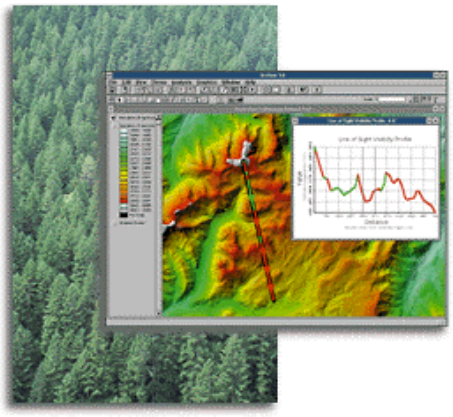
GEOGRAPHIC INFORMATION SYSTEMS

WHAT IS A GEOGRAPHIC INFORMATION SYSTEM?

A geographic information system (GIS) is a computer-based tool for mapping and analyzing spatial data. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. GIS is considered to be one of the most important new technologies, with the potential to revolutionize many aspects of society through increased ability to make decisions and solve problems.



The major challenges that we face in the world today -- overpopulation, pollution, deforestation, natural disasters – all have a critical geographic dimension. Local problems also have a geographic component that can be visualized using GIS technology, whether finding the best soil for growing crops, determining the home range for an endangered species, or discovering the best way to dispose of hazardous waste. Careful analysis of spatial data using GIS can give insight into these problems and suggest ways in which they can be addressed.

Map making and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving. Today, GIS is a multi-billion-dollar industry employing hundreds of thousands of people worldwide. GIS is taught in high schools, colleges, and universities throughout the world. Professionals in every field are increasingly aware of the advantages of thinking and working geographically.

COMPONENTS OF A GEOGRAPHIC INFORMATION SYSTEM

A working Geographic Information System seamlessly integrates five key components: hardware, software, data, people, and methods.

HARDWARE

Hardware includes the computer on which a GIS operates, the monitor on which results are displayed, and a printer for making hard copies of the results. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop

computers used in stand-alone or networked configurations. The data files used in GIS are relatively large, so the computer must have a fast processing speed and a large hard drive capable of saving many files. Because a GIS outputs visual results, a large, high-resolution monitor and a high-quality printer are recommended.

SOFTWARE

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components include tools for the input and manipulation of geographic information, a database management system (DBMS), tools that support geographic query, analysis, and visualization, and a graphical user interface (GUI) for easy access to tools. The industry leader is ARC/INFO, produced by Environmental Systems Research, Inc. The same company produces a more accessible product, ArcView, that is similar to ARCINFO in many ways.

DATA

Possibly the most important component of a GIS is the data. A GIS will integrate spatial data with other data resources and can even use a database management system, used by most organizations to organize and maintain their data, to manage spatial data. There are three ways to obtain the data to be used in a GIS. Geographic data and related tabular data can be collected in-house or produced by digitizing images from aerial photographs or published maps. Data can also be purchased from commercial data provider. Finally, data can be obtained from the federal government at no cost.

PEOPLE

GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. The basic techniques of GIS are simple enough to master that even students in elementary schools are learning to use GIS. Because the technology is used in so many ways, experienced GIS users have a tremendous advantage in today's job market.

METHODS

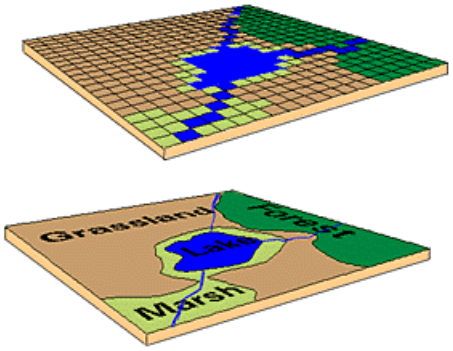
A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

HOW A GIS WORKS

A GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from modeling global atmospheric circulation, to predicting rural land use, and monitoring changes in rainforest ecosystems.

GEOGRAPHIC REFERENCES

Geographic information contains either an explicit geographic reference such as a latitude and longitude or national grid coordinate, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. An automated process called geocoding is used to create explicit geographic references (multiple locations) from implicit references (descriptions such as addresses). These geographic references can then be used to locate features, such as a business or forest stand, and events, such as an earthquake, on the Earth's surface for analysis.



GIS TASKS

General purpose GIS's perform seven tasks.

