Lesson 1: Geographic Information Systems

## INTRODUCTION

In this lesson you will learn about Geographical Information Systems (GIS) and the components that make up GIS as they relate to the geospatial technology industry. Various examples of how GIS can be used and the distribution of data as it relates to GIS technology are discussed in this lesson. You will also learn about the fundamental concepts of spatial analysis which are space, location, and distance through information and examples.

## LESSON OBJECTIVES

By the end of this lesson, you will be able to:

1. Discuss the geospatial technology industry and its sectors.

2. Describe the major technological systems uses within the geospatial industry.

## LEARNING SEQUENCE

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| Required Reading | Read the following:  Geographic Information Systems   * What are Geographic Information Systems? * Components of GIS * Thinking about Space |
| Resources | View the following:   * Geospatial Revolution |
| Assignments | Complete the following assignments:   * GIS Application Paper * Quiz: What are Geographic Information Systems? |

## INSTRUCTION

### What are Geographic Information Systems?

## What is “GIS”?

A GIS is a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial and non-spatial data and information. These key words are the action words typically associated with a GIS. Let’s go through each word one by one, to get a broad understanding of what a GIS is.

### Collection

Collection refers to the ability of a GIS to ingest many different types of information. In fact, using many different formats, and many different types of data, are one of the main functions and benefits of a GIS.

### Maintenance

Maintenance refers to the task of keeping the collected data up-to-date. The world is not a static place, therefore often times, data collected about the world needs to be updated. A GIS can support dynamic data that changes often. The flexibility of a GIS to collect and maintain static and dynamic data is another strength of GIS.

### Storage

Storage refers to the structure coding of information that is stored in a digital format on the computer. The data can be stored in simple or complex data structures. The GIS is well suited to collect, maintain, and store data sets ranging in size from very small, such as a few kilobytes, all the way up to multiple terabytes and beyond.

### Analysis

The fourth word, analysis, speaks to the analytical abilities of a GIS. When a GIS analyzes the spatial information that has been collected maintained and stored within, it turns that data into information. Analysis techniques are from a wide range of fields, and assist the user of a GIS –by uncovering spatial patterns in the data.

### Output

Output refers to maps, reports, and statistics. Typically, the output of a GIS is a map. A map is a visual representation of the spatial phenomenon known as reality. Through the collection maintenance storage and analysis of reality, a GIS can produce a visualization and model of the world.

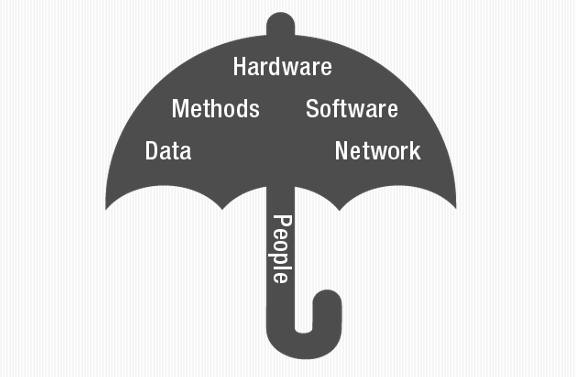
## Distribution of Information

A GIS allows for easy sharing of spatial and non-spatial data and information around the world headed both in a visual or tabular format. “Spatial and non-spatial data and information” refer to the fact that a GIS can hold all information whether it has a spatial component or not. The ability of a GIS to hold all types of information often makes the GIS the center of all information.

Ron Abler stated “GISs are simultaneously the telescope, the microscope, the computer, and the Xerox machine of regional analysis and synthesis of spatial data.” This quote really hits on many of the aspects of a GIS such as its ability to focus on a small or large area, to analyze that area, to store that information in the computer, and to copy and distribute that information like a Xerox machine.

## GIS as an Umbrella

GIS can be thought of as an umbrella composed of six parts that, when working together, produce a system that has many capabilities.



## What Falls Under the GIS Umbrella?

The six parts of a GIS are hardware, software, network, methods, data, and people. The people part of a GIS, is the part that operates and maintains the GIS. By successfully completing this course, you will begin your path as the people part of the GIS, and will be able to operate a GIS to collect, maintain, store, analyze, output, and distribute spatial and non-spatial information.

With the six parts of a GIS working together, the live capabilities fall underneath the umbrella of GIS. Capability such as: spatial data services, spatial data analysis, mapmaking, data collection, programming, and much, much more. As will be discussed throughout this first module, GIS can truly be applied to any situation at any location.



**Components of GIS**

## The Six Parts of a GIS

The six parts of a GIS are: hardware, software, data, methods, people, and network. Previously, there were only five parts to a GIS. Network was later added with the advent in popularity of the Internet.

