GIS Tutorial Series — I. Introduction to GIS

Learning Objectives

What a GIS is

What you need to set up a GIS

Basic mapping terminology

How GIS technology can help you produce maps and other information

Introduction: What is a GIS?

A Geographic Information System (GIS) is a computer-based system to capture, store, retrieve, manipulate, analyze and display spatial information and its associated attributes. It combines spatial and tabular information to produce maps and to perform spatial analyses.

This tutorial will provide you with some basic information about GIS, including an overview of what it is, what is needed for a GIS, basic mapping terminology, and how GIS is used to produce maps and other information.

GIS Components

To set up a GIS, you will need:

Hardware

Software

Data

People

In this tutorial, we will provide you with information about each of these components and how they interact with each other.

These four elements are essential components of a GIS setup.

Hardware: Components

The hardware portion of a GIS includes multiple pieces, such as:

Computers (desktops, laptops, handhelds)

Data storage

Data input

Data output

Hardware: Computers

Computer hardware used to run a GIS ranges from low-end desktop computers and laptops to high-end servers.

The type(s) of hardware and software required to set up a GIS depend on the needs of the user (i.e., GIS software processing requirements, data storage requirements).

Hardware: Data Storage

GIS data can include fairly large files. Data storage devices available include local hard disks, network storage, CDs, high-volume portable disks and tapes.

The type of data storage device selected will depend on the size of the data sets and whether immediate access to the files is necessary. Data storage requirements depend on the combined size of the data sets.

Hardware: Data Input

The heart of any GIS is the data used for analysis. Data input converts existing geographic information into a format that can be used by your GIS. Existing geographic information includes paper maps, aerial photos, addresses, coordinate data collected using GPS, satellite images, or digital geographic data in another system's format.

Various methods may be used to enter data into a GIS, including:

Digitizing data using a digitizing tablet
(i.e., paper maps)

Scanning data using a flatbed or drum scanner
(i.e., paper maps)

Using a computer keyboard or mouse (i.e., numbers, street and/or place names)

GPS (i.e., coordinate data such as latitude, longitude)

Digital cameras (i.e., structure photographs)

Hardware: Data Output

As is the case with any system, the data and analysis are only good if the information obtained can be communicated effectively.

Output devices such as printers and plotters are needed when planning for a GIS so that maps, charts, graphs, and tabular information can be printed. Additional output may include files that can be distributed via the Web and other media.

Hardware: Sample Setups

As we have discussed in this section, the hardware setup will be dictated by the needs of each user.

The following examples are provided to show a basic setup designed to handle simple data operations...

And a larger setup designed to process more complex data.

Hardware: Sample Setups

A simple, smaller setup to be used at home or in a small office may include the following*:

Basic computer
Inkjet printer (black-and-white)

*Please remember that these are just examples, and that your individual needs will dictate your final setup.

Hardware: Sample Setups

A larger, more sophisticated setup like the one described below is typical of systems used to create Digital Flood Insurance Rate Maps (DFIRMs).*

High-end computer

Large server

Digitizing tablet

Color laser printers and plotters (large format printer)

*Please remember that these are just examples, and that your individual needs will dictate your final setup.

Software

Although most GIS software packages share similar features (i.e., thematic mapping, labeling, geocoding, finding what's inside an area, determining quantities, etc.), programs vary in price and functionality.

Some have a number of built-in functions and others have additional modules that can be purchased separately to do specific types of analyses, such as flood hazard mapping and disaster planning.

The choice of software depends on the needs of each user. For your reference, we have provided a partial list of GIS software firms and their products. You may follow the links for each company for additional information.*

Selection of GIS Software Companies and Programs

ESRI (ArcView, Arc/INFO)

MapInfo (MapInfo)

Caliper (Maptitude)

Intergraph (GeoMedia)

Tactician (Tactician)

*Note: This is not a comprehensive list of the types of GIS software packages available and does not constitute FEMA's endorsement of any
of these companies and/or their products.

Software: Sample Setups

A simple, small setup like the one described below is typical of software packages used in a home or small office setting where users are making their initial forays into GIS.*

Basic computer

Inkjet printer (black-and-white)

Publicly available geographic data downloaded from the Web

Public domain software

*Please remember that these are just examples, and that your individual needs will dictate your final setup.

Software: Sample Setups

A larger, more sophisticated setup like the one described below is typical* of software packages used to create Digital Flood Insurance Rate Maps (DFIRMs).

High-end computer

Large server

Digitizing tablet

Color laser printer and plotters

Comprehensive GIS software package (see list shown in main Software section)

*Please remember that these are just examples, and that your individual needs will dictate your final setup.

Data

In a typical GIS setup, a small portion of the expenses are related to hardware and software. The acquisition and manipulation of data represents the largest expense in a typical GIS setup.

