## *What is GIS?*

A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on Earth. 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.

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.

---

## *Components of a GIS*

A working GIS integrates five key components: hardware, software, data, people, and methods.

### Hardware

Hardware is the computer on which a GIS operates. 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.

### Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are:

· Tools for the input and manipulation of geographic information

· A database management system (DBMS)

· Tools that support geographic query, analysis, and visualization

· A graphical user interface (GUI) for easy access to tools

**Data**

Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data.

**People**

GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.

**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 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 tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation.

**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 allow you to locate features such as a business or forest stand and events such as an earthquake on the Earth's surface for analysis.

**Vector and Raster Models:**

Geographic information systems work with two fundamentally different types of geographic models--the "vector model" and the "raster model."

In the vector model, information about points, lines, and polygons is encoded and stored as a collection of x,y coordinates. The location of a point feature, such as a bore hole, can be described by a single x,y coordinate. Linear features, such as roads and rivers, can be stored as a collection of point coordinates. Polygonal features, such as sales territories and river catchments, can be stored as a closed loop of coordinates. The vector model is extremely useful for describing discrete features, but less useful for describing continuously varying features such as soil type or accessibility costs for hospitals.

The raster model has evolved to model such continuous features. A raster image comprises a collection of grid cells rather like a scanned map or picture. Both the vector and raster models for storing geographic data have unique advantages and disadvantages. Modern GISs are able to handle both models.

---

## *GIS Tasks*

GISs essentially perform five processes or tasks:

· Input

· Manipulation

· Management

· Query and Analysis

· Visualization

## Input

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 into computer files is called digitizing. Modern GIS technology has the capability to automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing (using a digitizing table).

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

## Manipulation

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.

## 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 DBMSs, 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 surprisingly simple design has been so 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

· Who owns the land parcel on the corner?

· How far is it between two places?

· Where is land zoned for industrial use?

And analytical questions such as:

· Where are all the sites suitable for building?

· What is the dominant soil type for oak forest?

· If a new highway is built here, how will traffic 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 GISs have many powerful analytical tools, but two are especially important.

- **Proximity Analysis**

    · How many houses lie within 100 m of this water main?

    · What is the total number of customers within 10 km of this store?

    · What proportion of the alfalfa crop is within 500 m of the well?

    To answer such questions, GIS technology uses a process called buffering to determine the proximity relationship between features.

- **Overlay Analysis**

  The integration of different data layers involves a process called overlay. At its simplest, this could be a visual operation, but analytical operations require one or more data layers to be joined physically. This overlay, or spatial join, can integrate data on soils, slope, and vegetation, or land ownership with tax assessment.

## Visualization

For many types of geographic operation 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 other output, such as multimedia.

---

## *What Can GIS Do For You?*

### Perform Geographic Queries and Analysis

The ability of GIS to search databases and perform geographic queries has saved many companies literally millions of dollars. GISs have helped:

· Decrease the time taken to answer customer requests.

· Find land suitable for development.

· Search for relationships among crops, soils, and climate.

· Locate the position of breaks in electrical circuits.

A realtor could use a GIS to find all houses within a certain area that have tiled roofs and five bedrooms, then list their characteristics. The query could be further refined by adding criteria--

the house must cost less than $100 per square foot. You could also list houses within a certain distance of a school.

**Improve Organizational Integration**

Many organizations that have implemented a GIS have found that one of its main benefits is improved management of their own organization and resources. Because GISs have the ability to link data sets together by geography, they facilitate interdepartmental information sharing and communication. By creating a shared database one department can benefit from the work of another--data can be collected once and used many times.

As communication increases among individuals and departments, redundancy is reduced, productivity is enhanced, and overall organizational efficiency is improved. Thus, in a utility company the customer and infrastructure databases can be integrated so that when there is planned maintenance, affected customers can be sent a computer-generated letter.

**Make Better Decisions**

The old adage "better information leads to better decisions" is as true for GIS as it is for other information systems. A GIS, however, is not an automated decision making system but a tool to query, analyze, and map data in support of the decision making process. GIS technology has been used to assist in tasks such as presenting information at planning inquiries, helping resolve territorial disputes, and siting pylons in such a way as to minimize visual intrusion.

GIS can be used to help reach a decision about the location of a new housing addition that has minimal environmental impact, is located in a low risk area, and is close to a population center. 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.

**Make Maps**

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 GISs 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.