University Management System Based On BIM-GIS-Technologies[*]

Tatiana Tomchinskaya[1][0000-0002-4693-7478] and Maria Galanina[2][0000-0002-8951-2357]

Nizhny Novgorod State Technical University n. a. R.E. Alekseev, Russia
tomchinskaya@mail.ru, malanja1999@yandex.ru

Abstract. The work has an information system developed based on GIS and BIM technologies. The component of the geographic information system of the Nizhny Novgorod State Technical University n. a. R.E. Alekseev - information model of the NSTU, built in the REVIT tool environment. The models include a digital terrain model, a three-dimensional model of the educational building and utilities, a library of materials. The features and technology of creating external models of the university are considered. The project is intended for administrative and economic services of the university, decision support for engineering, and economic services. The information system implemented within the framework of this technology will make it possible to determine the optimal parameters for the operation of a building throughout its entire life cycle and take into account aspects such as meeting legal, environmental, and operational requirements. The unique integration of BIM and GIS technologies implements the apparatus for data exchange between BIM and GIS components.

Keywords: Building Information Model (BIM), Geographic Information System (GIS), Engineering Communications, Digital Elevation Model, Three-dimensional Model.

1 Introduction

Nizhny Novgorod State Technical University R.E. Alekseeva has a large number of buildings with complex architecture, engineering communications, and a large amount of equipment. Educational buildings and administrative buildings require constant maintenance, repair, and accounting of data on the state of engineering systems. Currently, the construction documentation of the university is stored in a disparate form, some in the form of paper drawings and specifications, and some in electronic form, in the format of tables, images. Also, today there is no clear information about the operating life of a particular facility, therefore, repair work to replace or improve elements of the engineering infrastructure takes place, as a rule, in emergencies. In this regard,

there is a need to create a unified information environment for solving the problems of university management [1].

The use of GIS technologies allows obtaining information about the territorial features of the placement of objects, and the BIM model contains complete information about its internal systems. Automation of this process will increase the speed of decision making, increase the accuracy and objectivity of information.

BIM and GIS models provide storage of both 2D and 3D information that is used for any task.

BIM is used to solve the following tasks for the operation of infrastructure facilities [2]:

— inventory, monitoring of the technical condition of objects;
— the planned replacement of technical means, modernization of production facilities;
— planning of repair work and maintenance of technical condition;
— monitoring of the general working condition of the building and utilities.

Thus, both tools are needed to build an effective information system. But it turns out that the same data, for example, floor plans are duplicated and stored in BIM and GIS subsystems in different formats.

Today, Russian universities are working on this task and creating their prototypes of systems to obtain a complete and unified information basis for managing administrative, economic, educational activities, and infrastructure facilities. Some universities, for example, Vladivostok State University, Ufa State Aviation Technical University, Astrakhan State Technical University have created information systems based on GIS technologies.

Irkutsk National Research Technical University, together with the Neolant Group of Companies, in 2018 began the development of the My Digital University project, an information model of the main building of IRNITU was built using BIM technologies.

For Togliatti State University, specialists from the Center for Urban Studies and Strategic Development of Territories, together with the service of the chief engineer of Togliatti State University (TSU), are developing information models of the university buildings. The BIM-model of the hostel, created by the project participants, will be used in the further operation or reconstruction of the facility.

Thus, we can conclude that, as a rule, in the information systems of universities, the advantages of either GIS or BIM technologies are used, there are no examples of interaction and implantation of elements of the BIM model in the GIS model, which can significantly increase the efficiency of the technology for managing territories and structures.

In the course of the project, it is proposed to integrate technologies and implement a data exchange apparatus between BIM and GIS components in such a way that each element of the system database is stored without duplication.

In the solution considered in this project, several tasks are performed simultaneously. In addition to the task of building an information model of the university, which is very expensive work - only building a BIM model of the sixth building of NSTU can cost about 30 million rubles, an important task of training personnel in this area is being

solved. Work on the project was introduced into the educational process, within the framework of coursework and diploma works.

2 Digital Terrain Model

The main goal of the information system, designed to support the operation of the engineering infrastructure of the university, is to create a single information space for specialists involved in the maintenance of the infrastructure [3].

The tasks that need to be addressed during the operation of the infrastructure include:

− technical audit, inventory, certification and accounting of engineering infrastructure objects;
− reconstruction and modernization of the building and utilities;
− planning of maintenance and repair of infrastructure facilities;
− assessment of the technical condition of buildings and engineering communications.

Since the information model of the building should include both ground and underground communications, taking into account the terrain [4], a digital model of the terrain of the territory where the educational building of the technical university is located in the Infraworks technology was previously built (Figure 1).

Fig. 1. Model of the relief of the territory adjacent to the sixth building of the NSTU.

