# DESIGN AND IMPLEMENTATION OF THE GEOGRAPHICAL INFORMATION SYSTEM OF ZOO IN BRATISLAVA

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**Abstract**

Creating a Geographic Information System (GIS) is a complex, step-by-step process that involves requirements analysis, creating the system's architecture, data acquisition, and implementation. This project outlines the development of a user-friendly GIS, using Bratislava ZOO as a case study. The paper describes the process of creating a GIS from formulating tasks to full practical implementation. The result is a website with four geoinformation modules: engineering networks, infrastructure, visitor app, greenery, and a file library. This project can serve as a reference for similar spatial object management systems in parks and other areas.

**Keywords**

Application, GIS, workflow, ESRI, ZOO

# 1 INTRODUCTION

Every day, we are faced with a large flow of information, which we absorb, process, and analyze. At present, more than ever, there is a need to streamline and sometimes generalize this information. Therefore, it is rational to store it in one place to avoid duplication and redundancy. In addition, for the system to be used, it should have a user-friendly interface and the ability to display data graphically.

Processed information is converted into data, and one of its forms is spatial data. Currently, Geographic Information System (GIS) is the way to store, process, analyze, and visualize spatial data [1], [2]. This tool, among other things, allows various organizations and groups to save financial and time costs, and also helps to make final decisions on any issues [2].

The purpose of this project is to create a GIS for the Bratislava ZOO, presented through web map applications for different areas of use by ZOO workers and administration, with different usage levels for each user group.

A GIS requires a well-formed, planned and protected structure capable of performing the required tasks . The scale and functionality of a GIS depend on the organization's tasks and the amount of data required . The method of designing and implementing the system is chosen based on these factors.

The implementation of a GIS is a complex process that requires detailed planning. Choosing the right approach for planning the system allows to avoid unnecessary expenditure of time, labor, finances and other resources during its creation. A well-planned process will affect the quality of the future GIS, which will determine its effectiveness in use. The practice shows that the most successful projects in the field of information technology (including GIS) are implemented according to well-structured plans that can ensure that users of this system get what they require [2].

The creation of the system can be divided into 4 main stages: requirements analysis, structure design, data collection, and implementation (Fig. 1).
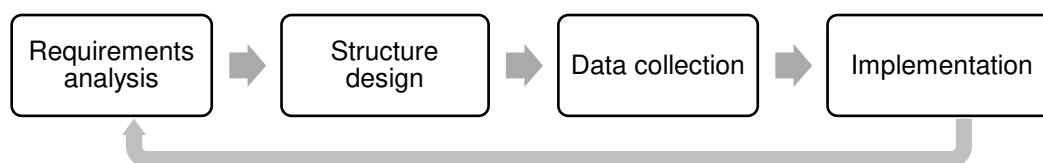


Fig. 1 Stages of creating an information system.

Each stage includes a certain number of tasks, the nature and specifics of which are formed by each organization in accordance with its focus.

In this study, several similar systems were analysed for better understanding and choice of a work strategy. For each designed section, several examples were found and their structure, interface, information content and functionality were analysed. One of the suitable examples considered in the framework of this work is the website of the Bratislava Magistrate [3]. The "maps" tab contains several sections, each of which contains certain information related to this area and a map window. For example, the City Special Plan section consists of a brief description of what a city plan is, some statistics, and a map application with a set of simple widgets, such as finding one's geolocation, switching layers, printing, and more. Another example considered was a web map of New York City trees [4], made using ESRI products. Spatial and attribute information about objects, in this case, trees, is presented in the form of a dashboard application. The application contains several customized filters with which the user can customize the display of objects on the map according to required attributes. Additionally, applications and online maps for visitors to various ZOOs around the world were considered. As a main example, we considered one of the most famous ZOOs in the world – the San Diego ZOO [5]. The considered applications have similar structures and functionalities, even if they are based on partially different user requirements. Initially, the user is provided with spatial information about the ZOO, including a map, with the ability to determine the current location and the ability to view information about animals. This information is often presented to the user in a pop-up window when clicking on an animal of interest, or in a new tab. Such applications usually also include information about buffets within the ZOO premises, their assortments, as well as other infrastructure facilities. However, most ZOO websites contain only a simple map diagram or an orientation plan of the area, rather than a GIS application.

