# GEOGRAPHIC INFORMATION SYSTEMS TECHNOLOGY

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This article presents the importance of using the Geographic Information System technology. It describes the activities of gathering and processing the spatial and descriptive data, both from the general perspective and by presenting the functionality of the software developed in this purpose. There are also presented the technology's characteristics and future possibilities for development.

**Keywords**: Spatial data, Geographic information system, technology, software

## Introduction

Geographical information systems have first appeared in 1970. Initially they could only be used by companies or universities that had expensive hardware and software. Today, any person who owns a computer can use geographic information systems technology. Over time, GIS programs have become easier to use, compared to previous periods, when in order to work with GIS software a preparation in advance was needed. As I will describe below, GIS software is not just a product but incorporates all aspects of management and use of digital geographic data.

The volume of information collected by any man of our time is growing due to the almost unlimited possibilities for managing and operating the retention of the information provided in digital form, in relational databases. One can appreciate that a percentage of 85 percent in databases in use contain one or more components regarding the geographical location of objects in inventory. Where cadastral databases can say that all the information is related in some way or another to the geographical location of the property defined by geographic boundaries of the land base unit. Creating and joint exploiting in a Geographic Information System of the information with spatial reference to the graphical representation of objects in surface or underground can bring great benefits to users or administrators of such information, primarily due to the existence of an operational data structures and well defined - primary requirement for any information system.

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When all information is ordered by relational rules to geographic reference – in digital format - and is administered by a system of programs designed for this purpose, this opens up new possibilities for management and use increasingly by a large group of users.

GIS is a computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System is used for handling different types of maps. These could be represented as several different layers where each layer holds data about a specific type of facility. Each feature is linked to a graphic image on a map and a record is retained in a table of attributes. GIS can reveal such hidden patterns, relationships, and trends that are not easily observed in spreadsheets or statistical packages, new information often existing data sources.

GIS technology integrates common database operations such as query and statistical analysis with unique visualization of geographic analysis benefits offered by maps. These abilities distinguish GIS from other Geographical Information Systems and capitalize it on a wide range of public and private enterprises in explaining events, predicting outcomes and planning strategies.

Representing an application that works with graphical components, likeness with computer assisted design (CAD) is natural. The perception of many is that GIS is a sub domain of the CAD's, in fact; among the first major CAD systems is GIS software.

Using GIS technology has many advantages over traditional geo-spatiality expense. Optimal structuring of data, accuracy of representations, calculations, faster access to information, current data, assisting decision-making in the short term, the possibility of performing complex studies and analysis are just some of the many advantages of using GIS.

Designing such a system brings in addition to designing a database application, the care for graphic components. A geographical component is often hidden in a data source: an address, postal code, city, county, or coordinates of latitude / longitude. With GIS, you can explore the elements of spatial data to display soil types, find the best location for a business expansion, create a path model for air pollution, and make decisions for many types of complicated issues. GIS involves complete understanding of models, space, and processes or methodology needed to address a problem. It is a tool that acts as a means to achieve certain objectives quickly and efficiently. Its applicability is realized when the user fully understands the whole concept of space in which a particular GIS is established and examines the application in light of the established parameters.

Before the implementation of GIS must be taken into account the objectives, both short and long term. Since the effectiveness and efficiency (benefits bigger then cost) of GIS depends largely on the quality of the original captured data, the organization of the application must be set to maintain this data flow continuously.

**Fields and methods of use of geographic information systems technology**

GIS technology is used by a multitude of categories of users (managers, academics, professionals in the field) depending on their specific needs. Each user group has its own educational and cultural background is associated with various companies, magazines, conferences, traditions, therefore each is identified with particular ways of approaching the problem. Finally, all the user-groups share the same technology to address specific problems.

The main areas of use of GIS technology can be classified as follows:

• Developed technologies that interact with GIS, interchange functions and supply data for GIS
  - Mapping
  - Topography and Engineering
  - Remote sensing

• Resource management and management decisions
  - Inventory and resource management
  - urban planning (Urban Information Systems)
  - record of land for property taxation and control (Land Information Systems)
  - facilities management (AM / FM)
  - planning and retail marketing
  - routing and scheduling

• Science and research activities of university and government laboratories

GIS technology can be used in mapping by two perspectives: automating the process of map making and creating different types of maps from the data analysis and manipulation. The undeniable advantage of automating the process of map making is that objects can be moved easily into the map without having to recreate them and work to change the scale and projection are easily accomplished.

