

GIS FOR SMALL MUNICIPALITIES

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Abstract

GIS for small municipalities is the topic of this paper. The project is based on the information needs of self-government of small municipalities or city districts. It solves the compromise between the lack of funds to build special-purpose GIS and the need for computer support in accounting and decision making processes. The article describes the construction of the project. The first phase is the design of the system included the determination of user requirements and data collection. The layers integrated into the system (national map series, ortho-photomaps, cadastre of real estates, town-planning documentation, environment, etc.) and data providers are described in this first part. The second phase is the implementation of this design system contained steps as the choosing appropriate software (primary ArcGIS software), the input, the data transformation and data analyses. The analyses were made for two types, the surface analyses based on created digital terrain model (terrain maps of exposure, slope, shadow, visibility, etc.) and thematic spatial analyses (finding the optimal place to live, selection localities for the construction of wind or solar power, a good place for a playground, etc.). The final phase is about the creating of required outputs and the installation of the system on the local authority. The project was exported into format *.pmf for freeware browser ArcReader because users have not had ArcGIS software. Some problems that appear in individual phases of creating are described in the article, too. To date the technology of GIS has been deployed using this method into small municipalities Křetín, Vranová, Jinačovice, Moravice, Želešice, Silůvky and into the District of Brno-Jundrov, Brno-Líšeň and Brno-Jih (Komárov, Horní and Dolní Heršpice, Přízřenice).

Keywords: GIS, municipality, administration, spatial analysis.

1. INTRODUCTION

In the recent years information technology belongs to the fastest growing science disciplines and cuts across all branches of knowledge. There is no difference in areas of the state administration, where the demand grows for its own geographic information system (GIS) over the territory of its autonomy. GIS arise at the regional level, as well as at the level of the small municipalities and smaller city districts.

The deployment of GIS technology into the ambience of small municipalities or city districts has its own special specifics. On the one hand, there is the modern technology that is certainly a very useful tool in the practice of the state administration and in many cases can be enforced by the legislation; on the other hand, there are very restrictive means for the acquisition of hardware and software components of GIS, including training of the operator, due to financial unavailability.

Both of these opposing factors have led to the idea of farming out the implementation of GIS for small municipalities (or city districts) in the form of master's thesis. The advantages are negligible cost of the system design and low, user-controlled costs on its running. To date the technology of GIS has been deployed using this method into small municipalities Křetín, Vranová, Jinačovice, Moravice, Želešice, Silůvky and into the District of Brno-Jundrov, Brno-Líšeň and Brno-Jih (Komárov, Horní and Dolní Heršpice, Přízřenice) [1].

2. DESIGN OF THE SYSTEM

2.1. Requirements for the system

The uniform frame of the structure of GIS for needs of small municipalities can't be defined easily, because each municipality has different requirements for the content of the system depending on the position, historical and industrial specifics of the municipality. Therefore there was firstly the need to arrange a personal meeting by the mayor (or mayoress) of the municipality or the city district. The interview determined what the requirements the representatives of the office have and what the idea about of the overall structure of the system the representatives have as future users of GIS. At the same time it was checked whether the office has some materials that could be utilized for the following creation of GIS. In conclusion of a meeting the creator of system arranged with representatives of the office to the possible future cooperation.

THE MOST COMMON USER REQUIREMENTS

- drawing of all underground services
- display of objects registered in the cadastre of real estates, including the database of the file of descriptive information relating to these objects
- valid town-planning documentation
- ortho-photos of the interest area
- planimetry and altimetry of map for given location
- technical characteristics and master plans (transport, greenery, waste management, culture, etc.)
- register of population, register of ratepayers behind dogs and waste
- price map of plots
- information about the environment
- thematic spatial analysis.

2.2. The collection of needed data

The data collection is a crucial phase of the design of the GIS because in simple terms any GIS would not have been created without data. Generally, data are located in different places, under different administrators or heads of departments. The result of system design is dependent not only on the availability of materials, but also on the willingness and helpfulness of the administrator of these data.

The following is a list of categories of data layers, which were included into the system on the basis of user requirements and the discretion of the system creator. Further, the main data providers are introduced here.

