

# **Chapter 1**

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## ***Introduction to GIS and ArcMap 10.5***

### **Learning Objectives**

**After completing this chapter, you will be able to:**

- *Understand GIS*
- *Understand ArcMap 10.5*
- *Start ArcMap 10.5*
- *Understand ArcMap 10.5 user interface*
- *Understand geospatial data*

## INTRODUCTION TO GIS

A Geographical Information System (GIS) is like a cartographic document in the sense they both contain examples of a base map, where additional data is added for providing information. There is no limit to the amount of data that can be added to a GIS map, which capitalizes on analysis and presents data in support of arguments.

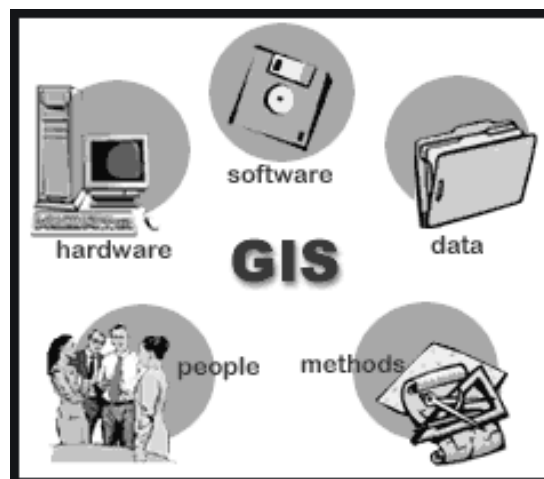
Geospatial technology covers a number of fields, including remote sensing, cartography, surveying, and photogrammetry; however, to integrate data from these different fields to produce useful geographic information, the geographic information system is required.

Information system most often refers to a system containing electronic records, which involves input of source documents, recording on electronic media, and output of records, along with related documentation and any indexes. The information system can be defined as an interactive combination of people, computer hardware and software, communication devices, and procedures designed to provide a continuous flow of information to the people who need information to make decisions or perform analysis.

A Geographical Information System (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geospatial data. Geospatial data describe both the locations and characteristics of spatial features. The ability of a GIS to handle and process geospatial data distinguishes GIS from other information systems and allows GIS to be used for integration of geospatial data and other data. It also establishes GIS as a technology important to geoscientists, cartographers, photogrammetrists, environmental engineers, urban and regional. Further the key components of GIS, brief of GIS, and application areas of GIS is described below.

### Key Components of GIS

The GIS consists of five key components, namely, hardware, software, procedure, data, and uses as shown in Figure 1-1 and is explained below. These five components need to be in balance to function any information system satisfactorily.



*Figure 1-1 Components of GIS*

**Hardware**

Hardware refers to the computer hardware system on which the GIS software runs. It includes the whole spectrum of computer systems ranging from portable personal computers to multi-user supercomputers. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in standalone or networked configurations.

**Software**

Software refers to the programs that run on computers to manage and perform specific functions. GIS software provides the functions and tools needed to store, analyze, and display geographic information. Some common GIS software are ArcGIS, ArcView, MapInfo. Some of these GIS software can work on desktop computers; some can work on networked server-based environment; and some (with extended features) has both capabilities.

**Data**

Data refers to geospatial and attribute data in GIS. The GIS facilitates integration of spatial and attribute data and this makes them unique in comparison to other database systems. The data that a GIS operates on consists of any data bearing a definable relationship to space, including any data about things and events that occur in nature. At one time this consisted of hard-copy data, like traditional cartographic maps, surveyor's logs, demographic statistics, geographic reports, and descriptions from the field. Advances in spatial data collection, classification, and accuracy have allowed more and more standard digital base-maps to become available at different scales.

