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Geographic Information System Usage Options in Facility Management

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Abstract

This article deals with the possibilities of using Geographic Information Systems in the construction practice with a focus on the facility management of buildings. The aim is to present the usage options and advantages of the GIS in the construction industry resulting from its analytical and visualization capabilities. The article deals with current trends in construction, which very often use information databases with the location of information. Emphasis is placed on the area of facility management, for which, in the case of possible studies, a general structure of an information database usable for site management is proposed. A case study of the university premises with lecture halls, classrooms, laboratories, studios, staff offices, etc., was used to demonstrate the Geographic Information System usefulness in the construction practice. The aim is to present the purpose and the extent of what can be created for the comprehensive management of both exterior and interior areas of such premises. The article describes the process of designing a geoinformation database usable for facility management, which facilitates the user's orientation and work with information.

Keywords: Facility management, Geographic Information System, Case study, Usage.

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1. Introduction

This article deals with the theoretical possibilities of using geoinformation systems (GIS) in construction and practical use in the field of facility management of buildings. The article aims at demonstrating the usage options of the Geographic Information Systems (GIS) in the facility management (FM) and tries to point out the benefits that can arise from mutual cooperation, specifically on the case study of the Brno university premises. The topic is very topical in the context of modern trends in construction. The article is based primarily on multidisciplinary interconnection, which is the common denominator of current trends in the economy and construction. The case study is carried out for a specific existing area and gives an idea of how it would be possible to work with all available information and increase the efficiency of work in the field of facility management.

In the past, Geographic Information Systems were used primarily for the analysis, acquisition and visualization of data related to the earth's surface and nature [1]. However, GIS has recently gained application in the management and mapping of structures that were artificially created by a man [2]. The main reason is that the analyses already established are easy to use even in a more detailed scale, such as premises, a building or an entire urban agglomeration [3]. GIS should be taken into account during both the operational phase and the entire life cycle of buildings and premises. It can serve as a very useful tool when choosing a suitable location, be helpful in the designing phase or during maintenance. Other uses comprise the visualization of transport systems, utilities, pipelines, etc.

The field of facility management is often understood solely as designated for the management of buildings and premises; however, its scope is much broader. It has still not been very popular in the Czech Republic, but the situation has gradually been improving. In short, this field can be defined as a branch that participates in the management of the organization and improves secondary processes and activities. It, therefore, takes care of everything that the organization cannot do without and is necessary for the proper functioning of a particular building or the entire premises in connection to the organization, respectively, the company, functioning. Its main task is to minimize all negative impacts and costs and make the most of the benefits of the facility, leading to increased efficiency of activities, prevention of incidental failures and thus minimizing operating costs.

Nowadays, the term BIM, i.e., the Building Information Modelling which offers a database of information about buildings, especially about individual elements and technologies embedded in the building, is associated with facility management [4]. A building is not just a building, but also a construction process. The whole information model of a building can be imagined as a database that can contain all the information that can be used during the entire life cycle of the building. That is, from the design, construction, management of the building in the operational phase to liquidation [5]. Therefore, in order to maximize the benefits of using the BIM method, it is important that all participants in the construction process contribute their results and do not refuse to use this model [6,7]. Previously, it applied to CAD (Computer-Aided Design) systems, which, however, offer information only about parts of buildings. FM systems thus work with background documents and data that were already created during the designing phase and can be easily used for editing. However, ever-expanding companies and growing demands for facility management services require both an overview of the buildings or premises themselves including the surrounding impacts. GIS seems to be ideal due to the scope it offers. The scope is so large that it can cover all from the property management of individual buildings up to the management of the entire premises of multinational companies throughout the world.

2. Literature review

GIS is an acronym for Geographic Information System. In general, this term is usually understood as a special type of information system that works with information concerning positional (geographical) characteristics. ESRI company provides the following definition "GIS is an organized set of computer hardware, software and geographic data designed to efficiently acquire, store, modify, manage, analyse and display all forms of geographic information". [8]

At present, there is no commonly accepted definition that would suit all the fields that GIS can apply to. However, each definition contains the basic components as data, hardware, software and organizational structure, the basic functions are represented by input, analysis, management and presentation of data, and last but not least, system content. [8]

The range of areas in which GIS can be applied is huge. It can be used mainly in the fields where it is necessary to work with spatial data, such as spatial planning, state administration, services of the integrated rescue system, transport, resource management, utilities, security and military sector, environment, retail, tax administration, finance, archaeology, etc. GIS has the potential to shift the circular economy to another dimension. [9,10,11,12].