The study of the aforementioned GIS applications has helped us create a vision of what GIS applications for ZOOs or parks might look like. This paper aims to describe the design and creation of a GIS application specifically for ZOO Bratislava. It includes a description of the GIS implementation process, which can theoretically be implemented to create similar systems. In our case, we focused on using ESRI products [6] as tools for system implementation, along with other tools for the design of a spatial information system.

## Customer requirements to the GIS of the Bratislava ZOO

The work on the GIS project began with a meeting with the management of the ZOO in February 2022, during which project requirements were approved, and various aspects and wishes were discussed.

The management's requirement was to create a system incorporating spatial and attributive information about certain objects within the ZOO, as well as carrying out cartographic surveys of selected areas of the ZOO for the purposes of accounting, planning, and cadastre.

After some clarifications regarding the future of the GIS, the following objectives of the project were formulated:

*1. App for ZOO visitors*

Make an app or web map available to the public. The application should display the user's position on the map, and provide information about ZOO animals and infrastructure, including restaurants, toilets, shops, playgrounds, and more.

*2. GIS engineering networks of the ZOO*

The main requirement of the customer is the creation of a GIS application for the ZOO's engineering networks, which include electricity, water supply, sewage and gas pipelines. Main information that the system should include is the location of engineering infrastructure facilities (with an accuracy of 14 cm), facility name, serial number, depth of underground linear facilities and photographic documentation. As a result of the discussion and subsequent implementation of the system, additional attributes such as pipe diameter, update date and source of information were proposed. Symbols according to technical standard STN 01 3410 [7] are selected to display engineering networks.

*3. GIS of ZOO trees*

Create a GIS application based on the dendrological report, that contains spatial and attributive information about trees within the ZOO premises. The system should allow filtering of displayed objects on the map according to specified attributes.

*4. Library of cartographic surveys*

Other requirement of the customer is to carry out a topographic survey on the ZOO's territory as tasks are received, with the aim of producing topographic plans for architects. Each survey should be negotiated with the architect in advance. Further, the final survey materials will be stored in the GIS in the form of tile layers and attachments in formats .dgn and .dwg.

It is important to note that the task is not to survey the entire territory of the ZOO but only its individual parts, as the need appears over time.

As a result of the discussion, the main sections and aspects that the GIS contain, as well as potential sections that we can offer when implementing the GIS at the Bratislava ZOO, were identified.

### Territory characteristics

The Bratislava ZOO is located in the cadastral area of Karlova Ves, in the Bratislava-Karlova Ves district (Slovakia). The area of this territory is approximately 50 hectares. Within this area, there is a public zoological park and facilities for administrative and economic management (Fig. 2).
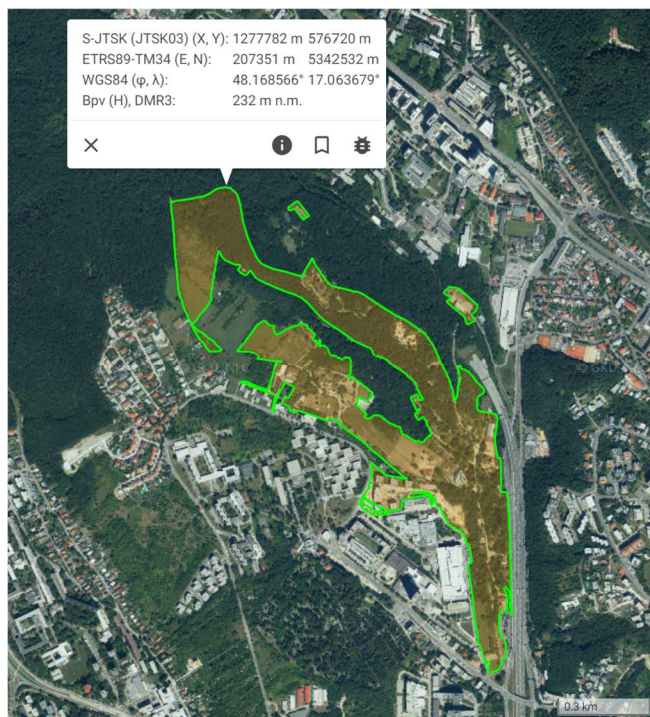