Topography’s main concern is measuring the objects’ locations on Earth's surface, in particular the property boundaries. Locations of a limited number of fixed points are extremely accurate, with precision instruments and measurements. These are monuments and landmarks. Using these specific benchmarks for reference, a large number of locations can then be accurately determined relative to fixed monuments. Topography is a leading provider of GIS data. However, it is not directly concerned with the role of GIS decision-making tool. Some engineers use GIS technology, particularly using digital elevation models and associated functionality to help in the planning and construction. For example, for calculations of earth quantities to be moved in construction projects such as building highways or to see the effects of major construction projects, such as dams.

As topography, remote sensing is a field producer for GIS data, it receives information about the earth's surface from airborne or space platforms. Remote sensing has well developed techniques and technologies in terms of data capture - high spatial and spectral resolution, transmission, processing, and archiving data, and interpretation, classification of images. By using remote sensing, GIS technology is provided with important roles such as increasing product quality and value using additional data to improve the accuracy of classification and assist in decision making by combining the product with other less observed layers in space, such as political borders. This area continues to be an area of active research in view of the fact that new tools must be evaluated for applications in various fields, careful research is needed to realize the enormous potential of technology and the volume of data accumulated is growing rapidly.

Applications for inventory and management of resources have dominated the providers’ sales in the early 1980’s. Many systems have been used by state governments, federal and industry resources, especially forestry, oil and gas. Among the most popular and successful applications developed for this purpose include: forestry applications - inventory timber, watershed management, infrastructure development (roads), forest regeneration, applications in agriculture - agricultural pollution studies, inventories of land capability, studies of productivity applications for land use - land use planning, zoning, impact assessments, applications for wildlife - habitat management.

Programs for urban planning involves developing file Dime (street axes locations, address ranges for each block, census reporting zones). An example of urban planning using is GIS community risk assessment. This example shows the modeling of community vulnerability to hazardous materials and is designed to reduce potential impacts.

Governments, developers and landowners require and use land use information every day. The most information which the Government uses and records refers to specific geographic locations under its jurisdiction: property lines, easements, utility and sewer lines, and more spatial data. The ability to store, retrieve, analyze, and report efficiently and accurately display this information public about the land is of great importance, since requests for information from a database that stores information about the land can reach a total of 1,000 applications per day. Legal description of land is based on precise measurements, points with precisely known location, and descriptions such as mid-evil (the river may change its course), marks on trees, etc... To prevent inconsistencies, the source of information about land and its accuracy can be as important as the information itself, such a database containing information on land may need not only the lands' coordinates. To increase the amount of information that there is need for the use of software becoming more sophisticated, GIS functionality is required. The question in this case the use of a powerful management system, relational database structured topologically. For some projects of land management, GIS technology characteristics are the essential: urban and regional planning - the ability to merge information with statistical information about geographic boundaries, resulting in the rapid creation of thematic maps in support of project planning, use of overlays to support the space search for feasible areas to meet the project requirements, community development - fast updates of area records , the rapid display of paper using the plot-space operations, public works - a use of 3D capabilities to the engineering calculations, utilities: hydrological modeling - using network modeling capabilities for predicting urban leakage, the effects of changes in fluvial system, schools: models -population forecasting to go to school in small towns based on population migration, housing development patterns, to obtain populations balanced schools.

Initially, interest in automation was simply recognition of the need for immediate automatic mapping as a way to record and process changes. However, during the planning system were also identified many other potential applications and other information. With control over various layers of information, facilities management offers a variety of ways to present existing information in a single database. A major advantage of using automated mapping is a better possibility of their maintenance, productivity increased to 10 times more than the manual methods of making maps. There is no question of physical deterioration or the content of the map as they are created as needed or updates. The increasing use of computers also offers easier access and better control over the maps, producing and distributing copies when necessary.