2.1. GIS data models

Geographic data contains three types of information, two basic and one supplementary:

- Spatial information (position, relation to other objects, shape)
- Descriptive information (other properties of a certain structure, e.g.: date of acquisition, type, thickness, temperature, etc.)
- Time information (date of the last repair, etc.)

Map objects are represented by the following elements:

- Polygon - displays objects that enclose a certain area using borders - for example, built-up areas, greenery, forests, lakes, etc.
- Point - displays objects that are so small that it is not convenient to display them using surfaces or lines or objects that have no dimension - for example lamps, trees, covers, benches, etc.
- Line - displays objects that are so narrow that they do not need to be recorded using areas or points – for example, roads, pipes, rivers, etc. [13]

2.2. GIS in the facility management

Today's world has been constantly globalizing. This happens due to evolving technologies that enable global connectivity. This has stimulated the field of facility management to respond by searching a tool enabling work at several layers, i.e., at the layer of the premises or building, as well as at the regional or supranational level. Geographic Information Systems have many uses for facility managers as they enable surveying, interpretation, insight into and visualization of data from several points of view. They can be used to visualize or control premises. Furthermore, to create analyses in the field of planning or to simulate various incidents and impacts that can occur in a number of other things. [14,15]

The field of facility management is a discipline that has been dealing with the management of buildings and their support activities since its origin. Such work requires knowledge of individual buildings, and therefore knowledge of the spatial arrangement of buildings [16]. Over time, CAD programs have become interlinked with facility management [17]. The whole process took place from hand-drawn designs through CAD drawings to current BIM models, i.e., information models of buildings, which no longer show only the information related to one floor, but try to approach the building as a whole [18,19].

More data and shared information are needed for facility management to be effective in a wide range of applications. As already described above, CAD systems are used to create structural designs, and GIS systems are used to manage spatial information within a landscape or premises. The possibility of the interconnection of these two and other systems tends to appear, thus significantly increasing the usability of this shared information in other areas. [20]

3. Methodology

Creating spatial data at the local level requires to deal with covered spaces, respectively, more spatial layers. Mobile or static terrestrial scanning can, for example, be used for this purpose. For example, working drawing documentation can be used as initial background material, however, it is always necessary to verify the up-to-datedness of the information available in the documentation. A huge advantage of data collection using optical and laser technologies is the recording of the actual current state by non-selective data collection. In fact, it is a digital image that captures all the information at a specific time, which can be used in the future for back-testing as well as completely different

applications due to non-selective data collection. Based on this data, it is possible to create layers of polygonal surfaces of floors, spaces, windows, doors together with linear and point elements such as switches, lightening, railings, etc.

Further layers with a different information value can subsequently be created on the basis of these basic layers, e.g., the usage of areas and spaces, security zones, rented areas, location of the property, cleaning zones, etc.

Defining and adding data representing the real state to the geodatabase follow and the information that is important for facility management can be subsequently provided, such as:

- Information and analyses on the space usage, availability and optimization within the region or premises.
- Information on energy consumption within the company, premises, building or room.
- Depicting the impact of new construction activity on the environment, etc.

4. Results and discussion

The aim of the case study was to design a GIS information database that would be usable for facility management of the Faculty of Civil Engineering of Brno University of Technology premises. The case study deals with the management of both exterior and interior premises. The actual condition of the entire premises was recorded within the exterior premises. A model floor of one of the buildings was approached by several possible solutions for the management and maintenance of the premises and equipment was designed within the interior premises. To illustrate the situation, the premises are currently used by approximately 4,500 people (students and faculty staff). The entire premises were considered to be new in order to illustrate the process of implementing the facility management system.

Firstly, possible services were identified in connection with the facility management system design. The whole project of the system of services, works and support was divided into four phases:

- Work on technical assistance in taking over the premises from the general contractor.
- Support the executive and administrative side in the facility management field to the administrator of the premises.
- Support technical facility management.
- Support energy facility management.

Secondly, the GIS database itself created in ArcMap 10.2 which can be used both for database designing, management and display, was presented. There is obviously the possibility of exporting the geoinformation database to SHP exchange files and subsequent implementation into other specialized software for facility management.

The ArcMap 10.2 and ArcCatalog 10.2 programs by the ESRI company were used to create the whole model of the premises, i.e., both exterior and interior areas [21]. AutoCAD 2021 by Autodesk company was used for visualization and editing the drawings in dwg format, and the Ricoh Theta viewer from Ricoh company was used to view 360° photographs.

Prior to the actual creation of the information model of the FAST premises, it was necessary to obtain important information and necessary documentation. Work on the project began following obtaining project documentation and operational information. The entire faculty premises were divided into two parts, the exterior premises and the interior premises.