Fig. 2 Case study area – ZOO Bratislava (Slovakia) [8].

The ZOO's area contains several bodies of water, such as lakes and streams. Approximately 2 hectares of forested area traverse the ZOO territory and contain distinctly planted tree species.

Based on LiDAR data [8], the landscape of the ZOO is characterized by an elevation difference of approximately 80 meters, with a maximum elevation of 228 meters and a minimum elevation of 148 meters.

There are around 60 biotopes with animals divided into 5 different zones based on the type of animal. Conditions have been created in these areas to suitably maintain the animals.

## 2 METHODOLOGY

### System design

During the design stage of the system, using the Unified Modeling Language (UML) [9], we created Class Diagrams and Use Case Diagrams, employing the StarUML software [10], which has the necessary set of tools for these purposes.

In the Class Diagrams, we created blocks for each designed section that display groups and their attributes. For example, when modeling the structure of the application for accounting engineering networks (Fig. 3), we created five blocks, each corresponding to a separate type of engineering network. Within each block, we designed attributes and their corresponding data types. We also created a separate –geometry block, indicating that the system will display the spatial position of objects. A 1:1 relationship means that each object will be rendered only once.
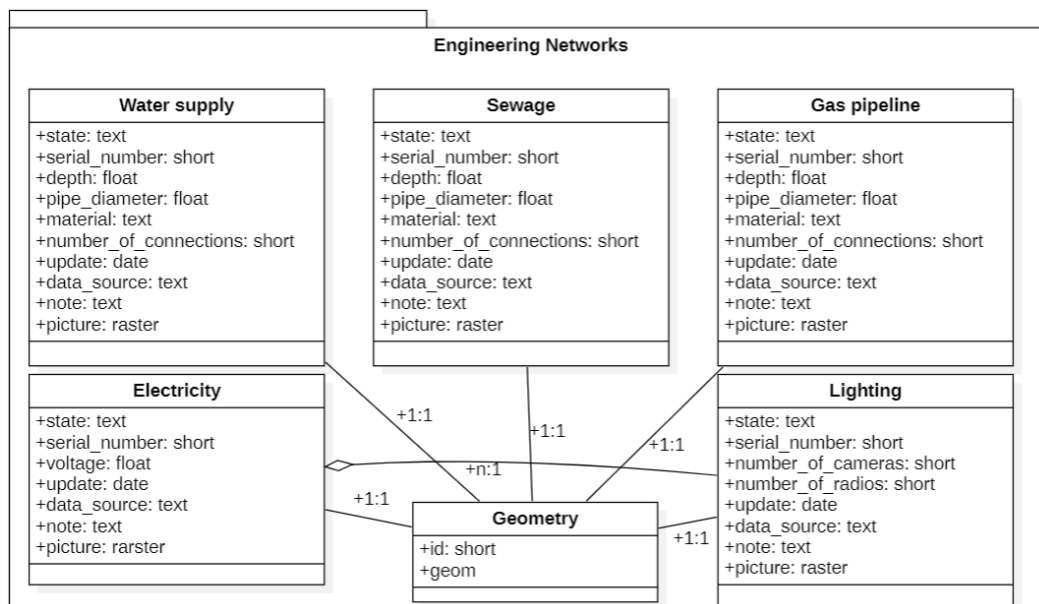
Fig. 3 Fragment of UML Class Diagram for GIS accounting of engineering networks of the Bratislava ZOO.