THE TOPOGRAPHIC LAYERS

- ortho-photomaps of the interest area (source: Geodis Brno, The Czech Office for Surveying, Mapping and Cadastre (COSMC))
- planimetry and altimetry of map, digital terrain model (source: ZABAGED - COSMC)
- cadastral maps (digital cadastral map, thematic cadastral map, raster of the cadastre of lands, orientation map of parcels; source: the cadastre office, the local authority (LA))
- tourist and bike tourist maps, nature trails (source: SHOCart, LA)

THE THEMATIC LAYERS

- town-planning documentation (source: Brno City Municipality (BCM), LA)
- utilities (source: BCM, network administrators - E.ON, JMP Net, Jihomoravské vodovody a kanalizace, Telefonica O2 and others)
- infrastructure - maps of roads, railways, public transport networks etc. (source: BCM, LA, ZABAGED – Fundamental Base of Geographic Data)
- Price map of building or agricultural plots (source: BCM)
- environment - waste management, significant green space, maps of protected areas, air quality maps, map of the main wind directions, noise maps, floodplains, soil maps and cover forest maps etc. (source: BCM, The Agency for Nature Conservation and Landscape Protection of the Czech Republic, T. G. Masaryk Water Research Institute, Lesy ČR)
- geological and geophysical maps - radon index, gamaspektrometry, radiometric and geomagnetic maps (source: Czech Geological Survey, Geofyzika Brno)
- historical maps, maps of immovable cultural monuments (source: server mapy.cz, The South Moravian Regional Authority)
- interactive maps with hyperlinks created on the basis of own photographs of objects in a given locality

The biggest problem in collecting data was the reluctance of some data administrators to provide data free of charge and therefore not been possible to integrate the data into the system. Another problem can be time-consuming communication between data providers and the applicant because it was not always easy to simply explain what one asks for, what purposes the data are needed, in what form, etc. Another complication was the incompleteness of the data so in some cases necessary data was supplemented by direct field measurements. In one case the problem was the lack of data for the requested data layer.

It is worth mentioning that a large amount of information and data can also be found on the Internet. Map services that may be used are particular so-called IMS (Internet Map Service) and WMS (Web Map Service). The important provider is primarily The Czech Environmental Information Agency that provides services through web geoportal of the public administration. You can find there a large amount of useful data not only from the environment, but also information on the administrative division, noise maps, population, transportation, etc. Other providers of WMS are for example COSMC and the Czech Geological Survey.

It is rewarding to use the data from these services for the creation of GIS. Either we can make the vectorization of maps from service and then enter the object information into the attribute table (this is useful when we know that the municipality has a problem with connecting to the Internet), or suffice to have these services connected with our GIS using the URL address.

3. IMPLEMENTATION OF THE DESIGNED SYSTEM

3.1. The choosing appropriate software

After designing the system followed by a phase of data processing and displaying in the appropriate software. The implementation itself can be divided into several steps.

For creating GIS was chosen primarily the software ArcGIS from ESRI Company, specifically product ArcGIS Desktop with the highest level of services, ArcInfo. Also the software Geomedia from Intergraph was used in several cases.

3.2. The input and the data transformation

This is generally about integrating the materials into the layers of a single coordinate system, in this case of the Czech system S-JTSK. The obtained data were in double form, either in the form of digital (vector or raster) or analog. With the materials that were digital and have already had the defined coordinate system S-JTSK was the least work. The data that were not delivered in this system had first to be transformed. Problems were for example in the transformation of historic maps because it was difficult to look for identical points needed for the transformation. In this part some errors in planimetry of individual layers had to be resolved.

The most of work was done with analog materials. The maps of these documents had to be first converted to raster form by scanning. These data were incorporated into the system either in the newly created bitmap format, or even further converted to vector form using editing tools.

Other materials obtained by analog can be various databases that the municipalities lead in the paper form (e.g. the population register). In this case, do nothing else but the database manually transcribe into digital form and then connect it with the graphic part of the system.

After the integration of various GIS layers remained the last step. To classify properly these layers, i.e. to define the graphic attributes of each class of elements and then to fill in attribute table of layers for additional needed information. If we do not create metadata, at least every object should contain in its attribute table the basic information about the type of object, data source, updating data, date of creation of layer, author, possibly hyperlinks to related documents, photos or web pages.

3.3. The analyses of data

Once we have created the GIS we can proceed to the next phase: the data analyses of this system. Thus we get more data and new information. Analyses can be divided into two groups: on the surface and thematic spatial analyses.