Then, the refinement of the terrain model was carried out in the Civil 3D program.
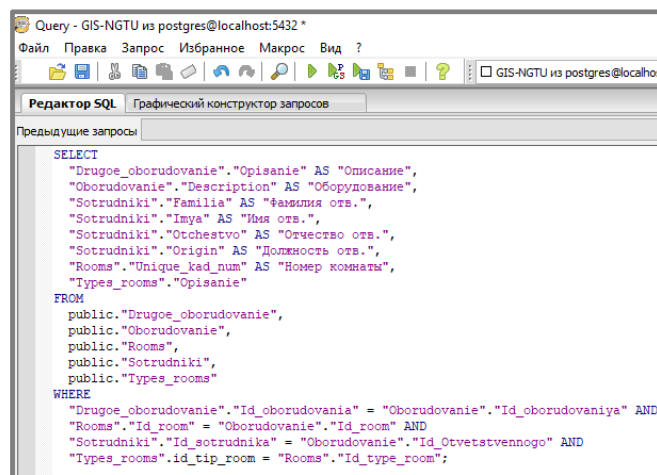
3 Database Development

At the next stage, the development of a database for the GIS-NSTU project was carried out by the main stages of the technological architecture life cycle.

The first stage in the life cycle of this architecture was the context stage. The initial task is to determine which entities are necessary to describe the structures of the university, and which database should be fully corrective and complete storage of both operational and static information. Identification of the main entities that are necessary for the operation of the system and their attributes, as well as their interaction with each other.

As a result of passing the first stage, a logical data scheme was created.

The next stage in the development of technical architecture is conceptual, the final one in the study of software products and technologies that made it possible to create a database.

At this stage, some difficulties arose. In accordance with the development of a geographic information system, it is necessary to work with spatial information, which is necessary for working with geometric objects. Microsoft SQL Server, PHP My Admin, Oracle, and Postgre SQL.

Fig. 2. The code of the query generated by the Postgre SQL graphical editor.

As a result, after comparing the DBMS, the Postgre SQL object-relational database management system was chosen. This product is free distribution, which has not only the ability to work with graphical data types, but also create your object data, data arrays and much more.

The next stage in the life cycle of an architecture is the logical stage. Further, the logical data schema was translated into a physical data schema. The result of this stage was bringing the database to normal form, defining all necessary exceptions and types of stored data. Thus, the properties of the tables that will store information were determined.

As a result of this step, a project database was created and configured in Postgre SQL DBMS on a local server and connected to geometric data saved in Autodesk AutoCAD Map 3D.

One of the useful features of Postgre SQL is the graphical querying mechanism, which increases their visibility, allowing the administrator to quickly create and verify the results of their work. Figure 2 shows the code of a request generated by a graphical editor. As a result, we received information about the employee responsible for a particular equipment, as well as the location and type of room.

4　Features Of Postgre SQL Administration And Possibility Of Their Application In GIS NSTU

System management, data input and manipulation is carried out through the web interface, which also provides differentiation of access rights to information. During the development process, problems related to safety and scalability were identified: rigid connection of the NSTU information system with the database architecture; an isolated user and group database that did not match Postgre SQL login roles and did not allow access control when connecting other data, such as AutoCAD Map 3D or Autodesk BIM 360 projects; difficulties in data security management; limited ability to compose requests.

After analyzing the initial architecture of the system, a scheme for the interaction of the GIS NSTU with the rest of the elements was proposed (Figure 3).
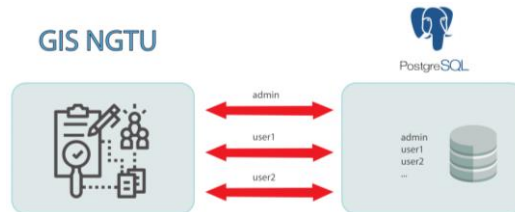
Fig. 3. Scheme of interaction between Postgre SQL and GIS components of NSTU.

According to the proposed scheme, all data access control tasks are performed directly on the Postgre SQL server. The system uses in the connection string only the login and password specified by the user, which increases the level of security. Using exclusively the system capabilities of Postgre SQL allows you to create a system that is theoretically adapted to any database architecture, which minimizes further intervention in the code.

5　BIM Components Of NSTU

At the next stage, the information model of the sixth academic building of NSTU is being developed by the efforts of students and teachers. The software product Autodesk Revit was chosen as the tooling environment for supporting the 3D information model of the building.

This is a software package that implements the principle of building information modeling. The complex provides the possibility of three- dimensional modeling of

building elements, engineering systems, as well as a flat drawing of design elements, creating custom objects, organizing joint work on a project, starting from the concept, and ending with the release of working drawings and specifications. Revit database can contain information about a project at various stages of a building's life cycle, from concept development to construction and decommissioning (4D BIM) [5].

One of the advantages of this program is the ability to convert data into a GIS system [6]. You can also add to this list promising work with open data and GIS tools that allow you to operate with large volumes of cartographic information and, at least, use these technologies to create GIS projects for enterprises with a developed engineering infrastructure.