Next, a Use Case Diagram was modeled for four user groups: the public, ZOO administration, ZOO workers, and system administrator. This diagram shows what actions a member of the group can perform in each individual application (Fig. 4).
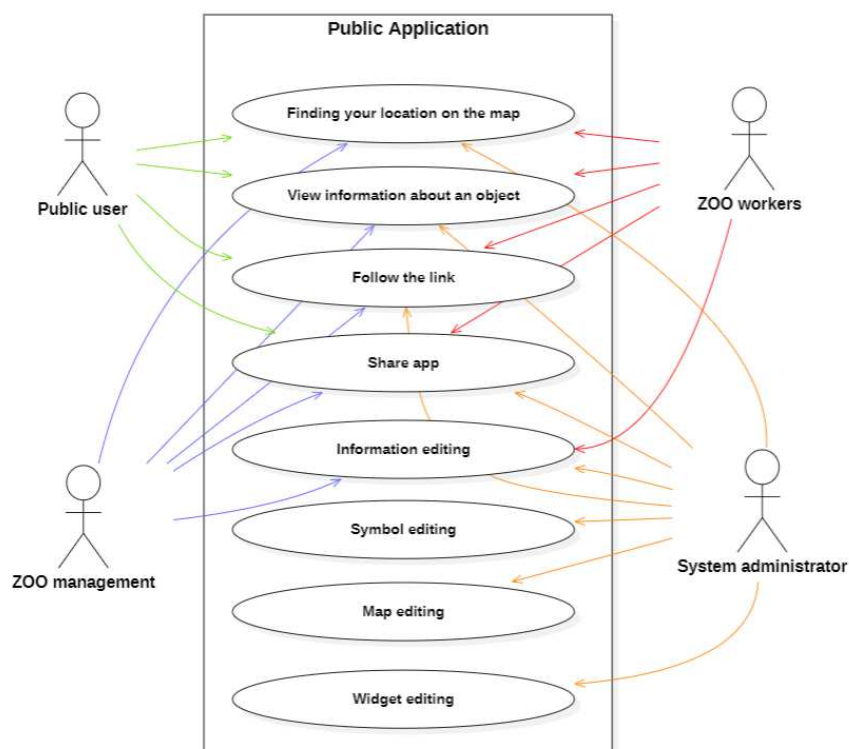


Fig. 4 Fragment of UML Use Case Diagram for the public application of the Bratislava ZOO.

## Development of the ZOO Public Application

The application creation initiated with the selection of spatial data to be utilized. This included address points of various objects within the ZOO:

- Animal areas.
- Food and restaurant locations.
- Souvenir shops.
- Restrooms.
- Playgrounds.
- Ticket booths.
- Entrance/exit.
- Parking lot.

As a base map, a raster map of the territory encompassing the ZOO was downloaded from the ZBGIS website [8]. Attribute data was also gathered from the ZOO website [11]:

- Animal names in Slovak, English, and Latin.
- Animal classes.
- General animal information.
- Restaurant operating hours.

Following this, the application's symbolization style was chosen, and a symbol library was created. To display the address points of animal areas, a circle with a colored outline indicating the animal class (as per the ZOO website [11]) was chosen. Inside the white inner circle is the black silhouette of the animal.

For the remaining symbols, a white circle with a thin black outline and an image inside was selected. As a base map, a cut-out from an orthophoto map outlining the visitor-accessible area of the park was selected. The park's boundary was manually vectorized from a raster map on the ZOO website. This raster image was georeferenced based on selected points. The orthophoto mosaic is overlaid on the 'Imager' world map, set at 70% transparency.

Attribute information collection began by gathering data from the Bratislava ZOO website. An Excel table was created, with columns corresponding to attributes in the database. Apart from the title, animal type, and brief information, an attribute 'More Information' was added, linking to the specific animal's dedicated page on the ZOO website.

