

# The present state of geographic information systems for towns and cities in Czech Republic

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## Abstract

*The vast development of IT in the last decade makes it possible for larger numbers of work places to introduce various IS. The data these IS work with are very often connected to a certain place in space, especially on the Earth's surface. Systems that work with these "geodata" enable its management, analysis, and visualization. They are called geographic information systems (GIS). These systems, if introduced to town hall, could be a very effective tool for the local governments and public administration. The use of such systems also helps fulfill the Free Access to Information Act 160/1999 Sb.*

*The geographic information system itself is composed of a set of software and hardware instruments and relevant data. In the case of town hall the choice of proper software is very important. There are over 20 companies dealing with issue of GIS for the local governments and public administration. The numbers of products themselves are even higher.*

*The first group of these systems are called "platform products". They take advantage of many functions of these "general" GIS (products of ESRI, Intergraph, Bentley, AutoDesk....) and add their own applications based on the particular use of such a product. They are something like a system upgrade of the "general" GIS that are prepared for anticipated most frequent usage. They combine the functionality of "general" GIS with application for particular use.*

*The other group are "independent products". Their lower functionality is compared to the "general" GIS and is most of the time balanced by their favorable price. And when used at town halls their functions might be sufficient. The graphical data are usually saved in their own file formats; therefore there might be problems with interoperability when moving data among different systems.*

*Due to the spread of the world wide Internet network it is desirable for some information to be posted directly on WWW. Posting of a map in the www is ensured by the map servers. It is also very popular to post maps on the web pages of the towns. A simple application is created using scripts for easy map management. A HTML or JAVA client is used to access the information and then the users are able to use ordinary www browser to work with the data.*

*The potential of relational database systems are rapidly developed within the GIS data base. More and more companies move to implementation of the connection of their products with*

*RDBMS (most often Oracle, MS SQL). All the data (attributes and graphical elements) are then saved in the same database. The advantages of this comparing to saving data in file format are obvious. The most important are probably uniform saving of data, multi-user editing, versioning, and other that derive from properties of relational databases. The disadvantage is a higher acquisition price and that is why some companies still use data saving in file format so their product would be affordable.*

*This report maps the present state of implementation of GIS to town halls from the customers (towns) point of view and from the provider's point of view as well. Based on email correspondence with system administrators the present state of implementation of GIS in particular towns was surveyed as well as information on what software and data are used. Information about particular products, its potential, functions, interoperability and possibility of interlinking with other IS and databases were gathered in a survey among the GIS providers.*

## **Abstrakt**

*Obrovský rozvoj informačních technologií v posledním desetiletí umožňuje na stále větší počet pracovišť zavádět různé informační systémy (IS). Data, s kterými IS pracují, jsou velice často spojena s určitým místem v prostoru, speciálně na zemském povrchu. Systémy, které pracují s těmito „geodaty“, umožňují jejich správu, analýzu a vizualizaci se nazývají geografické informační systémy (GIS). Tyto systémy, zavedené na magistráty měst a obce, mohou být velmi účinným nástrojem pro fungování veřejné správy a samosprávy. Jejich použití mimo jiné napomáhá naplňování Zákona o svobodném přístupu k informacím č. 106/1999 Sb.*

*Samotný geografický informační systém je tvořen souborem hardwarových a softwarových prostředků a příslušnými daty. V případě měst a obcí je velmi významný výběr správného software. Na českém trhu existuje přes 20 firem zabývajících se problematikou GISů pro veřejnou správu a samosprávu. Počet samotných produktů je pak ještě vyšší.*

*První skupinu těchto systémů tvoří tzv. „platformní produkty“. Ty využívají velkých možností funkcí „obecných“ GISů (produkce firem ESRI, Intergraph, Bentley, Autodesk,...), ke kterým přidávají vlastní aplikace dané použitím produktu. Jsou jakousi nadstavbou „obecných“ GISů, která je připravena pro předpokládané, nejčastěji používané postupy. Slučují v sobě funkcionalitu „obecného“ GISu a aplikace pro konkrétní použití.*

*Druhou skupinou jsou „samostatné produkty“. Jejich menší funkcionalita oproti „obecným“ GISům je většinou vyvážena příznivou cenou. Pro použití na magistrátech pak můžou jejich funkce stačit. Grafická data jsou většinou uložena ve vlastních formátech souborů. Někdy proto můžou nastat problémy s interoperabilitou při převodu dat mezi různými systémy.*