4.1. Exterior premises

Three layers were created for the exterior premises:

- Exterior areas (areas)
- Exterior lines (lines)
- Exterior point elements (points)

Exterior areas were created using the orthophoto map, however, in the first phase mainly using the working drawing of the situation. The individual edges of the surfaces e.g., the edges of travelling and walking paths, greenery, etc., were drawn according to these working drawings, however, the individual types were not determined. These individual types of areas were determined in the following step when passportization was used. 360° photo documentation, which recorded the current state, was acquired during the area passportization.

It was necessary to define the types of areas and the data structure (attributes) prior to the actual vectorization of exterior areas. The following attributes were assigned to the exterior areas in the case study:

- Area type
- Condition
- Last maintenance
- Planned future maintenance
- Administrator
- Note

79 types of exterior areas were subsequently created.

Exterior point and line elements were created according to the actual state, i.e., according to passportization. The procedure for designing types of points and lines was the same as for exterior areas. Subsequently, 38 types of exterior point elements and 12 types of exterior line elements were created. Similarly to exterior areas, a specific symbol was created for each element which enables the identification of each element type at a first sight. The purpose was always to create as many specific designations as possible making it clear for the user to imagine the elements.

Figure 1. General view of the BUT Faculty of Civil Engineering premises (Source: authors' own elaboration)

It was necessary to determine the scope of maintenance activities of exterior areas, both cleaning and routine maintenance, as well as winter maintenance within the scope of the facility management activities.

4.2. Interior premises

All interior areas were approached within one building. Firstly, layers representing individual floors 1st - 8th were created.

The space of the 6th floor was used to illustrate several possibilities of what can be created in GIS for interior spaces, both for maintenance, cleaning and registration of property. Specifically, 11 layers were created, namely: Orientation plan (areas), Materials (areas), Cleaning (areas), Lines (lines), Sanitary (points), Fire (points), Furniture (points), Electricity (points), Others (points), Windows (points) and Doors (points). Attributes important for the specification the purposes of facility management were subsequently assigned to these individual layers.

The current state of the approached floor was created by passportization which was caried out in the same way as for the exterior area by shooting it with a 360° camera. The property withing management was registered in the same way.

The individual floors of the building were created as the first of the interior areas. The main reason for this step was to demonstrate the possible sequence and a wide range of GIS options, i.e. that it is possible to record and manage the individual faculty premises for the whole university from one place, then focus on one specific premises, individual

buildings, individual floors to individual rooms and equipment. Gradually, all layers of individual floors of the building were created based on the construction working drawings.

It was necessary to determine and create attributes that should be recorded prior to the vectorization of individual floors. The following attributes were assigned to the individual floors of the building:

- Building
- Floor
- Area usage
- Note

Subsequently, all eleven layers were marked and registered.

The function of the "Orientation plan" layer is to guide the user when searching for a specific room, the purpose of the room, or when searching for specific people who have their office in the given premises. All types of use of individual rooms located on a given floor were created according to the working drawing documentation. Each such type received an original code in order to facilitate work during editing. Moreover, the division according to colours served for easier orientation between individual rooms.

Types of rooms in the "Orientation plan" layer: archive, corridor, office, kitchen, staircase, classroom, lift, etc. The following attributes were assigned to these room types:

- Purpose
- Room
- Floor
- Building
- Location
- Centre
- Faculty
- Number of staff
- Staff (list)
- Note

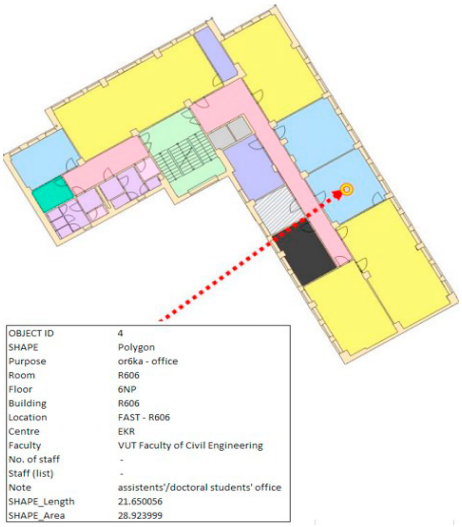

Figure 2. Example of "Orientation Plan" layer information (Source: authors' own processing)

The "Fire" layer was created using point elements that show individual types of objects and their location. The advantage is the possibility of displaying of all types of surface layers, i.e., that these points can be switched on by both the cleaning worker and the administrator who uses the material information layer. This layer can also be used for the property inventory and its easier search.

Specific symbols were created for each type of device, which enabled to identify the type of each device at first sight. The purpose was to always create such specific designation which enables the user to imagine the device easily.

Types of equipment in the “Fire” layer: fire extinguisher, water hydrant, fire detector, escape system light.