After setting up symbolization and filling in the attribute table, the selected layers were exported to ArcGIS Online. Final parameters for map and attribute display were configured here. The next step involved creating the application. To align with the application's concept and vision, a template focusing on the available catalog of animals in the ZOO was required, enabling users to obtain information about each animal and find their area of interest on the map.

The most suitable template among the proposed ones was the 'Attachment Viewer' from the Instant Apps Constructor. The previously created Web Map was chosen as the map application, with pre-set parameters for attribute display and symbolization.

On the right side, there is a catalog of all animals, categorized by their class. Upon selecting a specific animal, users can read its information and locate it on the map. Additionally, we added a widget for finding one's location on the map, transitioning to the main view, a legend, and a full-screen mode toggle button.

We also configured a pop-up window upon the application's launch, providing users with information about the day's events at the ZOO.

The final step involved publishing the application on the ZOO hub. This required adjustments in the publication settings to make it visible to the ZOO Private Team group. Then, by accessing the ZOO hub settings, we added this application. This ensured that, at this stage, the application became available to the ZOO management for further review, testing, and modifications.

## Application for engineering networks of the ZOO

We further implemented an application for engineering communications.
The interface of this application includes the following widgets:

- Layers.
- Base Maps.
- Edits.

This widget allows for editing attribute information about objects on the map. In the desktop application, settings were configured to determine which attributes users can modify.

- Scale.
- Drawing.
- Print.

The application also includes auxiliary tools for zooming, switching to full-screen mode, and displaying the user's current geolocation, which is beneficial when using the application in the field.

At the bottom of the screen, there is a dropdown menu used to toggle between objects and highlight them on the map.

Additionally, clicking on any object on the map brings up a pop-up window displaying its attributes.

During the implementation process of the engineering communications application, we encountered an issue regarding the display of symbols created in ArcGIS Pro and transferred to ArcGIS Online [12]. Symbols appeared incorrectly, displaying different colors, angles, and sometimes not at all. This problem is explained by the inability of ArcGIS Online to correctly utilize complex composite symbols created outside of it. Consequently, the relationship between attributes and symbolization is not maintained. For instance, in the public lighting layers, each lamp's angle is based on the 'angle' attribute and its sequence number in the database. When uploading data to ArcGIS Online, this relationship is not preserved, resulting in all lamps having an angle of zero.

This problem was resolved as follows: for the same layer, we published both types of layers – tile and feature. However, the feature layer was made entirely invisible on the map. In other words, when a user clicks on the desired object, they click on the area in the image (tile) beneath which lies the invisible layer (feature) with the incorrect symbology. This solution has no drawbacks other than requiring more time.

At the final stage, we created a section on the ZOO GIS website where all geodetic measurements are stored in .pdf and .dwg formats.

## Tree Application

A similar template used for utility applications was applied in creating the ZOO tree application. The foundation for attribute data was a dendrological assessment obtained from the ZOO management, detailing information about the condition of specific trees, their height, trunk diameter, and more. These trees were further mapped using GNSS measurements, accompanied by on-site photographic documentation of each tree.

During the map creation phase in ArcGIS Pro, emphasis was placed on attributes containing information about the tree type and its perspective. Based on this, layers were generated for deciduous trees and coniferous trees. Symbolization for these layers was configured according to the 'tree perspective' attribute.

# 3 RESULTS

The final product of the project is a GIS website of the Bratislava ZOO, containing the following web applications:

- Application for ZOO visitors, where each user can view information about animals, plants, restaurants, and other objects within the ZOO.
- Engineering networks of the ZOO. This application contains a map displaying the location of engineering objects, tables of attributes and tools for working with the map.
- Trees of the ZOO. The application contains spatial and attributive information about landscaping objects for which a dendrological study was carried out by a third-party company.
- Library of geodetic measurements and mapping of the ZOO.