*Vzhledem k rozšíření celosvětové sítě Internet je žádoucí, aby některé informace z GISů měst byly přímo publikovány na www. Publikaci map v síti zajišťují mapové servery. Velice populárním řešením je umístění mapového serveru do webových stránek města. Pomocí skriptů je vytvořena aplikace pro jednoduchou práci s mapami. Pro přístup k informacím je pak použit HTML či JAVA klient a uživatelům stačí k práci s daty obyčejný www prohlížeč (MS IE, Netscape, Mozilla,...).*

*V datové základně GISů se velmi rozvíjí možnosti relačních databázových systémů. Stále více firem přistupuje k realizaci propojení svého produktu s RDBMS (nejčastěji Oracle nebo MS*

*SQL). V databázi jsou pak uložena všechna data, tedy atributy i grafické prvky. Výhody oproti souborovému uložení dat jsou zřejmé. Nejdůležitější je pravděpodobně jednotné uložení dat, víceuživatelská editace, verzování a další možnosti, které plynou z vlastností relačních databází. Nevýhodou je vyšší pořizovací cena software a proto některé firmy stále řeší uložení dat souborově tak, aby jejich produkt byl cenově dostupný.*

*Tento příspěvek mapuje současný stav zavádění GISů na magistráty měst, a to jak ze strany zákazníků (měst), tak ze strany poskytovatelů. Pomocí e-mailové korespondence se správci systémů byl zkoumán současný stav zavedení GISů v jednotlivých městech, používaný software, používaná data a další údaje. Na straně firem poskytujících GISy byly zjišťovány informace týkající se jednotlivých produktů, jejich možnosti z hlediska funkcí, interoperability i možnosti propojení s jinými IS a databázemi.*

## **1 Introduction**

At the present time more and more we meet with possibilities of usage of geographical information systems (GIS) at public administration or local authorities. This work set a goal to map a situation about implementation of GIS in cities and towns. It deals with single software products and also with the situations at offices (municipal authorities, town hall offices) therefore with the actual level of implementation of GIS.

At first, it is necessary to define what GIS means. According to [1] GIS includes computer technology and program equipment for collection and the verification of data, their storage, selection, analysis, handling and presentation. Practically, there are three main groups: hardware, software and appropriate data.

The hardware part of GIS consists of computers (today mostly PCs) and their accessories. The most common among these accessories are ones for data collecting (scanners, digitizers,...) and ones for presentation of data in analog form (printers, plotters,...). The layout of hardware is also important. Computers may function as independent stations, may be linked in inner computer networks (intranet), or may be connected to the internet. The hardware part of GIS is not described in this report. I can add that at town hall offices there are mostly local computer networks with connection to the internet, in smaller municipality then they only have single station, most likely with internet connection. There, where the internet connection isn't yet established, we can expect its early implementation.

The main content of this work is a survey of usage of GIS software. I can say, software implementations are very heterogeneous. At the present time there are over 20 firms in the Czech Republic producing software solutions of GIS for cities and municipality. More and more of the geodetic firms also add to their offers their GIS solutions. These firms are mostly resellers of products of special firms.

The data part of GIS is evidently the most important. Generally, the biggest investments to GIS are directed just to the data. Cities and municipality use data from land register maps, air orthophotographic maps, technical maps of cities, urban plans, DTM. Some data can be provided by "GIS firms", other are gained right at the offices from present datasets (analog or digital). In

case of need, cities can hire geodetic firm, which will locate and survey specific elements. Because GIS isn't only digital map, the attributes of map elements stored in databases are also very important.

## **2 Specific survey**

The specific information on systems and level of their implementation, that are mentioned in this report are gained from two specific surveys, which I performed. During spring 2004 I sent questionnaires by e-mail to municipal authorities in district cities. The aim of this survey was to obtain maximum information about the level and the expansion of a single GIS solution. For the information, until today there was 58 returned out of 72 questionnaires sent, that is 81%. The second survey was begun early in September 2004. Again I sent a questionnaire by e-mail, this time to the firms producing several GIS solutions. The aim was to obtain detailed information about single software products. Another gigantic information source, which helped me a lot, were the internet pages of the firms. Last but not least the information sources that helped me were leaflets and materials of the firms. I also used conference reports concerning GIS. I used materials from these conferences:

