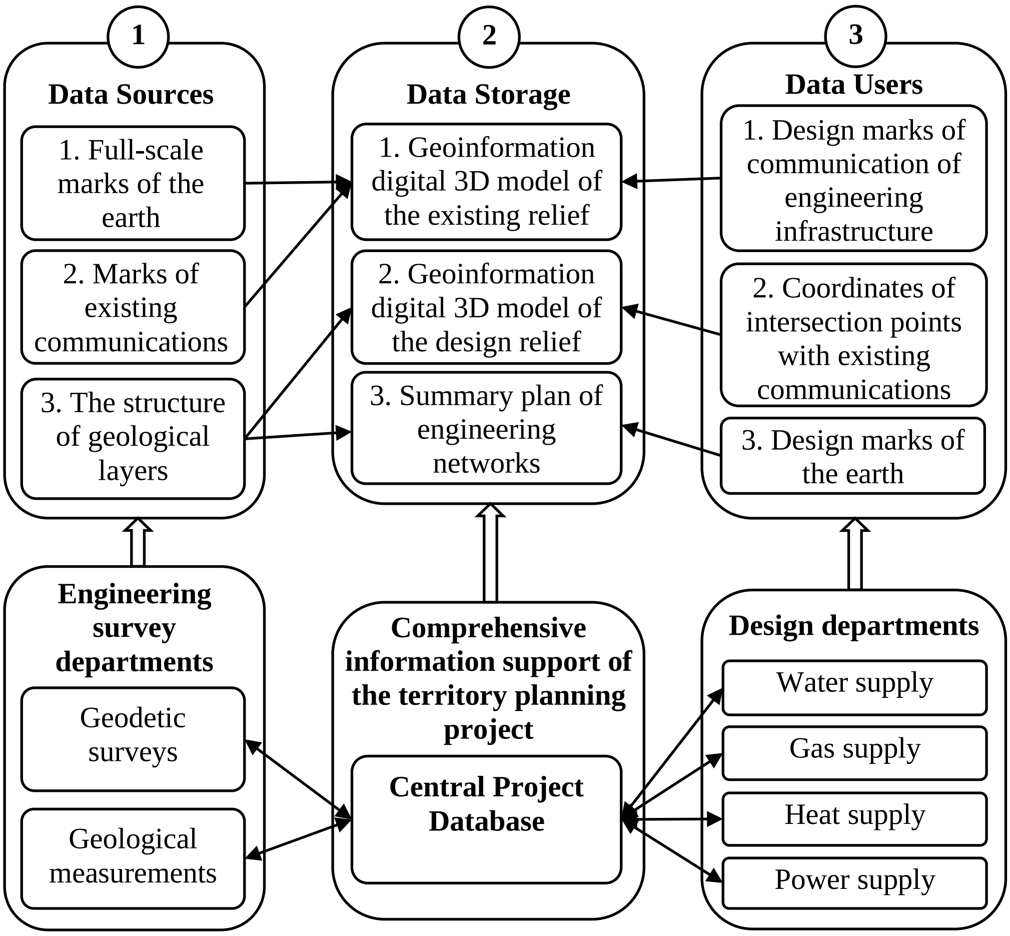


Figure 6: Central Project Database for comprehensive information support of the territory planning project

Users design with the software in BIM environment, which automatically interpolates the natural marks of the earth from the substrate opened on the server, recognizes communications passing at acceptable distances detects characteristic points of intersection and assigns design marks to communications. Databases of information modeling should be developed in a single system for different stages of the lifecycle of the building territory, including the following elements:

- formation of information cadastral data;
- geoinformation survey;
- comprehensive urban planning of the of territory planning project, taking into account the factors of influence of the adjacent territories. The information modeling of a building territory is a database about a construction object, which is accessed through graphical interfaces various software.

Information modeling allows obtaining a complete set of information data about a building territory at the stage of urban planning. Having this data, specialists have to make rational decisions about the further operation of the urban planning. Information models should reflect the actual state of the territory planning project at all stages of its lifecycle.

5. Conclusions

Building territory should be considered as a complex open system. It is advisable to develop and implement the system with BIM principles of the lifecycle, including at the level of national legislation.