THE SURFACE ANALYSES

The digital terrain model (DTM) was created from the 3D contour of ZABAGED. The following rasters were derived from DTM on the basis of surface analyses:

- exposure terrain map - gives information about the orientation to cardinal point
- slope terrain map - informs about slope conditions in the area
- shadow terrain map - shows rate of reflected light for each surface of terrain towards a defined light source
- visibility terrain map - specifies the visible area from a predefined position. The results of the analysis are places that are visible from this station and which are not visible and are shaded terrain.
- grid terrain model - the interpretation of elevation using colored hypsometry
- contour.

These layers were then used for following analyses.

THE THEMATIC SPATIAL ANALYSES

The following analyses were processed for the given locations using ArcGIS tools from data of created GIS and derived layers from the DTM:

- Finding the optimal place to live – the specific parameters of this place were identified on the base of the questionnaire. The layers used for the analysis were town-planning documentation (areas of housing, woodland, gardens and public transport stops), the noise maps of road transport, container space for waste separation, the price of building land map, slope and exposure map of the terrain [2].
- Site selection for construction of houses – data included in the analysis were from noise maps of road transport, thematic cadastral map (a nature of land use arable land, gardens and permanent grassland), bus stops and the boundaries of the floodplains Q100 [3].
- Assessment of stressor factors in the areas of housing from standpoint of environmental studies - the analysis was based on ten stressor factors. The data were used from dispersion studies, flood plain area, noise maps of road transport, area of groundwater contamination and areas of former landfill [4].
- Finding a location for solar power plant - the parameters given to companies engaged in construction of these buildings. Used data for the analysis were particularly from exposure and slope terrain map, from solar study and data of the Czech Hydrometeorological Institute (CHMI) [5].
- Finding sites for wind power plant - the parameters chosen for a specific type of wind power. Used data from the CHMI and the design of wiring [6].
- Appropriate location of a playground - the parameters of the plot for the location of a playground were given by the processor. Used data from the cadastral map and the slope terrain map [5].
- Location of ground water purifier - the parameters chosen according to the specific type of plant. It was worked with the data of cadastre of real estate [6].
- Choosing of location for the observation tower - used data from the maps of visibility terrain [6].
- Values of erosion for the interest area in the farmed land and the proposal of anti-erosive steps - used a cadastre data, DTM and BPEJ [6].
- Selection of parcels in the noise band - using cadastral map [7].

4. PRESENTATION OF DATA AND THE OUTPUTS

The last phase is the creation of so-called layouts, outputs from GIS, for presentation of project results. Next it was made an overview of all data layers that are located in the created GIS. In the end the animation of flight over the given territory and 3D visualization were created whose materials were ortho-photos and DTM.

This article contains two figures as the example of outputs. They demonstrate the outputs of GIS of the District of Brno-Jundrov. In the first figure is the structure of this GIS with 13 thematic layers and illustration of 16 data layers. The second figure is about the spatial analysis - finding of the optimal place to live. Seven parameters of this place were identified using the questionnaire and two parameters were given by legislation. In the figure are processing model of this analysis in ArcGIS interface and results of questionnaire.

5. CONCLUSIONS

The created GIS, including all of its outputs, was passed to the local authority (or the municipal authority) and the users were familiar with the content of the system. Because the software ArcGIS is for small municipalities unaffordable, the individual data sets were converted to the format *.pmf (Publish Map File). This file can be viewed in ArcReader application, which is freely available on the ESRI website. This application has a similar interface as ArcInfo, but there are editing functions suppressed. This browser was installed and briefly introduced to users.