### Hardware

Hardware is perhaps the simplest part of a GIS to explain. The harder part of GIS refers to powerful computers, printers, output devices, such as monitors, input devices, and large amounts of disk space to store the, typically, large GIS data sets. A typical GIS computer workstation has a powerful CPU, large amounts of RAM, large monitors, fast network connectivity, and large amounts of disk space.

### Software

The software part of the GIS refers to the many free and commercial software packages that allow a GIS user to perform GIS functions such as the manipulation, storage, query, and analysis of spatial and non-spatial information.

### Data

The data part of a GIS refers to any and all spatial and non-spatial information stored in a digital format on the computer. A GIS can ingest any type of data in many different types of formats. The ability for a GIS to consume such a wide range of data does produce the effect of “data overload”. With the wide proliferation of sensors, there is more data available to us today than ever before. With so much data, it is often difficult for a person to easily understand what is inside the data. A GIS can visualize the data as a map, graph, or other graphic, that helps humans understand and weed through all the massive amounts of data.

In fact, the problem of “too much data” does require a GIS user to spend quite a bit of time managing the data. In general, half of all the time you spend on a GIS project, will simply be working with and preparing the data for maintenance, storage, analysis, and output.

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| **Key Facts**  A GIS can ingest any type of data including both spatial and non-spatial  We are currently in “Data Overload.” Visualizing data helps humans weed through it all.  **Thumbnail for version as of 02:00, 4 May 2008**Half of all time spent on a GIS projects will simply be working with data. |

### Method

The methods part of a GIS refers to the formulas, statistics, analysis, and algorithms that are used to turn data into information, so that humans can turn that information into knowledge through interpretation.

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| **Key Facts**  Methods   * Formulas * Statistics * Analysis * Algorithms |

### People

People, refers to anyone that uses a GIS. This includes the general public that may be using a printed map, or a digital globe, all the way up to skilled GIS professionals, that build new functionality and push the limits of what is possible in a GIS.

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| **Key Facts**  People   * Skilled GIS Professionals * Skilled GIS Users * Novice GIS Users * Public Users |

## Network

Network refers to both the computer, and social network. Both of these networks assist in the dissemination of data. Whether the dissemination of data is through transferring of data sets or collaboration, sharing the data from a GIS is a very common and useful operation. Additionally, these networks allow for the display of information in the form of web maps, web applications, or even paper maps using our social network.

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| **http://upload.wikimedia.org/wikipedia/commons/d/d7/Network.pngKey Facts**   * Dissemination of data   + - Transfer datasets     - Collaboration * Display of information   + - Key FWeb maps     - Web Applications |

## How can a GIS be used?

Here are a few examples of a GIS in use.

* Cadastral Information
* Deliveries
* Military
* Farming
* Wildlife Mapping
* Disaster Management
* Infrastructure
* Decision Support
* 3D Analysis
* Mapping
* Redistricting
* Health
* Data Mining
* Natural Resources

Whether we are storing cadastral information to determine land valuation and taxes, tracking of our delivery vans commuting between our warehouses and customers, or managing our wildlife and natural resources, GIS can play a valuable role in assisting with these tasks.

To illustrate examples in which geospatial technology has been used, watch the [Geospatial Revolution](http://youtu.be/poMGRbfgp38) which is produced by Penn State Public broadcasting.

**Thinking about Space**

## Fundamental Concepts of Spatial Analysis: Space

There are three fundamental concepts of spatial analysis: space, location, and distance. Space can be measured in absolute, relatives, and cognitive terms.

### Absolute Space

Absolute space can be thought of as mathematical space. Absolute space involves the precise measurement of location and space, such as an X, Y, and Z coordinate. Absolute space should provide an unambiguous description of space.

For example, all the information coded on the topographic map shown here, is stored and displayed as a representation of absolute location in space. All locations and features, are all described using precise measurements and calculations.