Location factor is critical for success in retail business. Exact knowledge of the spatial distribution is essential for advertising online campaign. GIS technology is useful in the design of sales areas, analyzing trade areas of stores. Although still in an early stage, similar applications appear in politics: for example, planning voting centers has a major impact on elections results. GIS technology is very useful for routing and planning, which includes car navigation systems, help systems, emergency vehicle routing, and scheduling delivery vehicles. Functionality resulting from the use of GIS in this area is represented by the following aspects: simple data retrieval and display for vehicle navigation systems, finding the optimal route (requires a fast algorithm, intelligent), finding a location specified by address. Lately there is growing interest given the use of GIS technology to support scientific research: science supporting global-environmental-global investigations, epidemiology, to search for factors that cause disease-models, anthropology, demography, social geography - for understanding the changes of the population structure, distribution of population groups in cities, landscape ecology, to understand relationships between species distribution and habitats. Unlike statistical package, GIS development was related to applications other than scientific research. Lack of spatial analysis tools has meant that the role of location in explaining phenomena has been difficult to assess. Tracking data are available in libraries are difficult to map interfered with other information that are not part of the digital research environment. GIS has a great potential in scientific research by allowing space as an analysis of statistical packages can create statistical analysis.

**Geospatial and descriptive data**

GIS data represent real objects (such as roads, lands use, trees, waterways, etc.) with digital data. Real objects can be abstracted in two ways: discrete objects (ex. a house) and continuous fields (such as precipitation, increases in debt). Traditionally, there are two methods widely used to store data in a GIS for both types of mapping abstractions: vector and raster images.

The graphic entities that compose digitally the map are usually vectorially defined, this way an entity on a map is represented staring from the Cartesian Coordinates of its points. An alternative to this representation are the raster images that represent bitmap images, where an entity is defined by several colored dots. Unlike the vector representation, which can define single entities, in a raster image are represented several entities, the colors through these entities are represented helping them to differentiate from other.

Raster images may come from multiple sources like scanning existing maps on a physical medium, aerial photography of the land, from specialized satellites, drawing etc. Data capturing and introducing data into the system occupies a large part of GIS users time. There are several ways of collecting and processing data.

A first way of producing vectorial data is using and processing field measurements. A main objective of the field measurement process is to generate the coordinates of several points processing distances and determinate angles using a measuring device. GPS (Global Positioning System) is a specialized technology based on a set of specialized satellites that allow the continuous determination of the position points on Earth’s surface. The existing data on physical medium can be scanned or photographed, resulting raster images, which can also be processed after that in order to produce vectorial data. In GIS’ view important is not the modality of collecting data, but getting coordinates that define the graphic vectorial entity and additional information for this.

For obtaining raster images there are also several ways: scanning maps or plans in physical format, aero-photographic imagery, satellite images. The aero-shooting represents the process of photographing the land from an aircraft that flies over the territory. This way of obtaining the raster images brings in addition to documents’ scanning the characteristics of unity and actuality, but for a perfect accuracy of these characteristics, the data collected in this way will require some adjustments. The images from specialized satellites are obtained by shooting the earth's crust seen from the satellite’s orbits. Images obtained like this are then put to a process of analysis and processing in order to achieve optimal results.

The geo-referential process is a process by which a raster image that represents a ground coordinate system is transformed into the coordinates of the current project system, so that each entity contained in it reaches the positions corresponding to reality. Geo-referencing makes sense when the raster image is combined with vector data representation from the area. Therefore, the simultaneous achievement of precision given by the vector representation and the achievement of meaning given by the raster image. In (Figure 1) is presented a raster image after the process of geo-referencing.

***Figure 1*** *Raster image after geo-referencing*

Geo-coding involves placing unpretentiously the geospatial entities having as a landmark some alphanumeric attributes from the associated database. The fact that geo-coding offers pure geographical information, rather generating than asking for spatial data, extends amazingly the GIS functionality.

The key of GIS applications is the connection between the vectorial entities and the descriptive attributes, which also represents the distinction from digital cartography. The analysis and decisions' assistance skills are based mainly on descriptive data. Since relational databases dominate the market for more than three decades, most GIS applications use this model of data storage. In (Figure 2) is shown how the connection between a graphic entity and a record in the database is created.