The BIM model includes both the architecture and construction of the building, as well as engineering networks: water supply, sewerage, ventilation, heat supply, gas supply, electricity supply, communication networks (Figure 4). An important part of building a BIM model is also the creation of annotations, specifications, and the design of drawing views on sheets.
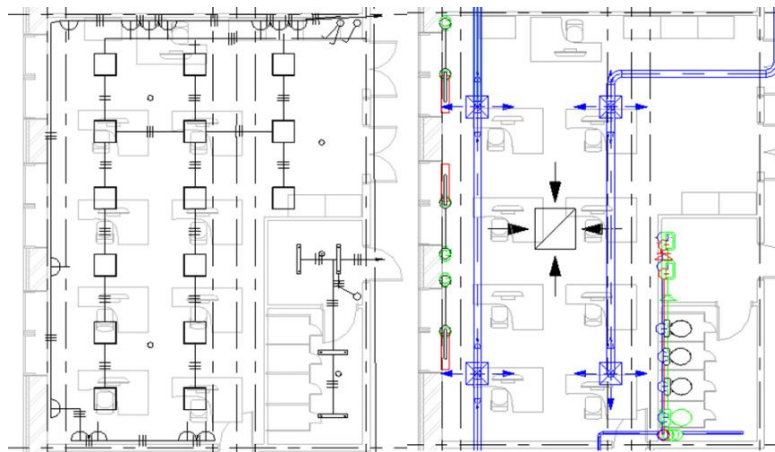
**Fig. 4.** Plan of power networks and ventilation of the auditorium and bathroom.

The main building of the building and blocks were developed in separate documents while maintaining the possibility of combining them into a single project [7, 8].

A distinctive feature of the Revit software package is the availability of related tools for the work of both an architect and an engineer [9]. Furniture and texturing of rooms are also carried out in Revit, using the information model as an example, you can present a technical task to repair teams (Figure 5).

Fig. 5. Computer class equipment, including radiators, lighting, ventilation.

In the file of the engineer, you can see the location of the networks, both individually and their relative location. A schematic floor plan is used as a substrate for them, but the walls are transparent (Figure 6).
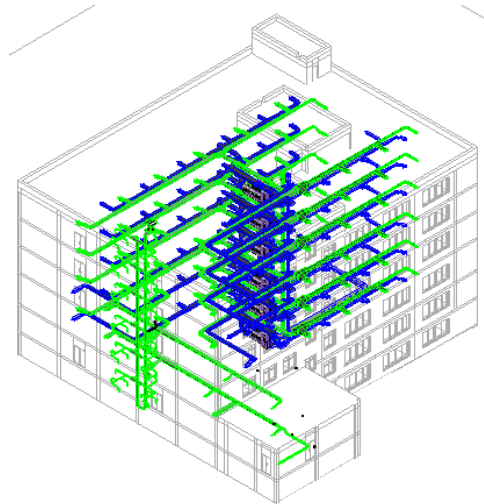
Fig. 6. Location of engineering networks.

Collections are created in Revit to set groups of elements with the same properties. An example of using the collections "Columns", "Turnstile" can be seen in Figure 7.

Fig. 7. Examples of visualization of the educational building model.

The means of the program allow you to calculate the HVAC zones (heating, ventilation, sewage) based on information about the temperatures of cooling, supply air, heating, heated air per person or unit area, calculate electricity consumption, power load on the power grid based on the purpose, weather conditions and location of the building.

If necessary, reports on the specified parameters are generated (Figure 8).

Параметр	Значение
Расчет энергопотребления	☆
Площадь на человека	4.000 м²
Ощутимый теплоприток на че	73.27 Вт
Скрытый теплоприток от прис	58.61 Вт
Удельная нагрузка от электроо	12.92 Вт/м²
Удельная силовая нагрузка	16.15 Вт/м²
Вклад в освещение камеры	20.0000%
Диаграмма использования по	Занятость в школе - С 08:00 д
Диаграмма электроосвещения	Освещение в школах - с 07:0
Диаграмма энергопотреблени	Освещение в школах - с 07:0
Время открытия	7:00
Время закрытия	22:00
Рабочая температура охлажде	27.78 °C

Fig. 8. Fragment of the energy consumption report.

Also, in such calculations, the materials of structures and objects are taken into account, the purpose of operating the premises is selected. Based on this data, the engineering parameters of spaces are formed.

6   Conclusion

In this work, an interface for designing the NSTU information system based on Postgre SQL is proposed and developed, an information model of the largest (sixth) educational

building of NSTU, which has a complex architecture, has been created in Autodesk Revit technology.

Modeling of the most information complex building of NSTU with engineering communications was undertaken to test the operability of the proposed unified information model and technology for solving problems by specialists involved in maintaining the infrastructure and educational process of the university. The BIM-model of the building is included as a component of the geographic information system of the university, it is planned to connect the elements of the building's geometry as elements of the unified external database of the GIS NSTU.

The effect of using the system is achieved due to the efficiency of search, completeness, reliability, and convenience of forms for displaying technical information about infrastructure objects, automation of calculation tasks and the creation of an integrated information environment for the interaction of planning processes, organizing and monitoring the functioning of the infrastructure.

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