**Methods**

A computer system for GIS consists of hardware, software, and methods designed to support the data capture, storage, processing, analysis, modelling and display of geospatial data. Besides the technical components like hardware, software and databases, institutional framework and policies are also important for a functional GIS. A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

**People**

The roles of the user are to select pertinent information to set necessary standards, to design cost-efficient updating schemes, to analyse GIS outputs for relevant purposes, and plan the implementation. Most definition of GIS focuses on the hardware, software, data and analysis components. However, no GIS exist in isolation of the user. There must always be people to plan, implement and operate the system as well as to make decisions based on the output. The GIS projects range from small research applications, where one user is responsible for design and implementation and output, to international corporate distributed system, where different type of users interact with the GIS in many different levels and ways.

**History of GIS**

GIS is not new. The first concept of GIS was first introduced in the early 1960s, and it was subsequently researched and developed as a new discipline. Dr. Roger Tomlinson is generally recognized as the father of GIS. He is the visionary geographer who conceived and developed the first GIS for use by the Canada Land Inventory in the early 1960s. The year 1969 was significant in the history of GIS because two major software companies were founded. First company is ESRI

(Environmental System Research Institute) which was founded by Jack Dangermond and his wife Laura Dangermond. Second company is Integrgraph which was founded by Jim Medlock in USA.

The second phase of development in GIS history occurred throughout the 1970s, and by the 1980s the concept progressed as national agencies adopted it, and interested parties began determining the best practices. By the late 1980s, there was a focus on improving the usability of technology and making facilities more user-centric.

There is little widespread information available on how the technology has been adopted and deployed. Those pursuing development in the field of GIS had different goals, meaning there was no set direction for research to follow. A single path finally surfaced when GIS became the focus of commercial activity with satellite imaging technology. Mass applications were thus initiated for business and private use.

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For many years, though, GIS was considered to be too difficult, expensive and proprietary. The advent of the graphical user interface (GUI), powerful and affordable hardware and software, and public digital data broadened the range of GIS applications and brought GIS to mainstream use in the 1990s.

## **Application of GIS**

To understand the advantages and importance of GIS in a better way, it is very important to know the applications and uses of GIS. GIS enables us to better understand and evaluate our data by creating graphic displays using information stored in our database. With GIS, you can change the display of our geographic data by changing the symbols, colours, or values in the database tables. GIS can be applied in various distinct application areas. Major areas of application of GIS can be grouped into five categories as follows.

### **Facilities Management**

Large-scale and precise maps and network analysis are used mainly for utility management. Automated mapping/facility management (AM/FM) is frequently used in this area.

### **Environment and Natural Resources Management**

Medium- or small-scale maps and overlay techniques in combination with aerial photographs and satellite images are used for management of natural resources and environmental impact analysis.

### **Street Network**

Large- or medium-scale maps and spatial analysis are used for vehicle routing, locating houses and street and so on.

## Planning and Engineering

Large- or medium-scale maps and engineering models are used mainly in civil engineering.

## Land Information System

Large-scale cadastre maps and land parcel maps and spatial analysis are used for cadastre administration, taxation, and so on.

# INTRODUCTION TO ArcMap 10.5

ArcMap is the main mapping application which allows you to create maps, query attributes, analyze spatial relationships, and layout final projects. This application is produced by Environmental Systems Research Institute (ESRI).

ArcMap represents geographic information as a collection of layers and other elements in a map view. There are two primary map views in ArcMap: data view and Layout view.

The map created in ArcMap will be saved as a file on disk. This is an ArcMap document and is referred to as a map document or mxd since the file name extension .mxd is automatically added to the map document name. The .mxd file saves all the layers that are added and you have worked on. Again you can work with an existing .mxd file by double-clicking the document to open it. This will start an ArcMap session for that .mxd file.

In ArcMap two types of data are used: vector data and raster data. Vector data is a format where points, lines, and polygons are used to represent real features on the surface of earth such as an address location, a street or a zip code area. Raster data is an image of a portion of the surface of earth and is made up of grid, cells or pixels as in an aerial image or satellite image.

