Learning Objectives in this chapter:

* Define what a GIS is, how and why we use it
* Identify types of GIS data and define GIS terms
* Give an overview of ArcGIS desktop and other GIS applications

# Introduction to Geographic Information Systems

**1.1 What is a GIS?**

A Geographic Information System (GIS) is a computer-based system used to capture, store, analyze, manage and display geographic information.

It is useful to describe a GIS as a process instead of a *thing*. A GIS is a system that is comprised of 4 main components:

**Hardware:** The computers, GPS units, servers, drives and equipment we use

**Software:** The application used to visualize, manipulate, and store data

(MoDOT utilizes ESRI’s ArcGIS products)

**Data:** Spatial data, tablular data, and metadata

**Personnel:** a thinking explorer who is the key to the power of a GIS

A GIS allows database information to be linked to map data. It enables a map to be more intelligent than just giving us the answer of *where*. We can now answer: Who, What, When, Where, Why and even How.

**1.2 Why use a GIS?**

***Improve Organizational Integration***

One of the main benefits of GIS is improved management of your organization and resources. A GIS can link data sets together by common location data, such as addresses, which helps departments and agencies share their data. By creating a shared database, one department can benefit from the work of another. Data can be collected once and used many times.

***Better Decision Making***

The old adage “better information leads to better decision making” is true for GIS. A GIS is not just an automated decision making system, but a tool to query, analyze, and map data in support of the decision making process.

***Creating Maps***

Making maps with a GIS is much more flexible than traditional manual or automated cartography approaches. A GIS creates maps from data pulled from databases. Existing paper maps can be digitized and translated into a GIS as well.

In summary, a GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

**1.3 How do we use a GIS?**

GIS uses a new concept of thinking called *The Geographic Approach*. It involves a new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet. We are able to create geographic knowledge by measuring the earth, organizing the data, analyzing and modeling various processes and relationships. The Geographic Approach also allows us to apply this knowledge to the way we design, plan and change our world.

Source: ESRI

There are 5 steps that we take in The Geographic Approach:

**Step 1: Ask**

What is the problem that we are trying to solve or analyze and where is it located? What is my end goal?

**Step 2: Acquire**

What data will be needed to solve the problem and how will I acquire the data?

**Step 3: Examine**

Visually examine the data as well as reviewing how it’s organized, studying its metadata, and determining its relevance to meeting your goals.

**Step 4: Analyze**

Analyze the data. What classification methods will you use in analyses, or what symbology best fits the representation of the problems you are trying to solve or display? How will you represent your data? And by what means?

**Step 5: Act**

Sharing and presenting the information. How will you display the results? Who is the audience? Will the information be displayed via maps, tables, charts, reports or graphs? Are they to be delivered in print, or digitally via a network or website?

**1.4 GIS Data Types**

Two types of data are used in GIS and briefly described here. A better understanding of these types of data will be learned throughout the various chapters and exercises in this book.

**Raster Data:**  Spatial data model that is made up of rows and columns of equal sized cells. Each cell contains an attribute value and location coordinates. Group of cells that share the same value, represent geographic features such as land cover types.

**Vector Data:** A coordinate-based data model that represents geographic features as points, lines, or polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells.

**1.5 ArcGIS Desktop Overview**

There are various GIS software products available to the public and private sector. MoDOT uses ESRI’s suite of ArcGIS products. The main applications we will cover in this class will be sufficient for anything you will need to accomplish. Those applications included ArcCatalog, ArcMap and ArcExplorer.

**ArcCatalog**

The ArcCatalog application helps you organize and manage all your GIS data. Tools are available to browse data, find geographic information, manage metadata, view datasets graphically and help setup the schemes for layering groups.

ArcCatalog organizes these contents into a tree view that you can work with to organize and manage various types of geographic information for ArcGIS Desktop.

*ArcCatalog View*



ArcCatalog can be run alone as its own application, or it can be accessed from within ArcMap as a window.

**ArcMap**

The ArcMap application provides tools to help users create visual displays of their data as well as to perform queries, analysis, work with tables, edit geographic data, create reports, and presentation quality maps.