The following attributes were assigned to these device types:

- Type
- Type of fire extinguisher
- Designation (inventory)
- Location
- Centre
- Person in charge
- Date of acquisition
- Serial number
- Year of manufacture
- Last revision
- Period
- Regulation
- Note

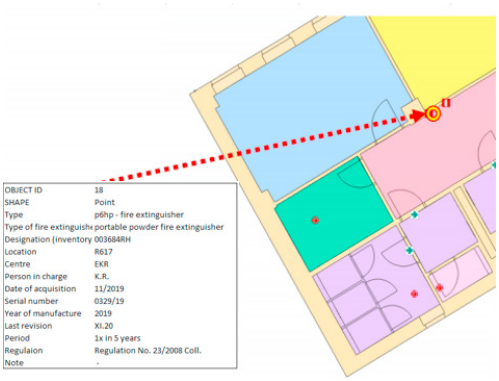

Figure 3. Example of “Fire” layer information
(Source: authors’ own processing)

Figure 4. “Fire” point layer
(Source: authors’ own processing)

The “Line” layer is created using line elements that represent objects that form a line from multiple identical objects placed in one row, or an object that forms a line itself. The advantage is the possibility of displaying them on all types of surface layers, i.e., that these points can be switched on by both the cleaning worker and the administrator, who uses the material information layer. This layer can also be used for the property inventory and its easier search.

Types of lines in the "Line" layer: railings, ceramic tiles, kitchen unit, a set of furniture, a set of hangers, other lines.

Attributes assigned to these line types:

- Type
- Designation (inventory)
- Location
- Centre
- Person in charge
- Dimensions
- Date of acquisition
- Acquisition price
- Note

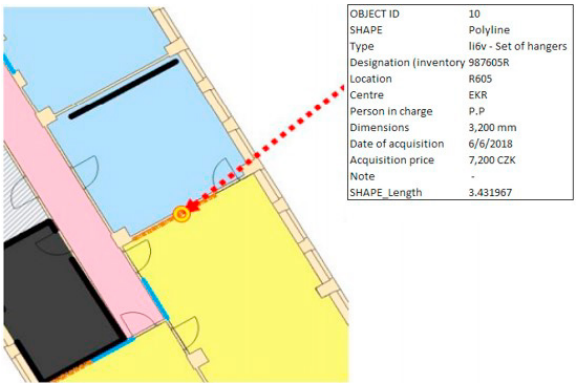

Figure 5. Example of "Line" layer information
(Source: authors' own processing)

Figure 6. "Line" line layer
(Source: authors' own processing)

Geographic Information Systems can be helpful throughout the whole property life cycle. It is therefore very difficult to describe all the functions and options that GIS can provide, as it always depends on the user and his preferences. Especially in the operational phase, as demonstrated in the case study, it is mainly about helping to manage and organize individual spaces, employees and users. In such cases, GIS is especially helpful in planning administration and maintenance, work evaluating, energy consumption monitoring, creating crises plans, recording and checking information, etc.

5. Conclusions

The aim of the article was to present the options of GIS usage and the advantages of databases of position information for facility management. The main principle of each information model is its functionality, which depends on the data structure. It is important to know what data it shall contain and for what purpose. This article was created with the idea of a practical example of a possible solution that could be beneficial for the premises due to the current absence of such an information model.

A number of analyzes and simulations can be performed on the model itself in the future, such as the energy performance of the building, the impact of the building on the environment, the size of the carbon footprint during the entire life cycle of the building or static and dynamic behavior of the building. It is thus possible to prevent possible risks even before the start of construction and thus reduce costs during construction and operation.

The field of facility management in the Czech Republic has still not been receiving much attention, however, the situation has been improving. It is so, mainly due to increasing pressure on reducing costs, increasing efficiency or due to environmental aspects. It is therefore important to work with the available data. Although this field does not concern the core business that companies do, it is very important for their proper functioning. It is therefore quite likely that the use of these systems will gradually begin to expand from the large companies to the smaller ones. Especially for large international companies that are located in different parts of the world or have a large amount of property, GIS systems in combination with facility management could become increasingly interesting mainly due to their analytical and visualization capabilities, which can respond quickly to otherwise very complex queries and thanks to the benefit of providing location information.

In facility management, geographic information systems have many uses, as they allow querying, interpretation, viewing and visualization of data, from several perspectives. They can be used to visualize or control spaces. Furthermore, to create analyzes in the field of planning or to simulate various emergencies and impacts that can occur in a number of other things.

The created information model presents the possible system appearance which would serve the purposes of facility management within the entire area of buildings and would be beneficial for both the facility manager and the users themselves

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