Therefore, the result of this work is an implemented GIS for the Bratislava ZOO. Currently, this GIS comprises three modules.

The first module is designed as a web application for ZOO visitors. It contains a map showing the locations of animal habitats, dining areas, playgrounds, toilets, and other facilities. Users can access information about each animal in the ZOO, view the café menu, and more (Fig. 5 and Fig. 6). Additionally, the application displays information about events scheduled for specific days upon launch.
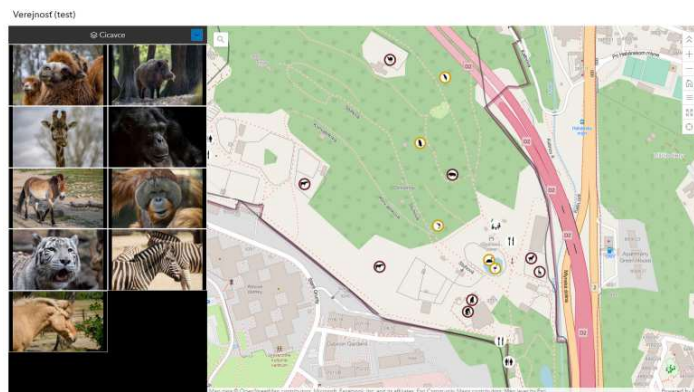
Fig. 5 Final view of the ZOO public application [13].
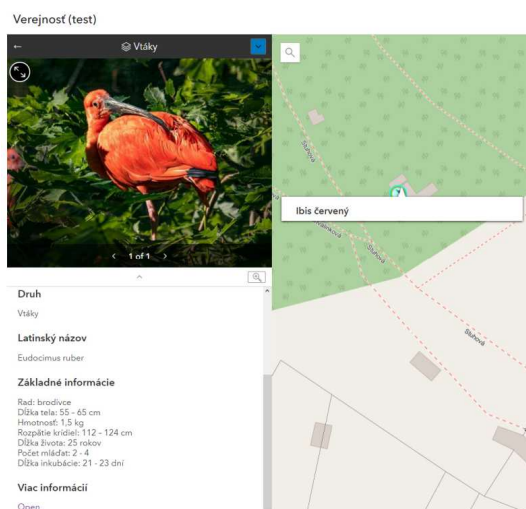


Fig. 6 Object information in the ZOO visitor application [13].

The second module is dedicated to the inventory of engineering networks and is designed as a mapping application displaying engineering infrastructure objects with a precision of 14 centimeters. The application includes widgets for toggling layers, base maps, object modification, searching for one's location, and other useful tools (Fig. 7). Each layer has its attribute table, also visible in the application. Selecting an object on the map allows access to all available information about it via a pop-up window (Fig. 8).
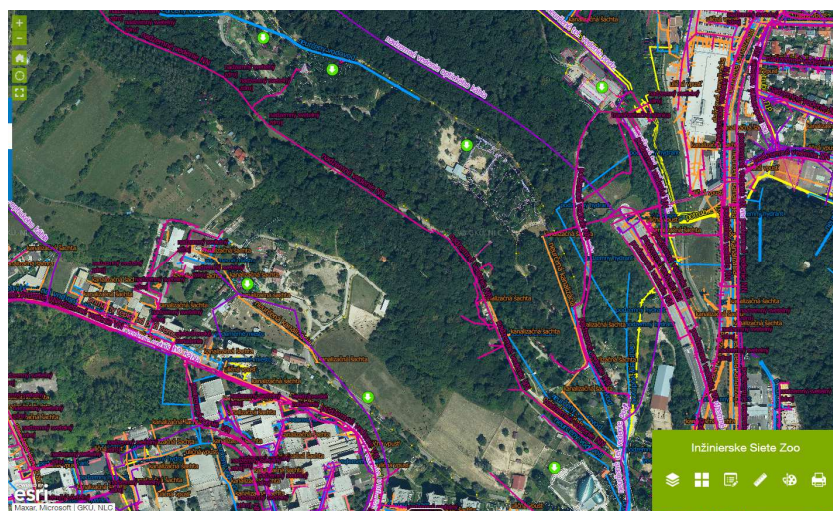