ArcMap consists of many useful tools to work with geospatial data.

The geospatial data can be loaded into ArcMap and viewed in two different ways: Data View and Layout View. In data view, the user can interact with the geographic information presented, and the map elements are hidden from view. Most projects begin in this view, and continue to the layout view for final editing and production. While in layout view, the user can incorporate a number of useful features such as scale bars and north arrows. These elements are crucial to map-making, and provide clients with appropriate reference information.

*Data View*

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*Layout View*



*ArcCatalog*

*Window*

**ArcCatalog Window**

C:\Program Files\ArcGIS\DeveloperKit10.0\Icons\CatalogWindowShow32.png

ArcCatalog can be launched as a window from within ArcMap. This is a new feature with the ArcGIS 10 version. The window will open and dock on the right hand side of the screen as seen in Figure 1.3. ArcCatalog may be opened by clicking on the icon that looks like a filing cabinet.

**ArcToolbox**

*ArcToolbox Window*

C:\Program Files\ArcGIS\DeveloperKit10.0\Icons\GeoprocessingArcToolboxWindowShow32.png

 ArcToolbox is an application that is either accessed through ArcMap or ArcCatalog and provides the tools for data conversion, coordinate system management, and map projection. Other tools allow for import and export of such data as: Cad files, ArcINFO Coverages, Geodatabases, Shapefiles, Raster Images, and tables.

You can open ArcToolbox by clicking on the icon that looks like a red toolbox.

**Licensing Levels**

****ArcGIS comes in 3 licensing levels, Basic, Standard, or Advanced (formerly ArcView, ArcEditor, or ArcInfo, respectively). Basic is sufficient for many of the things that we need to accomplish here at MoDOT. Advanced is available as well but we have fewer licenses due to the high cost. This license level may be checked out for short periods, however due to the small amount available, others in MoDOT that require these licenses for their daily functions have the priority. Transportation Planning maintains MoDOT’s ArcGIS licenses.

The difference between them is that with each upgrade in license, there are more capabilities in the tools and analysis.

You can tell what license you are using by opening ArcMap, left click on help and select

*ArcMap License*

About ArcMap.



**ArcGIS Explorer for Desktop**

ArcGIS Explorer is a free application to view data. You can download it for free to your computer via the ESRI website. <http://www.esri.com/software/arcgis/explorer-desktop/download>

ArcGIS Explorer allows you to explore, visualize, and share GIS information and can help you deliver data to a broader audience. ArcGIS Explorer is very similar to Google Earth-it’s fairly intuitive and easy to use for even the most inexperienced map reviewer. Ready-to–use basemaps and layers are available online, and you can fuse your local data with map services to create custom maps and geopresentations. You can also create layer packages through ArcMap, and send these to any individual who may not have ArcGIS installed on their computer. All they will need to do is download the free ArcGIS Explorer to visualize your data.

*ArcGIS Explorer Application*



**ArcGIS Online**

ArcGIS Online provides a common platform to find, share, and organize geographic content and to build GIS applications. Through ArcGIS.com, the Web interface for ArcGIS Online, you can access maps, apps, and tools published by ESRI and other GIS users, and share you own content with a broad community of users.

The only requirement to view and utilize ArcGIS Online map

service is the free download

of the newest version of

Microsoft SilverLight.

<http://www.microsoft.com/silverlight/>

<http://www.arcgis.com/home>

*ArcGIS Online Portal*



ArcGIS Online can be accessed from within ArcMap via the

File > ArcGIS Online within the main menu

*ArcGIS Online Data Portal*



By using the Add Data button in ArcMap you can either add Basemaps items or Search ArcGIS Online for data. You now need an online account to create maps online.

**ArcGIS Help**

The help files with ArcGIS are quite good. You can get to the help files in any one of the three ArcGIS applications. Choose Help and select ArcGIS Desktop Help or hit the F1 key.

With a table of contents to the left and the main reading screen on the right, it’s pretty intuitive to navigate through the help page.