- Input of data
- Map making
- Manipulation of data
- File management
- Query and analysis
- Visualization of results

Input of Data

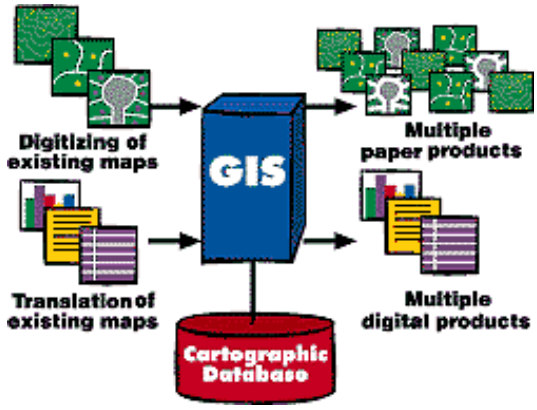
Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. The process of converting data from paper maps or aerial photographs into computer files is called digitizing. Modern GIS technology can automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing which requires the use of a digitizing table.

Today many types of geographic data already exist in GIS-compatible formats. These data can be loaded directly into a GIS.

Map Making

Maps have a special place in GIS. The process of making maps with GIS is much more flexible than are traditional manual or automated cartography approaches. It begins with database creation. Existing paper maps can be digitized and computer-compatible

information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics.



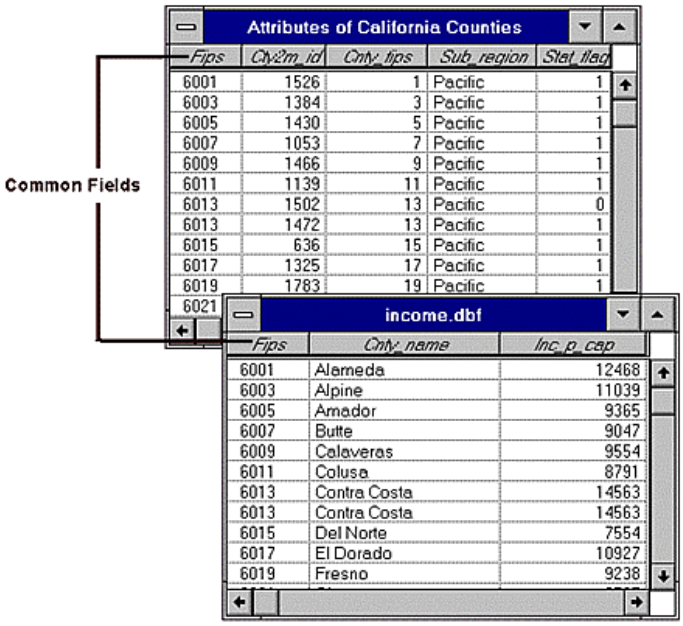
The characteristics of atlases and map series can be encoded in computer programs and compared with the database at final production time. Digital products for use in other GIS's can also be derived by simply copying data from the database. In a large organization, topographic databases can be used as reference frameworks by other departments.

Manipulation of Data

It is likely that data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with your system. For example, geographic information is available at different scales (street centerline files might be available at a scale of 1:100,000; census boundaries at 1:50,000; and postal codes at 1:10,000). Before this information can be integrated, it must be transformed to the same scale. This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

File Management

For small GIS projects it may be sufficient to store geographic information as simple files. There comes a point, however, when data volumes become large and the number of data users becomes more than a few, that it is best to use a database management system (DBMS) to help store, organize, and manage data. A DBMS is nothing more than computer software for managing a database--an integrated collection of data.



There are many different designs of DBMS's, but in GIS the relational design has been the most useful. In the relational design, data are stored conceptually as a collection of tables. Common fields in different tables are used to link them together. This simple design has been widely used, primarily because of its flexibility and very wide deployment in applications both within and without GIS.