## STARTING ArcMap 10.5

You can start ArcMap 10.5 by double-clicking on its shortcut icon located on the desktop. Alternatively, you can start ArcMap 10.5 from the taskbar. To do so, choose the **Start** button; a menu is displayed. Choose **ArcMap 10.5**, as shown in Figure 1-2; the interface screen will be displayed.

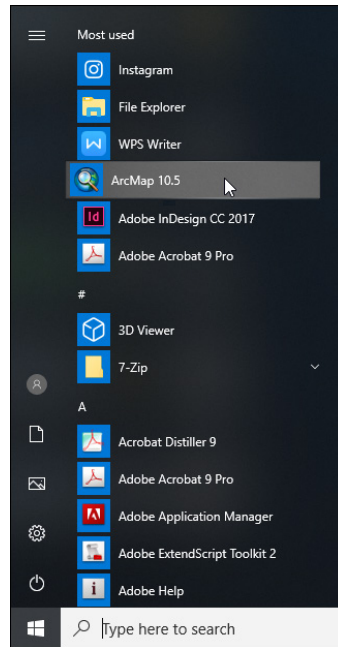


Figure 1-2 Starting ArcMap 10.5 from the taskbar

In the interface, the **ArcMap - Getting Started** dialog will be displayed. If you want to open a saved map, click on the **Recent** subnode under the **Existing Maps** nodes. All the saved or existing maps will be displayed on the right side in the dialog box, refer to Figure 1-3. Select a map and then click on the **Open** button.

Note that ArcMap saves the work in a map document or in a project having .mxd extension.

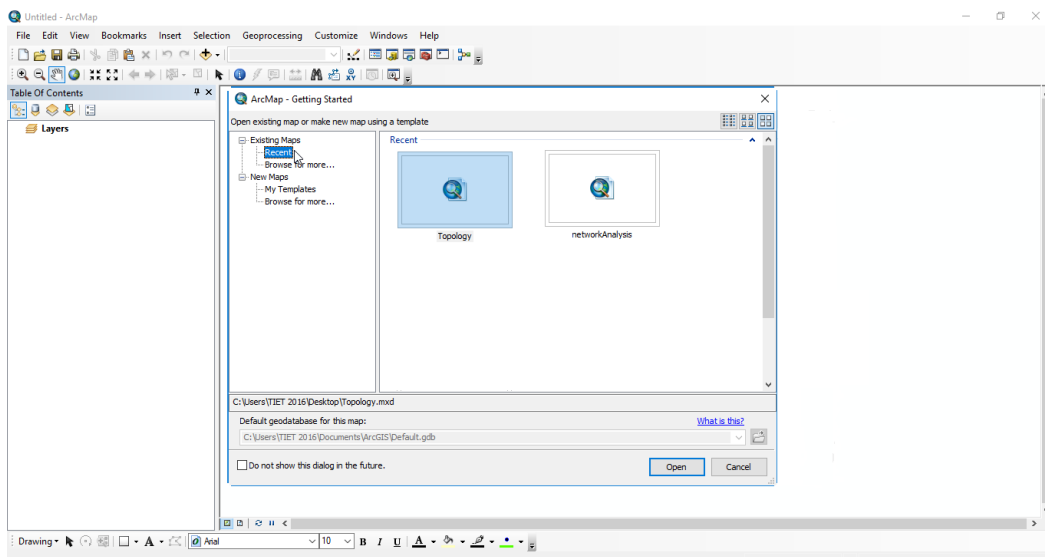
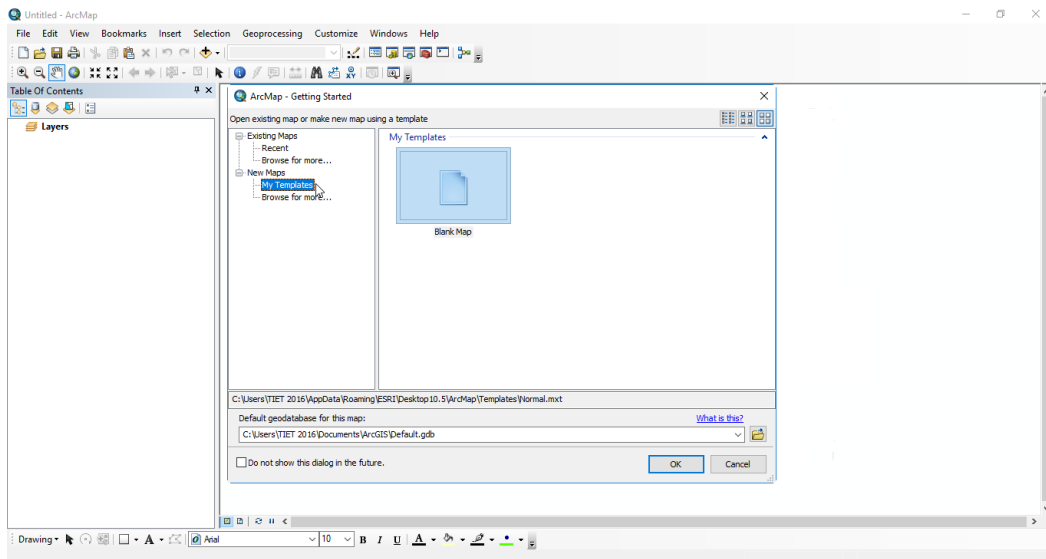