- GIS in administration, Seč, 2001–2004
- ISSS, Hradec Králové, 2001–2004
- GIS Ostrava, Ostrava, 2002–2004
- Conference MIS/UDMS, Prague, 2002

## **3 Complex IS vs. GIS**

Especially at municipal authorities and town offices we can meet with already functional information systems (IS) while implementing GIS. These systems more often work with descriptive information that don't have spatial character (economic data, documentation,...). However, these information use to have a relationship to spatially intended elements. It would be desirable then to join both systems while implementing GIS. The situation unfortunately isn't so simple and largely depends on the character of an already functional IS. Essentially there are two possibilities how to proceed. A firm creates it's software solution of GIS either to be capable of joining with other IS, or produces a new complex IS, to which certain data are migrated from an already functional IS.

During research I noted the following solutions. Complex IS as an implementation of GIS is offered by these firms:

- T-mapy, s.r.o., Hradec Králové – information system T-WIST
- Geovap, s.r.o., Pardubice – information system CityWare
- Unicom Consult, s.r.o., Prague – information system City2000

Systems T-WIST and CityWare have testimonials according to Law 365/2000 Sb. and therefore they meet the standards for public information systems.

Other firms offer GIS which can or cannot cooperate with other IS on certain level. Among those the most widely used information system in cities and municipality are:

- GINIS – by firm Gordic, s.r.o., Jihlava
- Radnice VERA – by firm Vera, s.r.o., Prague
- MUNIS – by firm Triada, s.r.o., Prague
- Stavební úřad – by firm VITA software, s.r.o., Prague

Further we can meet with products SAP R/3, Radní (HiPro, s.r.o.), ISMÚ (R-Info, s.r.o.), Starosta (Merit Group, a.s.) and others. The supports of these systems are different. In the questionnaires I also included question whether used systems support cooperation with other IS and we can conclude from the received replies that such support is not usual and only few products are capable of it.

The question, whether to implement complex IS or simple GIS in the city or town, isn't easy. It is most technically correct and logical in my personal opinion to establish the most complex IS. However cities and municipality would hardly like to leave their functional IS, because of already invested money and training of workers. This solution is also more expensive, because it isn't only GIS, but it's a complex system. It seems it is most useful to build systems with the maximum capability of cooperation with other systems and to found their construction base on public information systems standards. There where IS is not established or where there isn't satisfaction with current IS or if there is another reason for system reorganization, I would advise a creation of a complex system including GIS. Such products are T-WIST, CityWare or City2000. The advantage of products T-WIST and CityWare is the testimonial for public information systems standards as well as the fact, that GIS is one of modules of the whole system. Therefore it is possible to implement GIS only and then if interested step by step reorganize the whole complex IS. The GIS products which contain these IS are:

|                      |                                                                                                                                                                 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GIS part of T-WIST   | T-map server (contains thin client for web browser)<br>ArcGIS, GISel (thick client)                                                                             |
| GIS part of CityWare | GSWeb (contains thin client for web browser)<br>GeoStore (gate for storing data in relational database)<br>Microstation, MicroStation GeoOutlook (thick client) |

Table 1: GIS parts of complex IS

The product City2000 isn't so far very wide-spread and it only gains its users now. I unfortunately have not received a reply with a filled-out questionnaire from the firm Unicom Consult and from their web or from other presentations of their system I don't have sufficient amount of information.

Complex information systems with integrated GIS begin to be relatively wide-spread. In my research I noted these solutions in 14 district cities that is almost in 20% of cities. Mentioned products T-WIST and CityWare are approximately spread the same. As we can determine from the characteristics of both systems, their implementation is ideal for bigger cities above 10 thousand inhabitants.

|                       |                          | number    | percent<br>of total | percent<br>of sent |
|-----------------------|--------------------------|-----------|---------------------|--------------------|
| <b>Total cities</b>   |                          | <b>72</b> | <b>100</b>          |                    |
|                       | Didn't sent me data back | 14        | 19                  |                    |
|                       | Sent me data back        | 58        | 81                  | 100                |
| <b>Complex IS</b>     |                          | 14        | 19                  | 24                 |
|                       | T-WIST                   | 6         |                     |                    |
|                       | CityWare                 | 7         |                     |                    |
|                       | City2000                 | 1         |                     |                    |
| <b>Individual GIS</b> |                          | 38        | 53                  | 66                 |
| <b>Don't have GIS</b> |                          | 6         | 8                   | 10                 |

