GIS Technologies Implementation Based on The EU Directive Inspire

A case study of the Pabianice city

Tomasz Kroc¹, Bartosz M. Walczak²
¹,²Lodz University of Technology
¹tomasz.kroc@gmail.com ²bartosz.walczak@p.lodz.pl

This paper presents the experience of implementing GIS technologies at a county town urban planning department. The necessity to implement GIS technology is partly dictated by the requirements of the INSPIRE Directive. The discussed case provides valuable information about the problems and challenges that cities have in Poland, while performing their obligations under the directive. The process of preparing the necessary geographical database corresponding to existing planning documents raises many legal and technical problems. The presented case illustrates the whole process associated with the preparation of digitization and publication of urban plans. At the same time, it is worth to see the numerous benefits that the city obtains after publishing GIS data. Attention should also be paid to the further development of GIS and the chances of their use, especially in urban centers.

Keywords: INSPIRE, GIS technologies implementation, urban planning, sharing geographic dates

BACKGROUND

The history of geographic information system goes back to the 1960s, when the very first solution of this kind was implemented in Canada by Roger Tomlinson (Tomlinson 1968). He is therefore often acknowledged as the “father of GIS”. During the following decades, governments of other countries gradually realised many advantages of digital mapping and what is more dedicated software was developed. But it was not before the 1990s when the usage of GIS started to become a commonplace, supported with further technological advancements (Besio at al. 1998). Some ten years later standardisation allowed users to explore viewing process of GIS data through the Internet. More recently open-source software has been emerging as well as more and more geospatial data has become accessible to download for free.

Nowadays, in every EU member state, spatial data is collected by various organisations, institutions and administration bodies, both at the central and the regional level. The result of the above is a huge number of dispersed databases that cause the cumbersome acquisition of data. Furthermore, this situation also entails that comparing data between different EU countries is almost impossible, as they are not integrated. In order to change the above-
described situation, an initiative called INSPIRE was undertaken, which was the basis for the development of the European Union directive under the same name. The main idea was “to establish an infrastructure for spatial information in Europe that is geared to help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development” (EU 2007). The main aim was, therefore, to allow the unconstrained sharing of spatial data by public sector organisations and facilitate public access to spatial information in Europe.

The adoption of this directive by member states resulted among other things in the emergence of an increasing number of databases available on the Internet. Spatial planning websites are among the popular as they affect a large group of stakeholders. On the other hand, the possibilities of GIS software prove to be a smart, efficient and viable solution for urban planners to present their work in a way that is clear even to a laymen.

It is not surprising then, that many cities in addition to 2D mapping have been introducing 3D models of their city centres linked to the databases (Haala and Brenner 1999). A number of scenarios for such projects has been recently described e.g. for Newcastle (Thompson and Horne 2010). Most often, however, these are the models based on the point cloud acquired from an airborne scanning. Those models are not associated with any spatial databases, but only form a mesh. In a few cases, an attempt is made to combine the model with database. One of the most advanced works in this field is implemented in Berlin, where the model, shared in the network, is divided into individual objects (circa 550,000 buildings) and connected to a database containing, for example, the year of construction of the particular object and many others features. It is available to the public as Open Data model. It took several years to develop and implement such an extensive and complex GIS (Dollner et al 2006).

PROBLEM CHARACTERISTICS

The administration and public services count on the main fields of application of the GIS. They are both users and owners of the largest amount of spatial data. Moreover, local government organisations can implement citizen-engagement applications which transforms the urban planning into a truly democratic process. Portals for higher level authorities have been the subject of extensive discussions, as had been solutions implemented by large metropolitan cities. The development and the possible use of GIS in the form of geoportals at local levels still seems to have been insufficiently discussed.

It has been observed that despite the 50-year history of GIS, a number of local government units in Poland still do not have urban planning data in a digital form. But reasons for that are significantly different from those in other EU countries from around two decades ago (Bille, 1999). However, INSPIRE requirements are forcing local authorities to introduce digital technologies. Furthermore, there is a big demand for the geospatial data from other public institutions and private sector alike (Kaczmarek et al. 2014). Limited resources are among the main obstacles in this process. This problem will be illustrated with recent attempts done at Pabianice, a medium-size county town in Poland. The essence of this problem is the combination of an existing electronic mapping basis with a large-scale planning document.

CASE STUDY

The case study concerns the city of Pabianice, located in central Poland. It is a city of approximately 70,000 inhabitants, with an area of about 33 square kilometres. Its dynamic development in the 19th century was strongly connected with great industrialisation process in the whole region. Nowadays Pabianice city is a seat of the county authorities. However, it remains overshadowed by a nearby metropolitan centre - Łódź - the seat of the voivodeship i.e. provincial authorities. Currently, the industrial character of the city is only a reminiscence, but old factory sites still attract investors. The city is attractive due to the cen-
tral location in the country, well-developed communication network (intersection of highways, railway line), available number of qualified human resources (in the nearby provincial city there are five public universities).