Figure 1-3 Selecting **Recent** under the **Existing Maps** node

If you want to open a new map or blank map then expand **New Maps** and select **My Templates** from the left pane in the **ArcMap - Getting Started** dialog box. Next select **Blank Map** from the right pane and choose the **OK** button, refer to Figure 1-4.

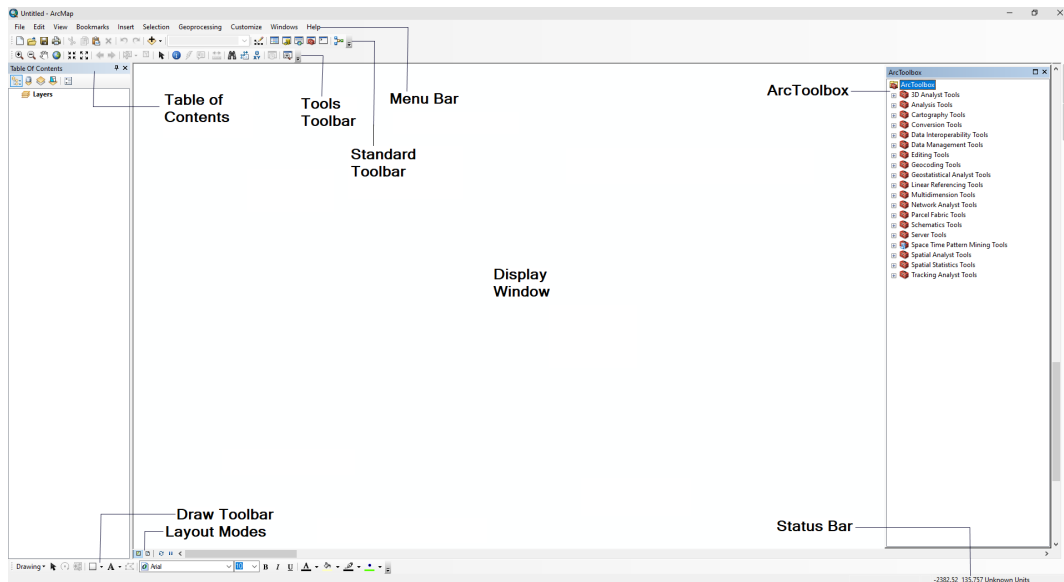


*Figure 1-4 Selecting My templates under the New Maps node*

## ArcMap 10.5 User Interface

All the tools in the toolbars of the interface are in dockable format and can be customized to form new toolbars. When you place a cursor over a tool, its description is displayed in a box under it. You can click on the **pin** button to hide the **Table Of Contents** window in the side of the display window. Also when you click on the **unpin** button in the **Table Of Contents** window to remove the hide and display it in the display window. You can also click on **close** button to remove the **Table Of Contents**. Similarly, you can also use the **pin** and **unpin** buttons to pin and unpin the ArcToolbox, Search, and Catalog accordingly.