Table 2: Statistics of complex IS municipalities

## 4 Platform GIS vs. independent solution

The software solution of GIS can be divided into two groups. Either products constructed as a superstructure of general products (so-called "platform products") or second group of independent solutions. General GIS products present solution, which de facto became standards in this area. They are made by firms, that are linked with development of GIS for a long time. In contemporary world of geographical information systems these five firms dominate:

|            |                                                                         |
|------------|-------------------------------------------------------------------------|
| ESRI       | ArcGIS and extensions                                                   |
| Intergraph | GeoMedia and extensions<br>MGE (graphics in MicroStation)               |
| Bentley    | MicroStation (only graphics) and extensions<br>MicroStation GeoGraphics |
| Autodesk   | Map and extensions                                                      |
| MapInfo    | MapInfo                                                                 |

Table 3: GIS firms and their products

Notable is also that the project MapServer is also getting more important. It is an OpenSource environment, which is developed by Minnesota university with the help of a grant by NASA. It isn't a full-value GIS system, but CGI application which allows an interactive on-line link with other data sources, assembling and presentation of various heterogeneous geographical data and many other services. The range of its capabilities is so wide, that it can replace other GIS programs in many ways without problems.

General GIS work with geodata and their attributes saved in datasets or database systems. However, to establish GIS in the cities and municipalities on such foundation isn't simple. We can hardly meet with such solution. It is given by Czech specifications and further also by necessity of creating a model of the whole system. Because establishing of GIS at local authorities is very often repeated (always for example we work with data from land register), the local Czech firms started to produce their own software, that is a sort of superstructure of a general GIS. There are conditions already prepared to work with Czech specifications. Here follows the list of Czech firms producing such platform products:

|            |                                                                                                     |                                                                                                |
|------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| ESRI       | T-Mapy, s.r.o., Hradec Králové<br>Digis, s.r.o., Ostrava<br>VARs, a.s., Brno<br>Elgeo, s.r.o., Brno | T-map server<br>Ameba, Ameba Web<br>applications above ArcGIS<br>application above ArcExplorer |
| Intergraph | Espace, s.r.o., Olomouc                                                                             | WebCity                                                                                        |
| Bentley    | Geovap, s.r.o., Pardubice<br>HSI, s.r.o., Praha<br>Berit, a.s., Brno                                | GS (GeoStore + GSWeb)<br>MacroGeo<br>LIDS, B-Forum                                             |
| Autodesk   | Xanadu, s.r.o., České Budějovice<br>DataSystem, s.r.o., Teplice<br>Sitewell, s.r.o., Ústí nad Labem | eObec, Město@Web<br>obec 2000i<br>modules above Map                                            |
| MapServer  | Help Forest, s.r.o., Olomouc<br>Help Service RS, s.r.o., Benešov                                    | Mawes<br>msBASIC, msEDIT                                                                       |

Table 4: GIS firms in Czech republic and their platform products

Contrary to the platform products are individual solutions, which don't need other software to function. The data in them are saved either in their own file format or they use some open file format of general GIS. The advantage of these solutions is often smaller financial burden of consumers, which is very important especially for small municipality. But these products often present only data viewer without any capability for deeper analysis. It is a question, whether such products can be considered as a real GIS. Here follows a list of firms and of their independent software solutions of GIS:

|                                      |          |
|--------------------------------------|----------|
| T-Mapy, s.r.o., Hradec Králové       | GISel    |
| Gepro, s.r.o., Praha                 | MISYS    |
| Geodézie-Topos, a.s., Dobruška       | Gramis   |
| MK Consult, v.o.s., Ústí nad Labem   | Kompas   |
| Geodézie Krkonoše, s.r.o., Harrachov | Gimis    |
| Ing. Svatopluk Sedláček, Brno        | G-View   |
| Foresta SG, a.s., Vsetín             | Pukni2   |
| Topol Software, s.r.o., Praha        | Topol NT |

Table 5: GIS firms in Czech republic and their independent products

According to my research, 21 district cities (29%) established platform solutions. If we add to this complex IS mentioned in chapter 3, which are also platform-like, we get 35 cities (48%). Platform solutions are widely used in bigger cities. They are as a matter of fact "gis part" of city IS. Significant platform products are made by firms T-mapy and Geovap. Their systems are "gis parts" of their complex systems and the remaining IS is taken care of by other software and those to communicate with each other. (T-WIST, CityWare). Other systems are used in a few cities in regions of their creators:

|                  |                  |
|------------------|------------------|
| Ameba, Ameba Web | northern Moravia |
| B-Forum          | middle Moravia   |
| Mawes            | Olomouc district |

|                 |                  |
|-----------------|------------------|
| WebCity         | central Moravia  |
| aplication VARS | southern Moravia |

Table 6: GIS products and their regions

The products of firms T-mapy (T-map server) and Geovap (technology GS) are evenly spread all over country.