Taking into account the rich history of Pabianice, its origins dating back to the 12th century, and its dynamic development during the 19th century, it is not surprising there are many listed buildings in the city and an unique historic urban landscape with importance on the scale of the whole region. As a result, there are numerous conservation protection zones. In addition, the river flows through the centre of the city, which causes the existence of flood zones, the area of nature protection of the landscape and habitats, as well as archaeological sites. All these factors are essential for urban planning and therefore must be included in a broader urban study in which the existing conditions and potential development directions are defined.

For many years, Pabianice city did not have a municipal department responsible for preparing and executing planning studies. Urban plans of this type were outsourced to specialised enterprises selected through a public procurement. However, a few years ago (in 2012), local authorities decided to establish their own autonomous unit within the public administration. As a result, a specialised team was created. This had a positive impact on a number of issues:

1. Improvement of the current urban planning due to the direct contact with local authorities, individual public units, as well as the community.
2. Accelerating the decision-making and implementation process by omitting the need for a tender-based public commission procedure.

Figure 1
The raster version of the urban plan of Pabianice
3. A holistic approach to all aspects of the city’s activities and their inclusion in a coherent strategy during the planning process, taking into account all conflicts occurring during its course, while at the same time caring for the interest of the city and its residents.

4. Direct management of all information and databases owned by the city.

5. Conducting an independent planning policy and raising funds for revitalization and promotion of the city.

One of the activities undertaken in 2015 by the Urban Planning Department was a decision aimed at digitisation of existing raster-version planning studies and their publication on the Internet. There were many companies on the market offering digitisation of 2D data, however, local authorities did not have the funds for such a large expenditure at that time. Similarly, they were sceptical about spending on specialised software even when it was offered by large providers such as ESRI. Lack of funds and little experience in this area were the main factors causing the slow digitisation process. It was decided to use a free Open-Source software and the human resources available to the administration department.

Before starting the activities related to the digitisation from raster to vector graphics, standards were obtained from the company that was to manage the database in the network. These standards included a set of internal procedures and requirements based on the company previous experience in similar projects. The aim was to minimise digitisation errors. They concerned mainly the coordinate systems and their definitions at the very beginning of the work, the georeferencing of a raster object, that is, giving the appropriate number of characteristic points in relation to geographical coordinates and introducing the geometry of polygons, lines, and other symbols.

Then, it was necessary to obtain all possible information from the available sources for verification of raster version. Only some public administration institutions provided the data digitally. It concerned the current ownership structure, natural environment, road network and technical infrastructure. The remaining information was drawn from the existing raster materials. As a result, there were created basic groups of layers containing information on:

1. Technical underground and overhead infrastructure, ie: main energy and gas transmission lines, including protective zones and major intermediate stations.
2. Street network and public transport including the distinction between road classes of local and regional importance, as well as some of the more important nodal points in the city.
3. Cultural environment with an indication of historic building under protection, heritage protection zones, and archaeological sites.
4. Natural environment including watercourses and their surroundings, protected areas, flood risk zone, areas with natural deposits
5. The current and planned land use which is one of the most important information for the residents, and which defines what is the possible form of development for a given building plot

The most important and the most difficult task was to develop data on the land use (zoning of the areas). The raster version of the study was prepared in a scale of 1: 10000, while the possibility of working with vector graphics gives the chance to enlarge each fragment of the map to the 1:1 scale. Thus, it was of utmost importance to ensure that the boundaries of the property coincide perfectly with the intended land use. In some cases, it was not obvious. The methods of making the raster version of the study caused obscurations of the property boundaries and as a result doubts arose as to the exact course of the boundaries between the different zones. This problem is shown on the figure 2 (Where exactly are the borders of road and building plot? On the raster version the width of road line interferes with plot borders. On the electronic version it is necessary to define borders more precisely). In a number of other cases, the consultations with with experts in spatial planning, or law and administration were necessary.
in order to determine the correct interpretation of the 2D image records. This was important due to the fact that the information available on the Internet allows to determine precisely a designated use of each of the bordering plots. In the case of incorrect introduction of spatial data and its misrepresentation, there is a huge probability of receiving claims from the property owners regarding the actual legal status of their plots and the neighbouring ones.

Since the issue of problematic boundaries had not only its graphic-representation dimension but was also of a legal importance, the whole process could not be automated. Therefore, it was necessary to follow the point by point coverage of all the zones, by a two-people team over the period of 2 months.

After completing the vectorisation of the raster drawing, it was necessary to verify its correctness. This basically meant to confirm the geometry of all polygons. It was important that the sum of their surfaces corresponded perfectly to the city area. For this purpose, aggregation of polygons and other analytical operations available in the program were used.

The created spatial database was transferred to a specialised IT company which was responsible for its maintenance and publication on the Internet in accordance with the requirements of INSPIRE. The data was structured and defined following the UML (Unified Modelling Language) rules. Then it was described using XML (eXtensible Markup Language). Afterwards, the accordingly structured data was made available with the use of the Simple Object Access Protocol (SOAP) frame. This protocol allows the transfer of data described using XML and its import in various software models. This was quite important because the main goal of the INSPIRE Directive is to build a coherent infrastructure of spatial databases in all member countries (Bartha and Kocsis, 2011). The final result published on the Internet is presented on the figure 3.