The ArcMap 10.5 user interface includes table of contents, menu bar, standard toolbar, tools toolbar, layout modes, draw toolbar, display window, and ArcToolbox, refer to Figure 1-5. They are discussed next.



*Figure 1-5 ArcMap 10.5 graphical user interface*

## Table Of Contents

This area lists all the layers on the map and shows what the features in each layer represent. The map in **Table of Contents** helps you manage the display order of map layers and symbol assignment as well as set the display and other properties of each map layer.

You can set the display properties for each map layer so that it draws within a specific range of map scales. When the map display is out of range for scale-dependent drawing, the layers will not be visible. Layers that are out of range of the current map scale are indicated in the table of contents by a gray check box with a scale bar under it.

## Menu Bar

The menu bar is located in the top of the ArcMap interface, refer to Figure 1-5. It consists of text-based menu choices. Menus can also be invoked using keyboard shortcuts by using the key combinations with <ALT> key. For example, the file menu can be invoked by using the <Alt-F> keys. Menus contain a list of commands. A context menu is a floating menu that pops up at the location of the pointer when you right-click.

The menu bar includes **File**, **Edit**, **View**, **Insert**, **Selection**, **Tools**, **Window**, and **Help**.

## Standard Toolbar

The **Standard** toolbar appears at the top of the ArcMap application window, refer to Figure 1-5. The tools included in the **Standard** toolbar are **New**, **Open**, **Save**, **Print**, **Cut**, **Copy**, **Paste**, **Delete**, **Undo**, **Redo**, **Add Data**, **Map Scale**, **Editor Toolbar**, **Table Of Contents**, **Catalog**, **Search**, **ArcToolbox**, **Python**, and **ModelBuilder**, as shown in Figure 1-6.



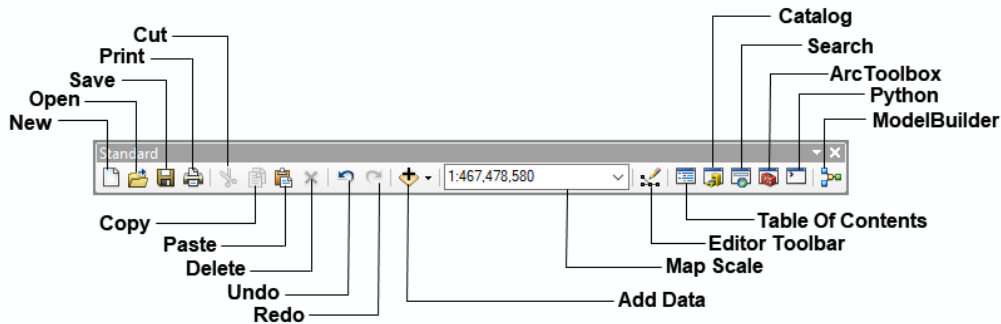


Figure 1-6 Tools in the *Standard* toolbar

## Tools Toolbar

The **Tools** toolbar is one of the common toolbars in ArcGIS. This toolbar includes tools such as **Zoom In**, **Zoom Out**, **Pan**, **Full Extent**, **Fixed Zoom In**, **Fixed Zoom Out**, **Go Back To Previous Extent**, **Go Back To Next Extent**, **Select Features**, **Clear Selected Features**, **Select Elements**, **Identify**, **Hyperlink**, **HTML Popup**, **Measure**, **Find**, **Find Route**, **Go To XY**, **Time Slider**, and **Create Viewer Window**, as shown in Figure 1-7.