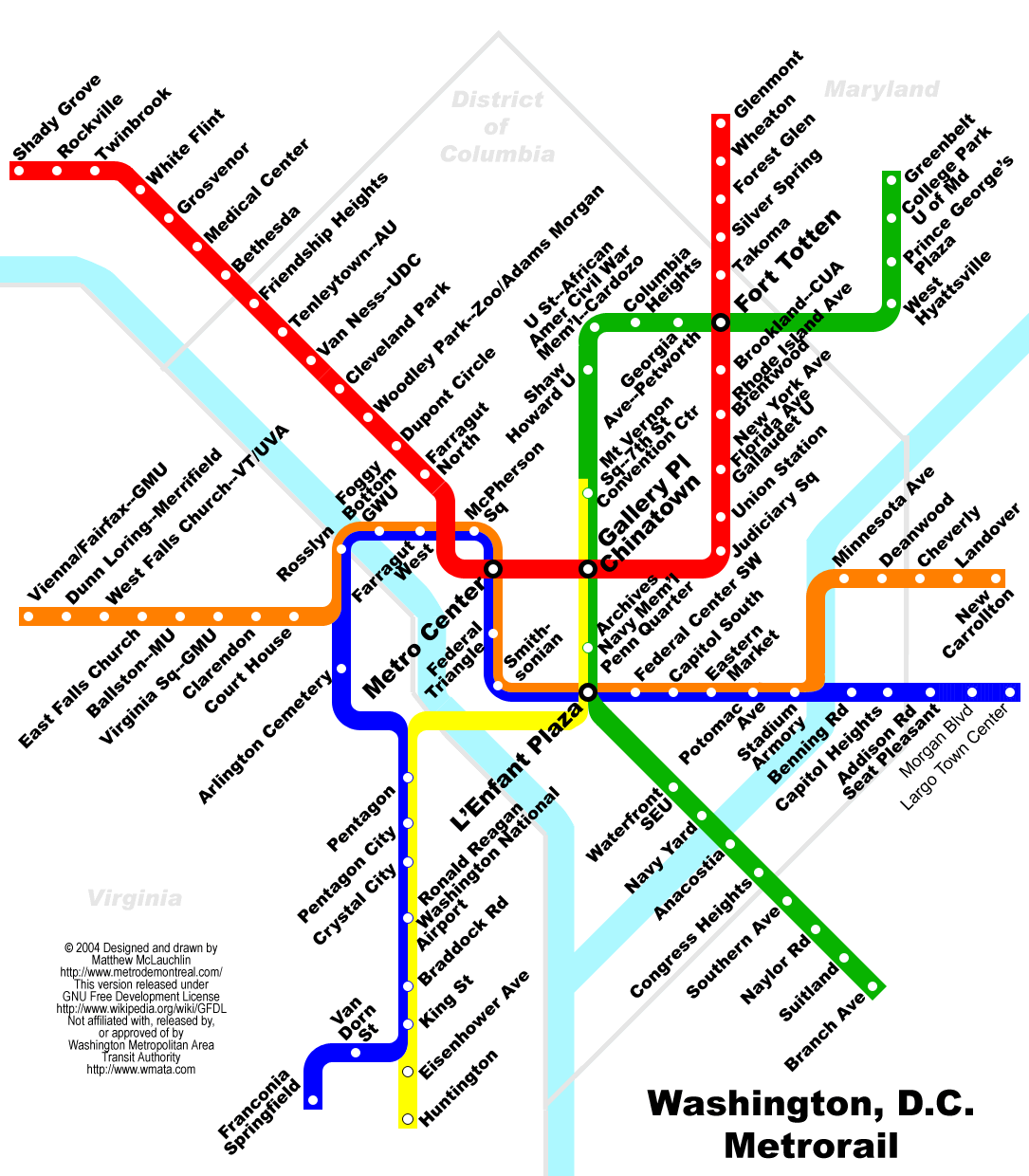


## Topological Space

Topological space can be thought of as relative space. Relative space deals with the definition of one location based on the location of another object. These topological relationships represent connectivity between features of the world. In topological space, precise measurement of space is not as important as the relative description of spatial features.

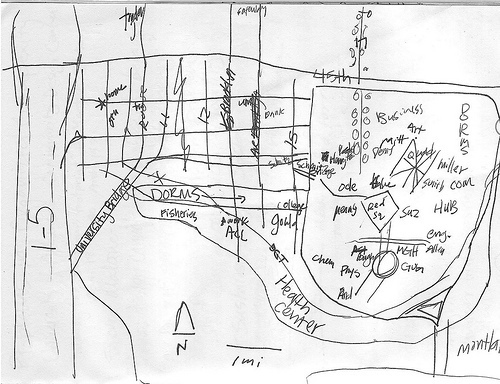
For example, this is a map of the Washington, DC Metrorail. This map shows all of the routes that the Metrorail takes. Notice that each stop is evenly spaced on this map.

Do you think that each stop is truly evenly spaced in the real world? No, of course not. As a rider of the Metrorail, are you concerned with how far apart the stops are, or how many stops before you exit the Metro? If you are a passenger on the Metrorail, topological space is much more important than absolute space as your only concern would be getting from point A to point B is how many times the doors open before you get off, not how many miles you travel before you exit the Metro.



## Cognitive Space

The third type of space is cognitive space. Cognitive space reflects people’s beliefs, experiences, and perceptions about places. For example, this is a drawing of a university campus that my student drew from memory. A freshman student, may know the location of the dorms, the student union, and the dining hall, very well, but not know the rest of campus at all. Conversely, a senior, who lives off campus, may know the location of every parking lot, the locations of many classrooms, the location of the student union, but who may not be familiar with the location of the dorms.