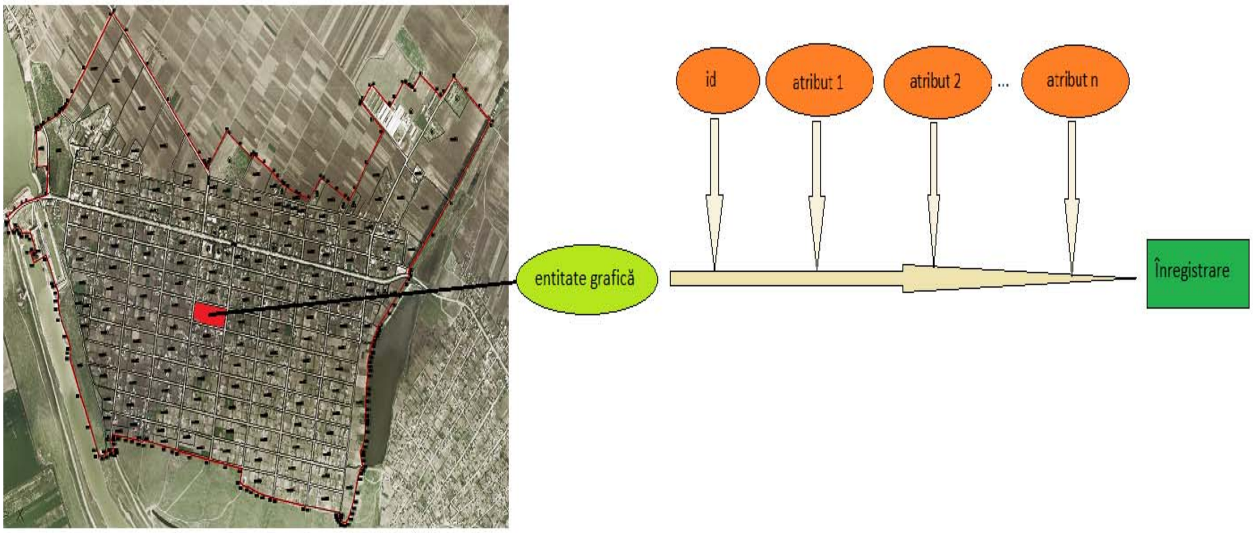


***Figure 2*** *Connection graphic entity - registration table*

Descriptive data collection can be done by explicit synchronous collecting, asynchronous or by importing data from databases related thematic to the GIS application. Explicit synchronous data collection involves placing data into the system by the designer with the creation of graphical entities. Asynchronous explicit collection involves creating the links between the table and the thematic layer and then introducing the attributes visually identifying each entity or working in groups, in which case consideration should be given to the unique identification codes of the graphic entities.

Using a GIS product reveals its true capacity, presuming frequently the engage of alphanumeric data in analysis and queries. GIS user should be able to quickly access the descriptive information associated to the graphic domain, but also should be able to aggregate them in more complex studies.

In addition to descriptive data, lately the GIS software manufacturers also store the vectorial entities into the database, so in many cases the model for databases transformed from relational to object-relational or pure object.

When constructing and using complex GIS projects, with multiple ways of access for enterprises, the control and the synchronization of their development is a key issue to be taken into account, traditional solutions being limited because they are forced to work at file level. Storing graphic data into relational databases adds, by conducting internal management to a project component level. This approach substantially affects productivity in complex projects.

**Description and use of MapSys software**

MapSys focuses powerful features, but easy to use for the producing and using the digital plan, functions for geo-referenced and management of spatial referenced information. Efficient exploitation of MapSys geo-data created or imported from other systems is provided by standard GIS functions such as those of geo-reference, collection of attributes, topological overlay layers, creating user queries or generating buffer area, but also specific functions by parceling cadastre duplication and mailing address search. Defining the right of access to program functions and data, and the possibility of cataloging operations performed, enabling better tracking and protecting data consistency. MapSys COM Interface offers the possibility of extending the functionality of the program by creating their own applications with available programming language functions and internal MapSys functions. MapSys Internet Map Server Map optional module allows authorized users to query information from databases MapSys work in an Intranet or the Internet.