GIS of the District of Brno-Jundrov

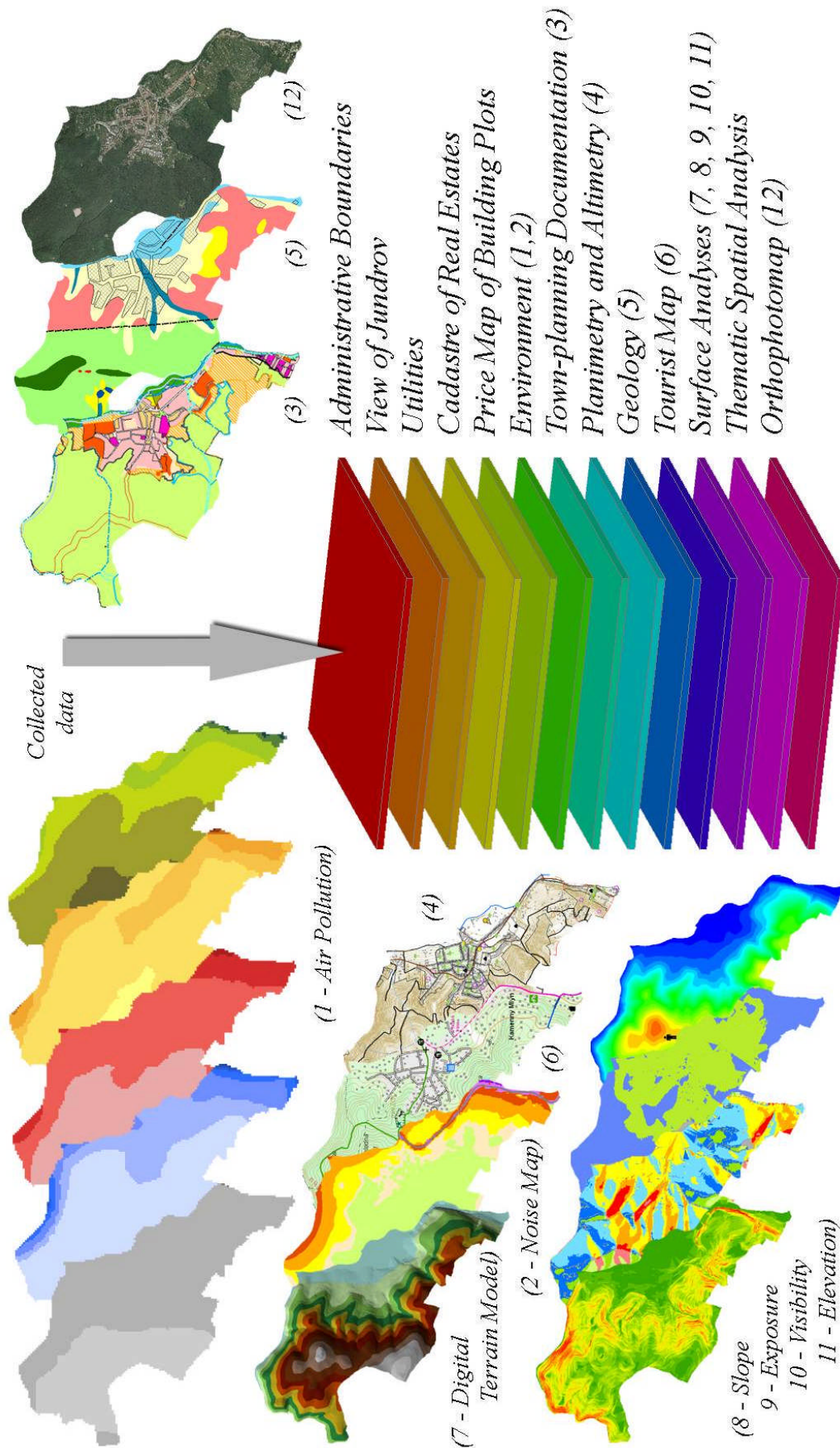


Fig. 1. The Structure of GIS of the District of Brno-Jundrov

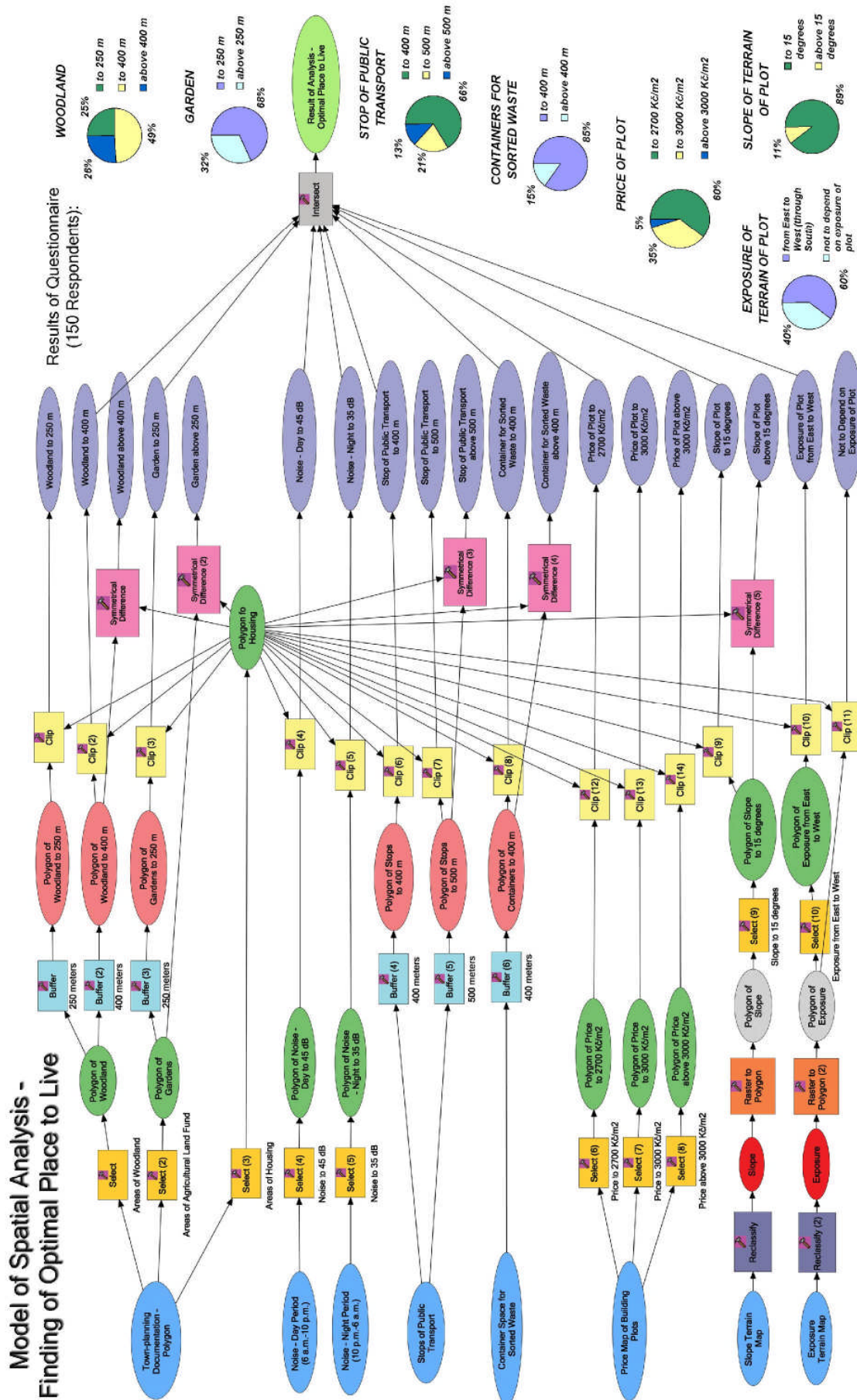


Fig. 2. The Model of Spatial Analysis and Results of Questionnaire

Among the most useful layers for representatives of municipality and citizens are undoubtedly plotting of utilities, cadastral map, town-planning documentation or information about the environment. The information system serves as support at making a decision and related processes for self-government municipalities. Can be used as a suitable material in the case of town planning or as a basis for construction activities. The results of the work may also serve to inform local citizens or visitors to the municipality.

Problems can occur at all phases of creating. For data collection the problems are especially reluctance to provide data, then the deficiency or absence of data. For data processing the aggravating factor can be laborious converting analog to digital form. The analog form of the materials occurs mainly in the office of smaller municipalities. For GIS of city districts data were obtained mostly on the BCM in digital form. Further complications may occur during data transformation. In the final phase of the project the training of a representative of users was always necessary, because unfortunately most workers on the offices of municipality have no experience with such an information system, as opposed to regional offices where there are separate departments with GIS staffers.

The biggest problem is the data update. Because it is assumed that an update will not be often under way (maximum once a year), it can be solved a one-off contract or again farming out the master's thesis. Some data layers can be solved from standpoint of updates at least through the IMS or WMS services (cadastral map, ortho-photomaps, ZABAGED etc.).

The most common reason why some smaller municipalities or city districts still do not use GIS is financial unavailability. Other reasons are lack of awareness of GIS, the supply of use GIS exceeds the need of the office, or the possibility that so far municipalities only think about the introduction of the GIS [8]. So the main target of this project was and still is the successful creation of a GIS for the needs of small communities without charge, as well as to familiarize them with issues of GIS and convince them that this system is benefit to its users.

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