Independent software solutions were noted in 15 cities (21%). Their character leads them to the smaller cities and municipalities. Such solutions are not so expensive. Although the products often miss analytical tools of GIS they are good enough for usage in smaller cities and municipalities. The use of their own file formats sometimes cause problems. It is necessary to convert data from the standard formats (SHP, DGN, DWG, DXF,...).

|                            |                      | number    | percent of total | percent of sent |
|----------------------------|----------------------|-----------|------------------|-----------------|
| <b>Total cities</b>        |                      | <b>72</b> | <b>100</b>       |                 |
|                            | Didnt't sent me data | 14        | 19               |                 |
|                            | Sent me data         | 58        | 81               | 100             |
| <b>Platform GIS</b>        |                      | <b>35</b> | <b>49</b>        | <b>60</b>       |
|                            | Platform ESRI        | 14        |                  |                 |
|                            | Platform Bentley     | 17        |                  |                 |
|                            | Platform Intergraph  | 1         |                  |                 |
|                            | Platform Autodesk    | 1         |                  |                 |
|                            | Platform MapServer   | 2         |                  |                 |
| <b>Individual solution</b> |                      | <b>15</b> | <b>21</b>        | <b>26</b>       |
|                            | City2000             | 1         |                  |                 |
|                            | MISYS                | 5         |                  |                 |
|                            | Gramis               | 4         |                  |                 |
|                            | GIMIS                | 2         |                  |                 |
|                            | Kompas               | 2         |                  |                 |
|                            | GISel                | 1         |                  |                 |
| <b>Only common GIS</b>     |                      | <b>8</b>  | <b>11</b>        | <b>14</b>       |
|                            | ESRI                 | 7         |                  |                 |
|                            | Intergraph           | 1         |                  |                 |

Table 7: Statistics of GIS in municipalities

## 5 Desktop vs. networks

Nowadays we can hardly find a local authority office, which doesn't have its own computer network and the internet connection. The hardware layout is therefore already set for GIS systems. The original GIS systems were created as desktop applications and functioned then separately on one computer. With the development of computer networks the network applications began to be created. Their benefits are evident. Users can simultaneously reach to saved data and work together on one project.

The desktop applications are used in small municipalities or where there is an assumption that

only one person will work with the GIS system.

The network applications make possible multi-user editing and uniform data storage. The individual applications which access the data can be divided in:

- thin clients (e.g . ESRI Arc Explorer, MISYS View,...)
- thick clients (e.g . ESRI ArcView, Bentley MicroStation, Intergraph Geomedia,...)

Thin client serves like a data viewer, without capabilities for editing. Firms mostly supply viewer to their software for free. Thick client is an editing tool that serves to supply and actualize data.

The development of internet offers a possibility of building GIS on the internet basis. Some firms already aimed their development this way. Various scripts (DHTML, JavaScript) are programmed as thin clients. For browsing data then, user can use a web browser. In this way data can be very effectively published for public in the internet. The use of such systems also helps fulfill the Free Access to Information Act 160/1999 Sb. The capabilities of internet go yet further. These days the biggest development can be seen in sharing data saved on many different servers. The best known services that make sharing possible are WMS (Web Map Service) and WFS (Web Feature Service). WMS transfer data as a raster picture, WFS transfer data using coding in language GML. This language and both services were created by OpenGIS Consortium (OGC), one of the most recognized organizations in the world of GIS. More detailed description in [2].

Most of the products that were subjects of my research allow both desktop and network application. Platform solutions can contain either only desktop application (ArcView, GeoMedia,...) or a map server also (ArcIMS, GeoMedia WebMap, MapGuide, MapServer). The Map servers are mostly supplemented by an individual solution for better functionality by the companies. (T-map server, GSWeb, Mawes,...). Independent solutions of GIS are supplied directly either like desktop or like network version.