Fig. 7 Engineering communications application [8].
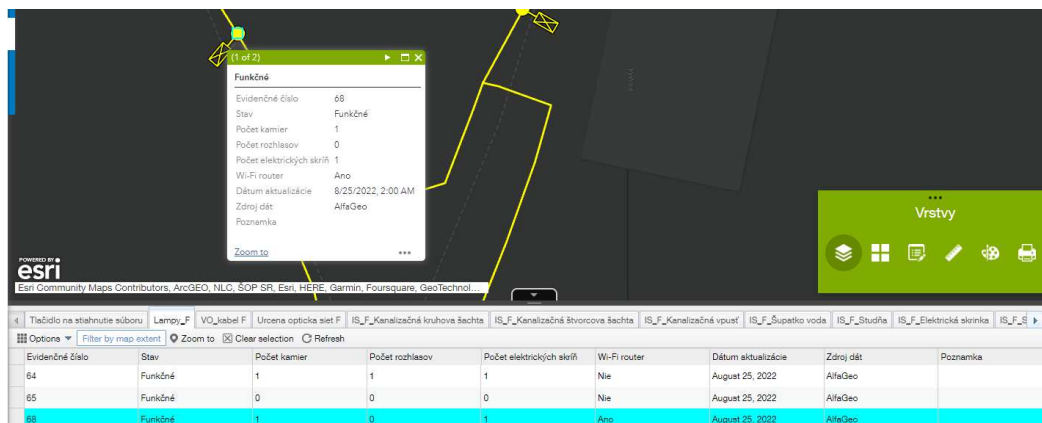
Fig. 8 Attribute table in the engineering communications application.

A user with editing rights can modify attribute information for any object using the edit widget in the tools pane (Fig. 9).
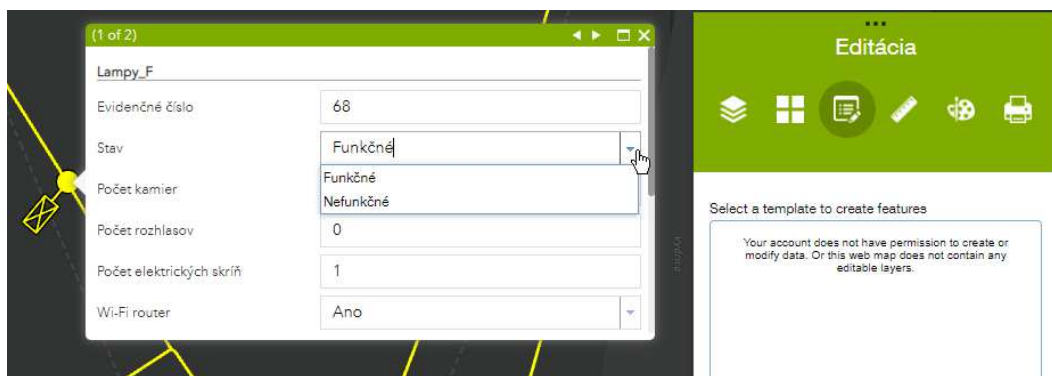


Fig. 9 Altering attribute information in the engineering communications application.