The results of work present information tools for project management of the building territory at the stage of urban planning based on BIM technologies. There are information model of the territory planning project, BIM-models of data storage and exchange for consolidation of information of different automated systems, Central Project Database for comprehensive information support of the territory planning project at the stage of urban planning. The benefit of this approach is that spatial and attribute data of planning territory can be organized and managed in one central database. Any modifications at the stage of urban design immediately appear in the information model of the project of planning territory and coordination issues can be detected.

Further research should be conducted in the areas of the development complex BIM management of urban infrastructure. It is noted that the design of any building is impossible without its interaction with the location territory and urban infrastructures. The quality of this interaction will determine not only the effectiveness of the construction solution as a whole, but also the comfort of the urban environment for the users of the facility, which fully corresponds to the modern trends in the development of the urbanized environment.

6. References

[1] C. Eastman, et al., BIM Handbook. A guide to building information modeling for owners, managers, designers, engineers and contractors. TH437.B53, 2011.

[2] M. Dyomin, A. Dmytrenko, D. Chernyshev, O. Ivashko, Big Cities Industrial Territories Revitalization Problems and Ways of Their Solution. Lecture Notes in Civil Engineering 73 (2020) 365–373.

[3] S. A. Biancardo, N. Viscione, A. Cerbone, E. Dessì: BIM-Based Design for Road Infrastructure: A Critical Focus on Modeling Guardrails and Retaining Walls. Infrastructures 5 (2020) 59.

[4] S. A. De Santana, Modeling urban landscape: new paradigms and challenges in territorial representation. Disegnare con. 6(11) (2013) 161–174.

[5] S. Bushuyev, B. Kozyr, N. Rusan, Modeling of Empathy, Emotional Intelligence and Transformational Leadership to the Project Success. Mathematical Modeling and Simulation of Systems, in: Selected Papers of 14th International Scientific-Practical Conference, MODS, June 24–26, Chernihiv, Ukraine. Springer Nature Switzerland AG 1019, 2019, pp. 209–223.

[6] R. Trach, S. Bushuyev, Analysis of communication network of the construction project participants. Scientific Review Engineering and Environmental Sciences 29(3) (2020) 388–396.

[7] A. Voitushenko, S. Bushuyev: Development of project managers' creative potential: Determination of components and results of research. Advances in Intelligent Systems and Computing, 1080 AISC (2020) 283–292.

[8] M. Shkuro, S. Bushuyev, Development of proactive method of communications for projects of ensuring the energy efficiency of municipal infrastructure, EUREKA, Physics and Engineering 1 (2019) 3–12.

[9] T. Honcharenko, Y. Chupryna, I. Ivakhnenko, M. Zinchenco, T. Tsyfra, Reengineering of the Construction Companies Based on BIM-technology. International Journal of Emerging Trends in Engineering Research 9(5) (2020) 8670–8676.

[10] P. Kulikov, G. Ryzhakova, T. Honcharenko, D. Ryzhakov, O. Malykhina, OLAP-Tools for the Formation of Connected and Diversified Production and Project Management Systems. International Journal of Advanced Trends in Computer Science and Engineering 8(10) (2020) 7337–7343.

[11] V. Mihaylenko, T. Honcharenko, K. Chupryna, Yu. Andrashko, S. Budnik, Modeling of Spatial Data on the Construction Site Based on Multidimensional Information Objects. International Journal of Engineering and Advanced Technology 8(6) (2019) 3934–3940. URL: https://www.ijeat.org/wp-content/uploads/papers/v8i6/F9057088619.pdf