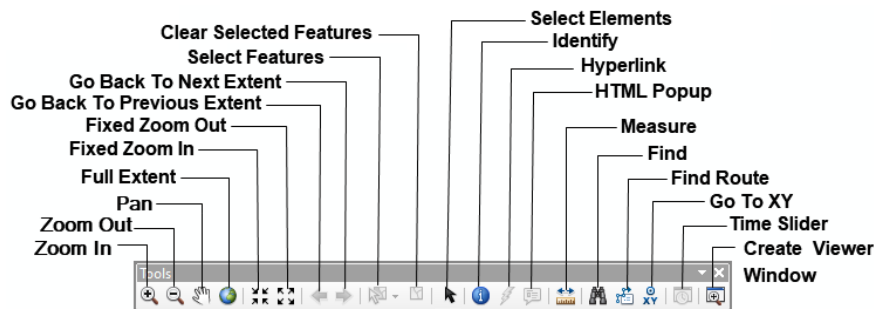


Figure 1-7 Tools in the *Tools* toolbar

## Layout Modes

The **Layout Modes** contains four tools on the bottom left corner of the display window. Basically, they change with the display of data in the display window, refer to Figure 1-8.

## Data View

The data view provides a full viewing screen and for data exploration.

## Layout View

In layout view, you set up exactly how your map layout will appear. For example, to create the map set up the elements such as legends, neatline, and annotations. This is how you will export maps for professional reports.

## Refresh

This button reloads data in the display window.

## Pause

This button stops data from loading in the display window.

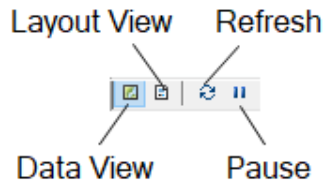


Figure 1-8 Buttons in the **Layout** mode

## Status Bar

The status bar is located at the lower right bottom corner of the application window shown in Figure 1-5. Status bar is also known as information bar. When you move or place the pointer on the display map area, the information of the map or the area is displayed in the status bar.

## Draw Toolbar

The **Draw** toolbar which is at the bottom left corner of the ArcMap, refer to the Figure 1-5. The **Draw** toolbar is used to add and edit graphical elements on your map layout page.

## Display Window

The **Display** window is located between the **Table of Contents** and **ArcToolbox**, refer to Figure 1-5. It displays all the layers in the **Table of Contents**. You can turn on/off a layer in the **Table Of Contents** by selecting the check box next to the layer. You can set the display window to data view and layout view from the layout modes.

## ArcToolbox

The **ArcToolbox** has geoprocessing tools to analyze your data. It conveniently organizes each tool into toolsets. Basically, toolsets are a set of tools for a specific task. For example, the conversion toolset changes the format of your data set.



### Tip

*If your **ArcToolbox** disappears, click **Geoprocessing > ArcToolbox** to display it.*

*If you cannot find a tool in **ArcToolbox**, click **Geoprocessing > Search** to find tools.*

## GEOSPATIAL DATA

Geospatial data separates GIS from other information systems. Therefore, before discussing GIS operations, you should understand the nature of geospatial data. To use geospatial data property in GIS, you must understand coordinate system and spatial data models that distinguish geospatial data from other types of data.

Most geospatial data is of general interest to a wide range of users. For example, roads, localities, water bodies, and public amenities are useful as reference information for a number of

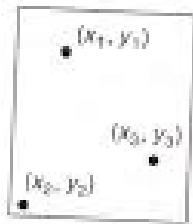
purposes. For this reason, whether collected by public or private organizations, large amounts of geospatial data are available as open data. This means that it can be accessed freely by users, and is made available through open standards. The development and use of open standards within the geospatial community have been heavily supported because of the wide range of uses to which applications of geospatial data and the involvement of a large number of agencies in collecting such data.