Once you have determined your hardware and software requirements, you will need to consider the backbone of your GIS: the data. The following provides some important information about data, including format types, data sources, data quality, and data analysis.

Data: Format Types

The two main types of data used in a GIS are:

1. Spatial Data

   a) Vector

   b) Raster

2. Tabular Data

Data: Spatial Data

Spatial data include the geographic information or boundaries that make up a map. It is tied to real world coordinates, which allows overlaying of spatial data from different layers for proper display and analysis. It includes two types: vector and raster.

Data: Vector Spatial Data

Vector spatial data is generally used to represent features with clear boundaries, which can be displayed as:

Point data, such as cities, schools, hospitals, or banks

Line data, such as pipeline locations, roads, railroads, or rivers

Area data such as states, parks, lakes, or floodplains

Real world phenomena have to be represented using these three data types. The method for modeling a particular feature may vary depending on the intended use of the data.

Data: Vector Spatial Data

Most maps are shown in a vector data format.

This example shows a land use map in a vector format by using areas.

This is the same land use map shown previously, portrayed in a raster format.

Raster spatial data is a set of discrete, uniform cells that are coded to represent the spatial information.

Like any other GIS layer, raster spatial data must be georeferenced.

Data: Raster Spatial Data

Raster spatial data may include satellite images, aerial photographs, and other related products. LIDAR and IFSAR data can be used to create raster spatial data.

GIS software allows users to link photos and other graphics to spatial data.

FEMA uses primarily vector-style GIS software packages that are usually capable of importing raster data as a visual backdrop to vector data.

Data: Tabular Data

The second type of data, tabular data, is generally “the brains” behind a map.

A large amount of the tabular data used in a GIS is linked to a specific spatial feature that provides details about the characteristics of that feature

Examples of tabular data suitable for use in a GIS include address books with street addresses or sales information compiled by ZIP code. Both of these formats are easily linked to spatial data to make a map.

Data: Tabular Data

The tabular data must have an element that links it to the spatial data in order to map the information or to perform spatial analysis functions.

In this example, the state name or abbreviation could link the tabular data to the spatial data.

Now that you have learned about the various types of data you may use, let's discuss where to find it.

Data: Sources

Data is available from several public and private sources including government offices (Federal, State, regional, local), universities and colleges, and various Web sites. In addition, many companies sell their own data and/or data repackaged from another source.

Sample Public and Private Data Sources

U.S. Geological Survey

FEMA

Natural Hazards Center

ESRI

MapInfo

U.S. Census Bureau

*Please note that this is not a comprehensive list, nor does it constitute FEMA's endorsement of these sources.

Data: Sources

Data may also come from within your organization. Click on me for a list of ideas.

Much of this data has a spatial component that could be used to incorporate it into a GIS.

Client databases

Delivery routes

Imagery

Building permit information

Tax assessor information

Data: Quality

So far, we have identified data formats and sources. Another important factor in the acquisition and use of data is its quality. All data (free or purchased) should be evaluated for the basic requirements of users.

Click on me for a list of some of the issues that should be considered when evaluating data quality.

Does it cover the geographic area of interest?

Does the level of accuracy meet the user's needs?

Does it meet the user's needs?

Does the production date meet the user's needs?

Is it in a format that can be transferred easily into your GIS?

What are the projection and datum?

Data: Displaying Real World Features On A Map

One of the issues we suggest you look into when checking the quality of the data is its projection. All features in a GIS correspond to a location on the earth, where they are referenced to a coordinate system.

These features are also referenced as x, y coordinates on a map. Because the earth is a curved surface, taking the information and putting it on a flat piece of paper requires mathematical formulas called projections.

Every map projection distorts some aspect of the spatial information when it is placed on a piece of paper. These distortions include data characteristics such as area, shape, distance, or direction.

Orthographic Projection - Imaginary light at infinity
Gnomonic Projection – Imaginary light inside the globe
Stereographic Projection - Imaginary light antipodal

People

An important component of a successful GIS is the people using the system.

With most software packages, it is still necessary to have people to operate them to produce usable information.

This is also true for GIS. As discussed previously in this tutorial, GIS users may choose from several versions of GIS hardware and software to suit their level of skill and knowledge as well as individual project needs.

The following is a brief discussion of the types of tasks individuals may perform, depending on their level of knowledge, the systems used, and project require

People: Basic Tasks

The new mapping functions in some desktop spreadsheet programs allow most users to map information through the operation of a simple GIS with a minimum amount of training.

The example shown here depicts total population by state. It was created with spreadsheet software and its associated mapping functions.

People: Advanced Tasks

More advanced tasks, such as developing new mapping routines to delineate flood boundaries automatically, must be performed by a more experienced user.

Summary

This tutorial has introduced you to GIS, while providing you with an overview of what a GIS is and what is needed for a GIS.

You have also learned basic mapping terminology and how GIS technology can help you to produce maps and other information.