All this process is responding to necessities connected with the INSPIRE Directive implementation. In 2010 the government obliged all the local authorities to share publicly all spatial development plans (created in CAD or GIS version) by the end of 2015. This was an impulse for the urban department in Pabianice. It was not a problem to share spatial information represented with vector graphics. The main problem was with non-digitalised urban plans in raster version, which have to be shared to the end of 2020 year. The director of urban department in Pabianice decided to create and share database providing more information than is mandatory. In other words - an appropriate metadata with a delimitation of urban planning in vector graphics would be enough to meet the requirements of the INSPIRE Directive. However, the geoportal of Pabianice allows everyone to have full access to faithfully mapped plan, which is linked with text information.

The shown example can be referred to other comparable territorial self-government units which faced similar challenges. It turns out that many other cities took much of the same actions. They concerned various databases, not just urban planning ones. According to Mendolińska et al. (2017) it happens that the vision of running a local geoportal, and publishing various geospatial information there, is positively perceived in nearly 90% of the cases (based on circa 60 responses from inhabitants, tourists, en-
entrepreneurs and government employees).

**FUTURE CHALLENGES**

The discussed digitisation of urban plans is the city’s first approach to sharing existing databases on the Internet. A large interest and demand for this type of initiative was noted among individuals and enterprises alike. On the occasions of working on subsequent spatial development plans, an attempt was made to use 3D models representing the adopted regulations in the plan (allowed height, percentage of built density, greenery, etc.). It is worth noting that some 20 years ago, along with the rapid development of software, many designers created 3D models for the needs of private investors. In those days, the presentation of 3D-originating data for the designed sites or buildings was becoming an increasingly common standard (Halla and Brenner 1999). Meanwhile, the constant development of technologies, such as point cloud, gives the opportunity to create more and more accurate, photorealistic urban models. However, this is still a very time-consuming and expensive process applies to both data acquisition and the 3D model creation. However, the demand for such information may lead some cities to try to obtain the already-made models, integrate and publish them using the established database.

The basic solution would be to create a simple model, based on the outlines of the buildings and field observations. Such models (Figure 4) are, however, not very realistic and carry a small amount of information - there are no textures representing the façades in any way. The reproduction of details is satisfactory, which is the result of conscious observation and interpretation of the person constructing the model. However, the implementation of such spatial mapping for the whole city is, yet again, extremely time-consuming, and in the case of, for example, representation of greenery - almost preposterous. Another way to obtain an urban model is by performing a so-called point clouds scan. Already in the 1990s, the aerial scanning method (by airborne laser scanning) was often used and several solutions were established to develop this data (Haala and Brenner 1999). Currently, this technology is becoming increasingly popular and widely available, which allows the use of laser measurements to transfer the real world to the virtuality of the 3D models perfectly. As a result, an object is created by excessive number of points with specific X, Y, Z coordinates and infor-
information representing the colour of a particular point in space (Figure 5). However, the implementation of scans does not provide a ready-made 3D model, and it is necessary to post-process the data obtained, so that, for example, fragments of private apartments are not shared, scanned accidentally due to open windows. But, one unquestionable advantage of this solution is the photorealistic representation of space, and especially all the green elements located in it.

Already in 1999, a vision of how to use 2D data to automatically create 3D models in GIS, was presented. Some issues were encountered related to the problem of matching various building parameters, i.e. roof geometry or different heights. An algorithm was tested trying to connect the basic body with information originating from DSM (Digital Surface Models) (Haala and Brenner 1999). Currently, there are GIS programs that allow an automated generation of a 3D model of any part of any city in the world. Collected data allow the identification of the function, the number of floors, and also in a slightly random way - the shape the building (figure 6). This effect could be not satisfying for experts, but for layman it is a great information about the space in the city. Taking into account the aforementioned, small county towns, without extensive budgets, could attempt to create a simple model and make it available on the Internet following the example of more advanced solutions deployed in large cities, such as Berlin (Döllner et al. 2006). Currently in Pabianice attempts are being made to create animations (figure 7) showing the possibilities resulting from the regulations of the urban plan, whose 2D representation and specialised legal language is not always understood by the residents. It is possible that the combination of these two visions - a simple 3D model and the above-mentioned way of visualisation will become the future reality in Pabianice. It would be a great tool to communicate with inhabitants and potential investors. It could be also a useful instrument for urban planners. However this would entail an extensive database linked to all buildings in the city, which would be a challenging task for the local planning department.

CONCLUSION
The presented case study of the usage of GIS tools in everyday practice in a county town shows how considerable amount of use-possibilities these systems have. This is mainly due to the fact that for the man-
Management needs local government authorities collect a lot of different information that can be presented using GIS technology. The INSPIRE Directive and the development of digital technologies have had a significant impact on the increasingly widespread availability of spatial databases, which in turn has been very well received by the community. There is a great demand for the availability of such data on the Internet, which is now the basic source of information for majority of people. The connection of a 2D representation of development plan with the database is definitely a great help for all who could come across a problem with the interpretation of all markings visible on the map. One can expect that thanks to the use of open-source software, it will be possible to continue the independent development of databases available in the network created by smaller county towns.

REFERENCES