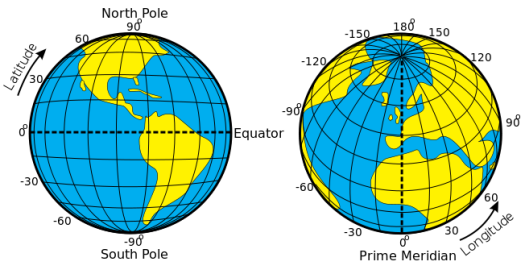


## Fundamental Concepts of Spatial Analysis: Location

There are three fundamental concepts of spatial analysis: space, location, and distance. Location can be described in four ways: absolute, relative, cognitive, and nominal.

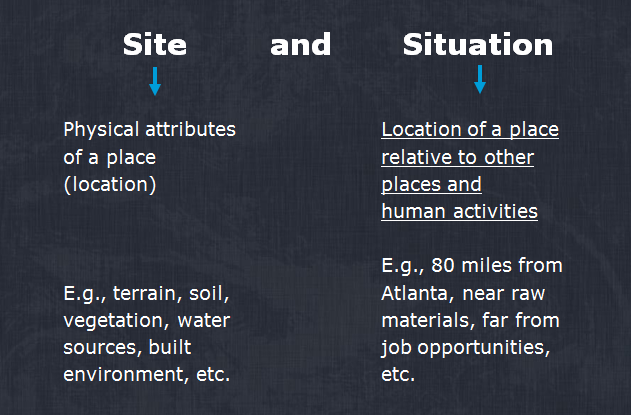
* Absolute - Latitude/longitude
* Relative – Site and situation
* Cognitive - Place name
* Nominal - “Where were you when…?”

## Absolute Location

Let’s start with absolute location. Absolute location is considered an unambiguous descriptor of the location, typically expressed as a coordinate, such as latitude and longitude. An absolute location must not be confused with any other location on earth.

## Relative Location

Relative location is expressed as both the concept of the site, and a situation. Site refers to the physical attributes of the location, for example, the terrain, soil, vegetation, water source, built environment, and so on. The situation refers to the location of a place relative to other places and human activities. For instance, Walkula Springs is located 80 miles from Atlanta, near raw materials, far from job opportunities, etc.



## Cognitive Location

Cognitive location refers to the personal cognitive images of places and regions compiled from personal knowledge, experiences, and impressions. For instance, the same water body was considered an important fishing ground and source of food for the native inhabitants. Now, the same source of water is seen as a recreational area. So while this is the same physical location, it is perceived differently based on how it is experienced.



## Nominal Location

The last way in which we think of location is nominal location. A nominal location is a location that you remember being at when you heard about an event that took place at a different location. For instance, many people remember where they were when they heard the news of the 9/11 attacks. Even though they may not have been near the attacks, the location of the attacks is linked to the location the person was at when they heard the news. Therefore, the location where they heard the news is the nominal location that is linked to the distant location where the event took place.

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| **Key Fact**  **Systems of Measuring and Representing Location**  It is important to note that the systems of measuring and representing locations for instance absolute, relative, nominal are cultural systems which are embedded in different cultures and worldviews and can become inscribed in landscapes. Each culture will have influence on the way in which space is described and perceived. |

## Fundamental Concepts of Spatial Analysis: Distance

There are three fundamental concepts of spatial analysis: space, location, and distance. Distance is described in absolute, relative, and cognitive terms.

**Absolute**

Absolute distance is a physical unit of measure, for instance, number of miles between downtown Houston, and downtown Toronto.

**Relative**

Relative distance is calculated measuring distance, using metrics such as time, effort, or cost. For instance, the distance of two cities maybe 2000 miles apart, which is an absolute description of distance, becomes the distance of two cities measured in tanks of gas, or mileage charge.

**Cognitive**

Cognitive distance refers to an individual’s perception of how far things are part. For instance, to some, driving 200 miles between Houston and San Antonio Texas is a reasonable drive. However, for others, a 200 mile drive may seem like a very, very far distance to travel if they are not used to traveling such a distance regularly.

## First Law of Geography

Lastly, you should be familiar with the first law of geography.

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| “*Everything is related to everything else, but near things are more related to each other.*”  Waldo Tobler  (Professor Emeritus, UCSB, Dept. of Geography) |

This is widely considered the first law of geography and speaks to the idea that space, and relative and cognitive relationships featured in the space have an influence on the development and interaction of those features.

## SUMMARY

In this lesson you learned about GISs and their components as they relate to the geospatial technology industry. The six parts of a GIS were outlined and explained to help you gain an understanding of what information is needed and why. The distribution of data as it relates to GIS technology is discussed in this lesson. You also learned about the fundamental concepts of spatial analysis which are space, location, and distance and how these concepts relate to mapping.

## ASSIGNMENTS

1. GIS Application Paper

2. Lesson 1 Quiz: What are Geographic Information Systems?