## **6 File oriented GIS vs. RDBMS**

It is an important question during the design of GIS how to store data. The older original option is to save data into independent datasets (vectors, rasters, attributes). File oriented GIS is sufficient for desktop application or simple networks. The modern approach is to store data to the relational databases. Their advantage is the support of multi-user editing, transactions, versioning, background processes... The most recognized products in this area are Oracle by Oracle Corp. and MS SQL by Microsoft. Further we can meet with Informix, IBM DB2, Sybase, PostgreSQL and others. The relational databases are connected with GIS by the help of special tools. ESRI offers for connecting to RDBMS a gate ArcSDE (this solution is used for example by the firm T-mapy). The firm Geovap store data to the database with the product GeoStore or GeoArchiv. Three-dimentional data are stored into the database PostgreSQL by the help of PostGIS. We can easily store raster data to the database (by ArcSDE or product RasterArchiv by Geovap).

The most supported databases are:

- Oracle – products by firms Geovap, T-mapy, Unicom Consult, Berit, Sitewell

- MS SQL – products by firms Geovap, T-mapy, Unicom Consult, Geod. Krkonoše

Many of other products solve their external connection to the databases by interfaces ODBC, OLE DB, ADO or by MS LINK.

## 7 Standards and interoperability

When implementing GIS it is necessary think about some standards. We will never know, whether it will be needed to converted the system to another etc. Also the interoperability is very discussed expression, which is in other words the ability to work with various data. It could be just various formats of data that can often cause problems.

The first group of problems represents the formats of the vector data. Among most widespread are:

- SHP, Arc/Info coverage (ESRI)
- DWG, DXF (Autodesk)
- DGN (Bentley)
- MIF, MID (MapInfo)
- VFK (interchange format of Czech cadastre)

Practically every general GIS forms its own format of data. Fortunately the migration of data among systems is relatively frequent so converse functions are refined. Unfortunately independent software solutions very often create their own formats (e.g . VYK by product MISYS or BD by product Gramis). Some solutions are based on common formats (very often SHP). It's good, that format GML defined by OGC becomes a more definite general standard. It's supported by big corporations (ESRI,...) and it is beginning to be used for distributing data (e.g. Czech dataset ZABAGED). The format that is in GIS for cities and municipalities mostly supported is SHP, followed by Autodesk formats and VFK. More about openness of individual systems in [3].

The second group represents the formats of raster data. The best known formats are TIFF, GeoTIFF, JPEG, GIF, BMP, CIT, WMF, ECW, PNG, PCX, MrSID, RLE, RAS, COT and others. These formats are used for imaging raster maps (at our place for example land register maps distributed in the CIT format) or for imaging orthophotographic map (often the TIFF format or compressed JPEG). Not every software support all the formats. The most often supported formats are TIFF and BMP, followed by CIT and JPEG (see [3]).

The attribute tables are often stored in the DBF format. A much more modern approach is to save all the data to the relational database.

Many of GIS standards are produced by OGC. Among those is for example meta language GML or services WMS and WFS. While implementing GIS to offices in cities and municipalities we also have to concentrate on standards for public information systems. Products T-WIST, CityWare and GISel have the testimonial for public IS.

## 8 Functionality and modularity

While comparing individual products it is necessary to realize, what functions the given software manages. The individual GIS tools can be divided to the several groups:

- tools for geometrical data upkeeping
- tools for attribute upkeeping
- analytical functions
- visualization tools

Geometrical data upkeeping represents operation, which have no linkage to attributes. Transformation of spatial data, editing of graphic elements, topology functions and others belong to this category.

Attribute upkeeping represents the work with attribute tables of individual elements. The inquiry language SQL is used to access to the database.

Analytical functions represent the work with geometry and with attributes. Functions for searching, classification, metering, operations overlay and buffer, network analysis and many others belong to this group.

Visualization tools make possible to put the results of analysis data into a form for presentation. It represents functions for visualization on computer screen and functions for the print setting.

Groups of functions for data upkeeping in products are introduced in two levels. In the first simpler form they represent capabilities to create a drawing above current data. Then it is possible to edit such drawing, optionally to add a database to it. In the second more advanced form they represent capabilities to edit original data of GIS. To do this these functions are used: editing, pasting, snapping, collective corrections or generation of topology rules and their verification. Independent products differ in “the power” of graphic parts of their software. General GIS (ArcGIS, GeoMedia, MicroStation, Map) but rarely independent products based on graphic system (e.g. MISYS based on system KOKES) have these functions very refined.