To generate graphical data, the user can take advantage of the usual import duties, digitization / vectorization and graphic design functions. There are specialized functions for creating, searching, selecting and modifying of points, lines, curves, texts and symbols. Multiple specialized functions for building graphical geometric topographic and cadastral plans, generating cross longitudinal profiles. The targeted plans can be scanned, cut or merged and displayed in order to be digitized. For digital plan printing are standard functions for plan sheet generation, multiple overlapping plans or placing on worksheet open graphics windows. The features import / export permit graphic and alphanumeric information transfers in the most popular graphic formats, or GIS, such as DXF, SQD, SHP, MIF, E00, etc...

MapSys work units are called Works. They contain all the information entered or created by a given time. Graphics functions create information like dot, line, arc, curve, text or symbol. Generates topological features with spatial reference objects of type point, line or polygon. These objects are composed of graphics, object identifier and object attributes. In the Works, graphic and alphanumeric information are kept in their own formats in the form of files. MapSys is a Geographic Information System that allows the creation, management and use of spatial reference information.

Keeping them in relational databases requires very broad definition of categories of objects that satisfy the minimum conditions of consistency andpositioning graphics. These objects are called topological objects, and can be summarized in three categories. In (Table 1) are three categories oftopological objects.

**Table 1** Definition of topological objects

| Nr. | topological objects | definition | conditions |
|---|---|---|---|
| 1 | point | ID, point coordinates | - |
| 2 | line (arc) | ID, point coordinates | without interruption |
| 3 | polygon | polygon identifier, coordinates splitting points | to be a closed contour be defined uniquely * |

In MapSys, each object type has a corresponding topological structure built database. In (Table 2) presents the structure of topological objects in the database.

**Table 2** Structure of topological objects in the database

| Nr. | topological objects | basic attributes | attribute type |
|---|---|---|---|
| 1 | point | NRCAD, X,Y,Z | Text, Num, Num, Num |
| 2 | line (arc) | NRCAD, length, average share | Text, Num, Num |
| 3 | polygon | NRCAD, area, perimeter, average share | Text, Num, Num, Num |

Structure given above is automatically created when MapSys topology generation for a class of graphic and alphanumeric objects contained in a combination of graphic layers. Standard structure can be expanded by the user, creating new fields, or creating tables or relational databases.

Topological information and related attributes are maintained in Database Management Systems such as those listed above. Working on multiple workstations with specific update operations of a functional GIS system is ensured by management functions the statements of Works extras that can be distributed to the workstations will that after completion, can be integrated into the basic Works. Database query functions allow creating, saving and running complex SQL queries, view query results or creating thematic representations. There are special functions of graphic search features of postal address, buffer zone generation, and analysis overlay plot (re-plotting), generation of thematic representation.

Functions and data access can be restricted so that each registered user can access only those functions and data that have been granted by an authorized person named administrator, who has authority to access and modify all functions and all data. Users are identified by name and password system.

By using Internet Map Server Mapsys, geo-information data value is multiplied by the fact that they are made available to potential users where and when they need them as soon as data manager and potential customers are connected to the Internet. For Intranet users connect through a local network configuration and user functions are the same as for the Internet.

The information provided in the network are MapSys normal Works located on a server which may have a degree of detail set by the user. Configured MapSys Works may be the original set - which are constantly changing - or copies of theirs. Thus there is a permanent control over the “news” factor of the information provided.

**Future development trends for geographic information systems technology**

The Geographic Information Systems already offer more precision than the basic mapping scales. A first future trend would be to redefine some of the data collection methods and their levels of accuracy. At one time GIS technology can be influenced by the possibility of multimedia data storage and that of networks’ creation. The ability to display text, maps, data, photos, video, and sound for locations from a multitude of sources from the network will give a new definition of what constitutes a spatial database.

Creating 4D GIS geographic information systems (XYZ and time) is the next major challenge. Currently, time is treated as a series of stored map layers that can be animated for visualizing the changes on the landscape. Adding predictive modeling along with the actions proposed by the management (ex, timber harvesting and subsequent growth of vegetation) can be introduced as methods for looking into the future.

Data structures will host tomorrow's time for a fully integrated size and thus will change the paradigm of conventional mapping.

## Conclusions

GIS technology has greatly changed the perspective about map's utility. This perspective has moved from classical mapping to an active and vital ingredient in making decisions. The professionalism of nowadays is challenged to understand the new environment and to formulate innovative applications that fulfill the complexity and the ever-changing needs.

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