*ArcGIS Help Screen*



**ArcGIS Desktop Resource Center**

The Resource Center can be accessed from the Help menu. It will take you to a website that is authored by ESRI personnel and contains a plethora of information from ArcGIS users. You can search for a topic in white papers, forums, information sites, and how to’s written by GIS users. Online tutorials and videos are also housed on this site.

*ArcGIS Resource Center*



**Google Earth**

Google Earth is a virtual globe, map and geographical information program that is maintained by Google and is available for free to use. The native format of GE is the KML/KMZ format. (KMZ being a compressed zip of KML files…) It is useful for sharing information with the public and is becoming a popular format to share files with people who do not have ArcGIS on their computers. You can send someone a KML file and they can open it into Google Earth to view your data on their screens. Microstation v8i SS2 can now export a KML file as well. This file can then be brought into ArcMap. It is essentially another way that you can bring DGN line work into ArcMap.

Google Earth can be downloaded for free from this link:

<http://www.google.com/earth/index.html>

There are tutorials to help you get started within Google Earth available here:

<http://www.google.com/earth/learn/>

There are many people who believe that the imagery within Google Earth is the most up to date imagery. This is not exactly true in all instances. Google Earth acquires imagery from different sources that may have different resolutions applied, may have been taken in different times of the year (leaf on vs leaf off) and may have different dated imagery mosaicked together to form a seamless representation of the earth. If you would like to know what the date on the imagery is that you are viewing, simply look at the bottom left hand corner of the screen to find the date.

*Google Earth Interface*

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This imagery was taken on June 7, 2011.

Google Earth is free to use in distributing or sharing data commercially. However, if you would want to create a brochure or any maps using Google Earth to sell, you may not do so without a professional license.

**1.6 GIS Terms**

Geographical Information Systems utilizes terms that you may not be familiar with. The following terms will be used frequently. Also, you will find more terms and definitions in the glossary of this manual.

**Aerial Photography:** The use of high-resolution imagery to capture information regarding visible facilities and their locations.

**ArcCatalog:** Similar to Microsoft Explorer, users can use catalog to browse, manage, create and preview data.

**ArcExplorer:** A free application that allows the viewing and printing of GIS data.

**ArcGIS:** A system created by ESRI (Environmental Systems Research Institute) that allows you to author data, maps, models on the desktop. It is the leading GIS software.

**ArcMap:** The primary display application of GIS data, which allows users to display, edit, query, analyze, chart and report information concerning the GIS data.

**ArcView:** The basic level of licensing for ArcGIS software.

**Coordinate System:** A way of looking at data, either based on a spherical plane by using latitude and longitude or a planar type of projection in x, y, z coordinates.

**Data Frames:** Containers for Layers. Data frames allow users to organize or group layers in a logical order such as, themes or geographical locations.

**Dataset:** Any collection of related data usually grouped or stored together.

**Datum:** An ellipsoid shaped reference frame uses to locate features on the earth’s surface to measure surface locations.

**Features:** Objects such as cities, roads, counties defined by points, lines, polygons, and other closed shapes.

**Geodatabase:** A collection of geographic datasets for uses by ArcGIS. There are various types of geographic datasets, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others.

**Georeferencing:** Data is reference to a location on the earth’s surface by using a coordinate system to locate real-world data.

**Google Earth:** A free application that allows the viewing of GIS data.

**KML:** A file format that is specific to Google Earth application. It can be utilized within ArcMap.

**KMZ:** A compressed file format for multiple KML files.

**Layers:** A representation of spatial data. Layers reference outside source data, such as tables and contain information about source location and symbolization.

**Map Projection:** A method for converting the earth’s 3d surface to a map’s 2d surface.

**Metadata:** Supporting descriptive information about GIS data. It contains information about projection type, source, date, etc.

**Query:** a question asked about GIS data in a table. Questions may be based on a single table or several tables. Example: How many wetlands are in Boone County?

**Raster Data:** Spatial data model made up of rows and cells.

**Spatial Data:** Features that have location and attributes such as points, lines and polygons.

**Vector Data:** Represents each feature as a row in a table, and feature shapes are defined by x, y locations in space.