According to the analytical functions we can recognize the main differences between GIS and a “mere” graphic system. In a general GIS we can find a wide spectrum of analytical functions. The products intended for cities copy or specify some of such functions that are then already prearranged for the most frequent use. The independent solutions unfortunately miss such functionality. The users are in advance limited by only several functions that are supposed to be used.

Visualization tools are part of all the products. They consist of functions for working with the screen (pan, scale, content windows, legend) and for working with the printing (scale setting, content, format setting,...).

Generally we can say that general GIS and their platform solutions have “stronger” tools.

Independent products are made for specific use. They also are more user-friendly. Their smaller functionality is redeemed by favorable price and no need to have a qualified operator. In my own opinion the best option of implementation of GIS is to create a system with some thick clients, operated by a qualified operator (GIS expert) and further enable all other users to access it with a thin client. Such users could be any of the employees.

Because of the big financial stress while implementing GIS, some firms offer their products as modular. Practically it means that a basic module for simple work is purchased first and step by step other modules are bought as needed. Most of the surveyed products have the modular structure (T-WIST, CityWare, GISel, MISYS or Gramis). Some applications like eObec, Kompas, G-View or Pukni2 are offered as compact. There is no need to have a modular structure on these products, because they are not that expensive, however bigger and more extensive systems do need the modularity.

## **9 Data for GIS**

As I already noted at the beginning, the data part of GIS is evidently most important. 80% of money is spent for the data. The cities and municipalities are using data from large datasets:

- New data format of Czech land register (now together DKM and SPI in format VFK)
- Older data format of Czech land register (DKM in format VKM and SPI in format DBF)
- Raster maps of Czech land register (format CIT)
- Raster maps of PK (old Czech land register) (format CIT)
- Raster maps SMO5 (format TIFF, BMP, GIF)
- State map SM5 (digital SMO5 including orthophoto)
- Orthophotographic maps (mostly formats TIFF, JPEG)
- Urban plan (mostly Autodesk formats – DWG, DXF)
- Digital technical maps of cities (DTMM, mostly in format DGN or VF DTMM)
- Rasters of basic or topographic maps (1:10 000 as far as 1:50 000, format TIFF, BMP, GIF)
- ZABAGED (formats DGN+DBF, SHP, GML)
- Digital terrain models (DTM)
- Digitally processed areas of interest - transportation, greenery, culture...
- Price maps
- Street map

We can divide data into two groups according to their acquisition costs - data which may cities and municipalities obtain without charge and data that are necessary to be bought. According to current legal regulations the cities and municipalities have the right to obtain data of the Czech land register for free (SPI once in three months, map once a year). Starting 1.1.2005 data from ZABAGED should be also available for free. Other groundwork is necessary to be bought.

It is possible to purchase maps SMO5, SM5 at land register offices, at geodetical office in Prague it is possible to purchase base maps, orthophotographic maps and ZABAGED. Other groundwork is offered by various commercial firms.

According to the answered questionnaires from offices in district cities it is obvious that land register data are used by absolute majority of cities, orthophotographic maps and DTMMs are used in more than 40% of the cities, urban plans in more than 20% of the cities. These numbers might be distorted because the question in the questionnaire wasn't aimed to specific data.

## **10 Price of GIS for cities and municipalities**

As it was the beginning was mentioned at the beginning, GIS is a set of hardware, software and data. The individual components affect the price unevenly. The biggest sum is definitely the price of data. It also depends on dimension of the city. The bigger the town, the bigger is the percentage of the price of data. For most of GIS the data represents more than 80% of all the costs. The rest is covered by software and hardware.

Here it is necessary to consider whether current hardware resources at the town offices are sufficient, or whether it would be beneficial to upgrade the hardware. In any case, a GIS workplace should be equipped with an efficient PC with big monitors, scanner, colored plotter (or at least printer of a bigger format). A fast internet connection is also essential.

The software can be divided into GIS software and supportive software. The price of any individual product is in a wide range. It is possible to get the simplest desktop product around 10 thousand crowns, a vast network system can cost a million crowns. Relational databases (Oracle, MS SQL), web servers (MS II, Apache) and others belong among supportive software.