Query and Analysis

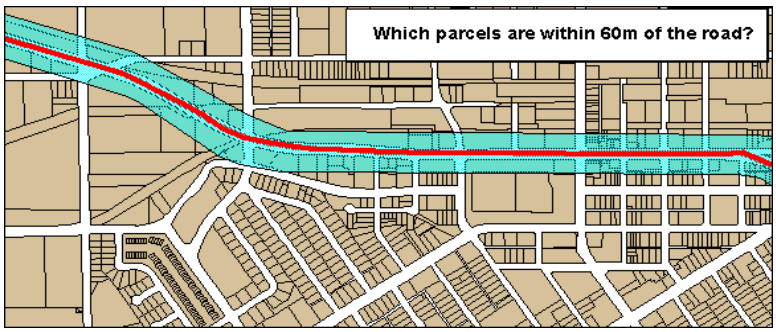
Once you have a functioning GIS containing your geographic information, you can begin to ask simple questions such as

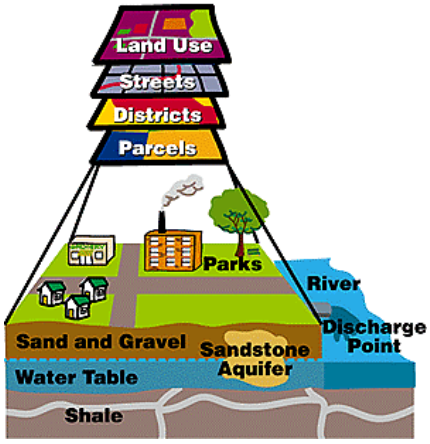
- How far is it between two places?
- How is this particular parcel of land being used?
- What is the dominant soil type for oak forest?
- Where are all the sites suitable for relocating an endangered species?
- Where are all of the sites possessing certain characteristics?
- If I build a new highway here, how will animals in the area be affected?

GIS provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information to managers and analysts alike. GIS technology really comes into its own when used to analyze geographic data to look for patterns and trends, and to undertake "what if" scenarios.

Modern GIS's have many powerful analytical tools, but two are especially important.

Proximity Analysis is used to examine spatial relationships by determining the proximity relationship between features.

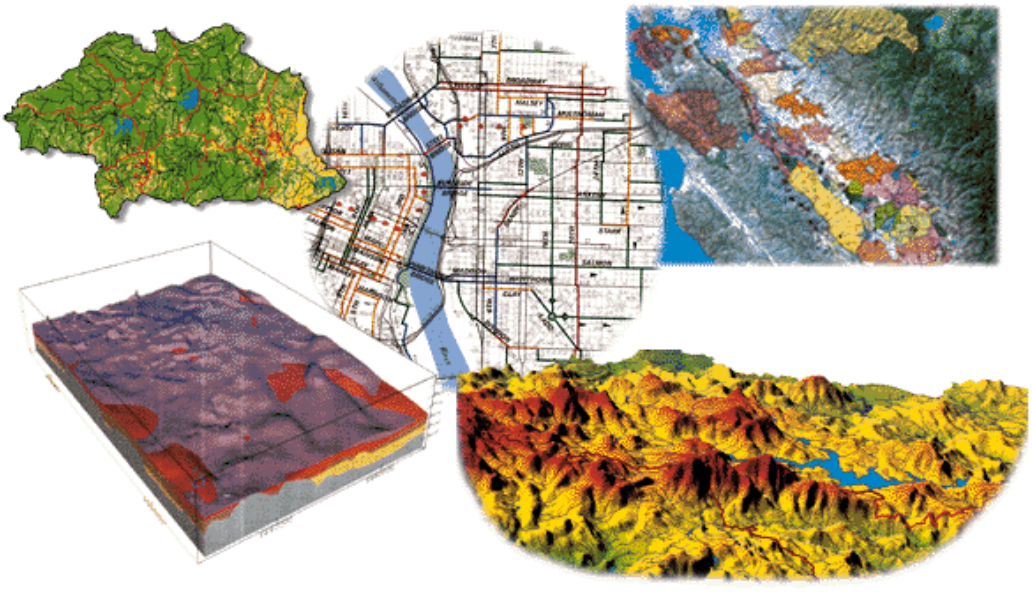




Overlay Analysis integrates different data layers to look for patterns and relationships. At its simplest, this could be a visual operation, but analytical operations require one or more data layers to be joined physically. For example, to analyze the impact of urbanization on ecological characteristics of an area, an overlay could integrate data on soils, hydrology, slope, vegetation, and land use. Queries could be used to identify sources of pollution, to delineate potentially sensitive areas, or to plan for increased population growth in the area.

Visualization

For many types of geographic operations, the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and with multimedia.



THE IMPORTANCE OF GEOGRAPHIC INFORMATION SYSTEMS

The ability of GIS to search databases and perform geographic queries has revolutionized many areas of science and business. It can be invaluable during a decision-making process. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data. Because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively. For this reason, in today's world, the ability to use GIS is increasingly important.