## Coordinate Systems

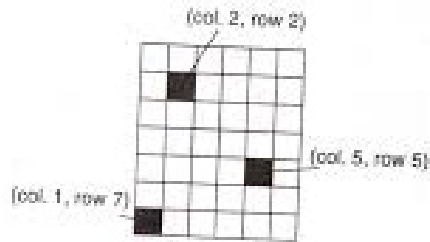
Geospatial data are geographically referenced. Spatial features on the surface of earth are referenced to a geographic coordinate system in terms of longitude and latitude values. However, when features are displayed on maps, they are typically based on a projected coordinate system in terms of  $x, y$  coordinates. These two spatial reference systems are connected by the process of projection, which displays spherical surface of earth as a plane surface.

## Vector Data Model

The Vector data model uses points and their  $x, y$ -coordinates to represent discrete features with a clear spatial location and boundary. A vector view, which records location coordinates of points, lines and polygons that make up a map. In the vector view, features present on the map are listed and they represent each as a point, line, or polygon object. Examples of vector data are point features such as wells, line feature such as streams, and polygon features such as land parcels, refer to the Figure 1-9 and Figure 1-10.



**Figure 1-9** The vector data mode that uses  $x, y$  as coordinates



**Figure 1-10** The raster data model that uses cells in grid to represent point features

The Georelational Data Model uses a split system to store spatial data and attribute data. The object-based data model, on the other hand, stores spatial data and attribute data in a single system.

## Raster Data Model

The Raster Data Model uses a grid and grid cells to represent continuous features such as elevation and precipitation. Raster data represent points by single cells, and lines by sequences. Each cell has a value that captures the magnitude of the continuous surface at the cell location. Cell values can be either positive or negative, integer, or floating point. Integer values are best used to represent categorical (discrete) data and floating-point values to represent continuous surfaces. Unlike the vector data model, the raster data model has remained the same in terms of its concept and data structure since the beginning of GIS, but methods for storing and compressing raster data have continually changed over the past three decades.

## Attribute Data

Attribute data is qualitative data that can be counted for recording and analysis. Examples include the presence or absence of a required label, or the installation of all required fasteners. It describes the characteristics of spatial features. For raster data, each cell has a value that corresponds to the attribute of the spatial feature at that location. A road segment may only have the attributes of length and speed limit, whereas a soil polygon may have dozens of properties, interpretations, and performance data.

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### Self-Evaluation Test

Answer the following questions and then compare them to those given at the end of this chapter:

1. Full form of ESRI is \_\_\_\_\_.
2. \_\_\_\_\_ is a computer system for capturing, storing, querying, analyzing and displaying, geospatial data.
3. Data that describes the characteristics of spatial features is called \_\_\_\_\_.
4. Spatial features on the surface of earth are referenced to a geographic coordinate system in terms of \_\_\_\_\_ and \_\_\_\_\_ values.
5. Raster data model uses a \_\_\_\_\_ and \_\_\_\_\_ represents the spatial variation of a feature.

**Review Questions**

Answer the following questions:

1. The concept of GIS was first introduced in the year 1960s. (T/F)
2. Laura Dangermond was the founder of Intergraph. (T/F)
3. Raster data model uses points and their x, y coordinates to construct spatial features of points, lines, and polygons. (T/F)
4. Who is the father of GIS?
  - a) Jim Medlock
  - b) Dr. Roger Tomlinson
  - c) Jack Dangermond
  - d) None of these
5. Which year was significant in the history of GIS?
  - a) 1960
  - b) 1945
  - c) 1969
  - d) 1972
6. Which country founded the Intergraph and ESRI?
  - a) Canada
  - b) UK
  - c) Germany
  - d) USA

**Answers to Self-Evaluation Test**

1. Environmental System Research Institute, 2. Geographical Information System, 3. attribute data, 4. longitude, latitude, 5. grid, cells