At the present time Open Source projects are very popular. These products are distributed and developed mostly under Linux operation system. Their characteristics are zero purchase price given by the public license. Among significant products from GIS area it is necessary to mention these:

- GRASS – analytical GIS under operation system Linux
- PostgreSQL – relational database
- PostGIS – gate for storing data into relational database (like ArcSDE)
- MapServer – map server, a project of University of Minnesota
- QGIS – tool for browsing many formats of spatial data
- JUMP – tool for browsing and manipulation of many formats of spatial data (like ArcView)
- Deegree – Java framework for geo-spatially enabled solutions, it is based on general GI standards and allows building applications

These products are more less only discussed in scientific and academic area, but for example implementing MapServer at some offices shows the development of OpenSource technology and its practical use. The firm Help Service Remote Sensing, s.r.o. was even awarded the price Geoapplication of the year 2003 in Czech Republic for its implementation of the project OPRL based on MapServer.

My research shows, that the total spending on GIS is considerably different. The question about

the purchase price was answered by 36 offices (62% from received answered questionnaires). We can divide the GIS solutions into three groups according to their price.

The first group is represented by the GIS solutions in municipal authorities of the big regional cities. The costs climb up above tens millions crowns here. In my survey 6 cities fit to this group (out of 36 answers it is 17%). Very well processed GIS solutions are in these cities:

- Plzeň (SW by firm Geovap, <http://inf.plzenfeelings.cz/gis/>)
- Ostrava (SW ESRI, <http://gisova.mmo.cz/>)
- Hradec Králové (SW by firm T-Mapy, <http://www.hradeckralove.org/cz/Mapy.html>)

The second group is represented by the GIS solutions in the bigger district cities. The costs are in the range from 5 to 15 millions here. The research encountered 9 cities with such solutions (out of 36 answers it is 25%). Typical examples of such solutions are:

- Kladno (SW from firm Gepro, [http://www.mestokladno.cz/dig\\\_map.asp](http://www.mestokladno.cz/dig\_map.asp))
- Vyškov (SW from firm Geovap)
- Litoměřice (SW from firm Topos)
- Most (SW from firm T-mapy)

The third group is represented by the GIS solutions in smaller district towns. The GIS solutions aren't so refined here and the costs for their acquisition reach from several hundred thousands to several millions. The rest of the answers falls in this category - 21 cities then (out of 36 answers it is 58%).

## 11 Other details of GIS implementation

In my questionnaire there were other questions concerning GIS at town offices. I asked for year of the implementation of GIS, subject which implemented GIS and how many managers does GIS have.

Concerning year of the implementation of GIS, several town offices regularly build GIS yearly since 1996. It is impossible to observe a trend among the years. Some cities attempted to implement GIS already in the beginning of the 90's. In that case GIS were mostly rebuilt or implemented completely again.

Subjects that implement GIS to cities are mostly the manufacturers of software themselves. Only rarely are the products installed by other subject. The only firm that actively cooperates with geodetic firms is Gepro. Other firms implement their software themselves. Unfortunately mostly it is IT people and not land surveyor who do that. The land surveyor field now begins to focus on GIS and on the possibilities of distribution of GIS software.

The question of the number of managers of GIS is often discussed. According to my research we can see 4 levels of management:

|  | number | percent of total | percent of sent |
|--|--------|------------------|-----------------|
|--|--------|------------------|-----------------|

|                      |    |    |    |
|----------------------|----|----|----|
| More than 2 managers | 6  | 10 | 13 |
| 2 managers           | 9  | 16 | 20 |
| 1 managers           | 25 | 43 | 56 |
| 0 managers           | 5  | 9  | 11 |
| unknown data         | 7  | 12 |    |
| don't have GIS       | 6  | 10 |    |

Table 8: Statistics of GIS management in municipalities

Only at municipal authorities of regional cities there are more than 2 managers. In 9 cities the situation is satisfactory because there are 2 managers. The question is though, how many percent of their work time these workers spend on GIS and how many percent on other activities. In most of the cities GIS has only one manager. In few cities the situation is so bad that town does not have resources to afford a function of a GIS manager and leaves the GIS management for an external firm. The personnel of the office only use GIS data.

## 12 Conclusion

At the end it can be added that the field of using GIS still has reserves. There are over 20 firms offering their solutions on the GIS market in Czech Republic. It is necessary to hope that especially the quality of products will grow not only their number. In my own opinion the GIS is heading to interoperability and standards. I think that this is where the development of next individual products will lead.

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