[12] O. Terentyev, S. Tsiutsiura, T. Honcharenko, T. Lyashchenko, Multidimensional Space Structure for Adaptable Data Model. International Journal of Recent Technology and Engineering 8(3) (2019) 7753-7758. URL:https://www.ijrte.org/wp-content/uploads/papers/v8i3/C6318098319.pdf
[13] R. Sacks, C. Eastman, G. Lee, P. Teicholz, BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. 3rd ed. John Wiley & Sons: Hoboken, NJ, USA, 2018.
[14] M. Pepe, D. Costantino, A. Restuccia Garofalo, An Efficient Pipeline to Obtain 3D Model for HBIM and Structural Analysis Purposes from 3D Point Clouds. Appl. Sci. 10 (2020) 12–35.
[15] C. Hu, S. Zhang, Study on BIM technology application in the whole life cycle of the utility tunnel. Smart Innov. Syst. Technol 127 (2019) 277–285.
[16] J. C. P. Cheng, Q. Lu, Y. Deng, Analytical review and evaluation of civil information modeling. Autom. Constr. 67 (2016) 31–47.
[17] M. Gerges, S. Austin, M. Mayouf, O. Ahiakwo, M. Jaeger, A. Saad, T. El Gohary, An investigation into the implementation of building information modeling in the Middle East. J. Inf. Technol. Const. 22 (2017) 1–15.
[18] G. Dell'Acqua, S. G. De Oliveira, S. A. Biancardo: Railway-BIM: Analytical review, data standard and overall perspective. Ing. Ferrov. 73 (2018) 901–923.
[19] S. Azhar, A. Behringer, A. Sattineni, T. Maqsood, BIM for Facilitating Construction Safety Planning and Management at Jobsite, in: Proceedings of the CIB-W099 International Conference: Modelling and Building Safety, Singapore, 10–11 September 2012.
[20] F. D'Amico, A. Calvi, E. Schiattarella, M. D. Prete, V. Veraldi, BIM and GIS Data Integration: A Novel Approach of Technical/Environmental Decision-Making Process in Transport Infrastructure Design. Transp. Res. Proc. 45 (2020) 803–810.
[21] M. Odrekhivskyy, V. Pasichnyk, A. Rzheuskyi, V. Andrunyk, M. Nazaruk, O. Kunanets, D. Tabachyshyn, Problems of the intelligent virtual learning environment development. CEUR Workshop Proceedings 2386 (2019) 359–369.
[22] V. Tomashevskyi, A. Yatsyshyn, V. Pasichnyk, N. Kunanets, A. Rzheuskyi, Data Warhouses of Hybrid Type: Features of Construction. Advances in Intelligent Systems and Computing book series 938 (2019) 325–334.
[23] R. Kaminskyi, N. Kunanets, V. Pasichnyk, A. Rzheuskyi, A. Khudyi, Recovery gaps in experimental data. CEUR Workshop Proceedings 2136 (2018) 108–118.
[24] A. Rzheuskyi, H. Matsuik, N. Veretennikova, R. Vaskiv, Selective Dissemination of Information – Technology of Information Support of Scientific Research. Advances in Intelligent Systems and Computing 871 (2019) 235–245.
[25] H. Lypak, V. Lytvyn, O. Lozynska, R. Vovnyanka, Y. Bolyubash, A. Rzheuskyi, D. Dosyn, Formation of Efficient Pipeline Operation Procedures Based on Ontological Approach. Advances in Intelligent Systems and Computing 871 (2019) 571–581.
[26] R. Kaminskyi, N. Kunanets, A. Rzheuskyi, A. Khudyi, Methods of statistical research for information managers, in: Proceedings of the 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, 2018, pp. 127–131.
[27] A. Kazarian, N. Kunanets, R. Holoshchuk, V. Pasichnik, A. Rzheuskyi, Information Support of the Virtual Research Community Activities Based on Cloud Computing, in: Proceedings of the 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018, 2018, pp. 199–202.
[28] A. Rzheuskiy, N. Veretennikova, N. Kunanets, V. Kut, The information support of virtual research teams by means of cloud managers. International Journal of Intelligent Systems and Applications 10(2) (2018) 37–46.
[29] V. Pasichnyk, D. Tabachyshyn, N. Kunanets, A. Rzheuskyi, Visualization of Expert Evaluations of the Smartness of Sociopolises with the Help of Radar Charts. Advances in Intelligent Systems and Computing 938 (2020) 126–141.
[30] V. Pasichnyk, N. Kunanets, N. Veretennikova, A. Rzheuskyi, M. Nazaruk, Simulation of the Social Communication System in Projects of Smart Cities, in: Proceedings of the 14th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2019, 2019, pp. 94–98.