The third module contains spatial and attribute information about the ZOO's trees from a dendrological assessment (Fig. 10).
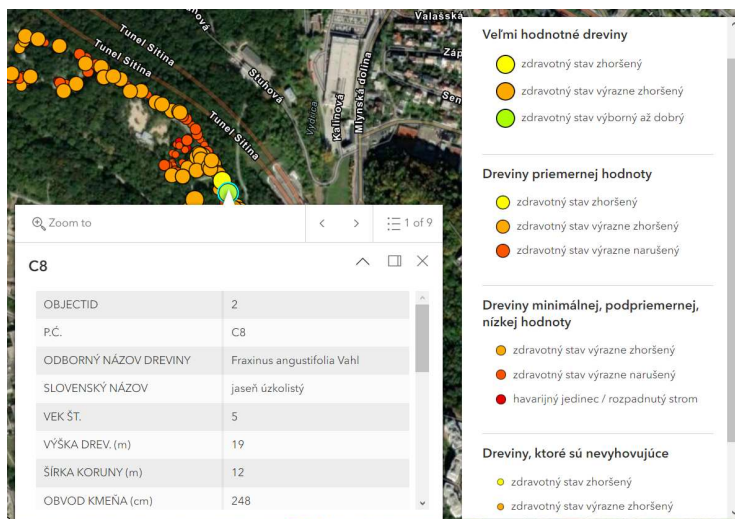


Fig. 10 ZOO tree application interface, which includes names of the tree species, age, height, crown width, trunk diameter, and condition of trees.

The fourth module is created as a file library where system users can find area plans in .dwg and .pdf formats. This module aids in storing existing plans in one location and facilitates document exchange among engineers (Fig. 11).
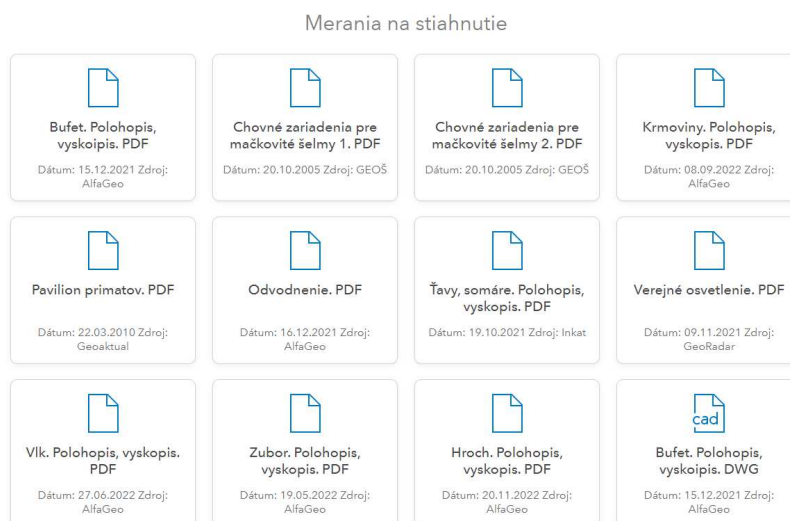


Fig. 11 Geodetic measurements library that includes survey outputs in .pdf and .dwg formats.

# 4 DISCUSSION

The paper outlines the successful design and implementation of the GIS for the Bratislava ZOO. The results showcase the development of a user-friendly GIS.

The paper refers to ESRI products for GIS implementation. While it provides a detailed account of the stages of GIS implementation, it would benefit from studying other similar projects [3], [4], [5] or methodologies before the implementation of similar systems. Comparing the design choices and methodologies with those of other projects could provide additional insights and strengthen the validity of the chosen approach.

The paper briefly touches upon an issue encountered during the implementation of the engineering communications application related to the display of symbols. It is crucial to expand on this limitation, providing insights into the impact it had on the project timeline, resources, and the steps taken to mitigate or resolve the issue. Additionally, unexpected results or challenges that arose during the project should be discussed in more detail, contributing to a more comprehensive understanding of the GIS implementation process.

# 5 CONCLUSION

The Bratislava ZOO did not have such a system before. This GIS can serve as a useful tool for ZOO management, aiding in analyzing specific areas and planning development concepts. The implementation process involved several stages: user requirement analysis, system structure design, data gathering, GIS implementation, subsequent system functionality testing, and system presentation to ZOO users. The creation of this system not only demonstrates the development of a user-friendly system based on spatial data using ESRI products but also showcases its potential applicability in other GIS applications, especially for parks, public gardens, and ZOOs.

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