Chapter 1

Introduction to GIS and homeland security planning and operations

Geographic information systems (GIS) technology offers unique and valuable applications for policy makers, planners, and managers in many fields, including homeland security operations. GIS software and applications enable you to visualize and process data in ways never before possible. The purpose of this book is to provide you with hands-on experience using the premier GIS software package, ArcGIS Desktop, in the context of homeland security operations. You need not have any previous experience using GIS.

The next section describes GIS, its inputs and special capabilities, followed by a discussion of homeland security operations and GIS applications. There is also a preview of the upcoming chapters in this book, and an introduction to ArcGIS in a short tutorial exercise.
What is GIS?

GIS is a multidisciplinary software system that engages geographers, computer scientists, social scientists, planners, engineers, and others. Consequently, it has been defined from several different perspectives. A preferred definition emphasizes GIS as an information system: GIS is a system for input, storage, processing, and retrieval of spatial data. Except for the additional word “spatial,” this is a standard definition for an information system. Spatial components include a digital map infrastructure, GIS software with unique functionality based on location, and new mapping applications for organizations of all kinds. A definition and discussion of these distinctive aspects of GIS follows.

Spatial data

Spatial data is information about the locations and shapes of geographic features, in the form of either vector or raster data. Graphic maps, also known as vector maps, are created with layers that have features drawn using points, lines, and polygons. Geographic objects have a variety of shapes, but all of them can be represented as one of three geometric forms—a polygon, a line, or a point. A polygon is a closed area with a boundary consisting of connected straight lines. For example, figure 1.1 is a map with one polygon map layer (state boundaries), a line layer of roads (USA Interstates), and a point layer (cities with populations greater than 100,000). Fill color is used here within the state polygons to show the total population per state as of the 2000 census.

Associated with individual point, line, or polygon features are data records that provide identifying and descriptive data attributes. For example, in figure 1.1 the labels for the names of states and cities come from tables of attribute records associated with each map layer.
Raster maps are aerial photographs, satellite images, or images created with software that are stored in standard digital image formats, such as tagged image file format (TIFF) or Joint Photographic Experts Group (JPEG). An image file is a rectangular array, or raster, of tiny square pixels. Each pixel has a single value and solid color, and corresponds to a small, square area on the ground, from six inches to three feet on a side for high-resolution images. (Pixels are also referred to as cells.) Accompanying the image files are world files or headers that provide georeferencing data, including the upper left pixel’s location coordinates and the width of each pixel in ground units. The world file or header provides the data needed for the GIS software to assemble individual raster datasets into larger areas and overlay them with aligned vector datasets.

Viewed on a computer screen or a paper map, a raster map can provide a detailed backdrop of physical features. Figure 1.2, an aerial photograph overlaid with vector map layers, shows locations around a bridge plaza, a noted piece of critical transportation infrastructure where security and surveillance operations are upgraded if a homeland security threat increases.

Figure 1.2

Map layers have geographic coordinates, projections, and scale. Geographic coordinates for the nearly spherical world are measured in polar coordinates, angles of rotation in degrees, minutes, and seconds, or decimal degrees. The (0,0) origin is generally taken as the intersection of the equator with the prime meridian (great circle) passing through the poles and Greenwich, England. Longitude is measured to the east and west of the origin for up to 180° in each direction. Latitude is measured north and south for up to 90° in each direction.
The world is not quite a sphere because the poles are slightly flattened and the equator is slightly bulged out. The world’s surface is better modeled by a spheroid, which has elliptical cross sections with two radii, instead of the one radius of a sphere. The mathematical representation of the world as a spheroid is called a datum; for example, two datums commonly used for North America are NAD 1927 and NAD 1983. If you use the same projection, but with two different datums, then each corresponding map will have small but noticeable differences in coordinates.

A point, line, or polygon feature on the surface of the world is on a 3D spheroid, whereas features on a paper map or computer screen are on flat surfaces. The mathematical transformation of a world feature to a flat map is called a projection. There are many projections, some of which you will use in exercises throughout this tutorial. Each projection has its own rectangular coordinate system with a (0,0) origin conveniently located so that coordinates generally are positive and have distance units, usually feet or meters.

Necessarily, all projections cause distortions of direction, shape, area, and lengths in some combination. So-called conformal projections preserve shape at the expense of distorting area. Some examples are the Mercator and Lambert conic projections. Equal area projections are the opposite of conformal projections: they preserve area while distorting shape. Examples are the cylindrical and Albers equal area projections. 2

Map scale is often stated as a unit-less, representative fraction; for example, 1:24,000 is a map scale where 1 inch on the map represents 24,000 inches on the ground and any distance units can be substituted for inches. Small-scale maps have a vantage point far above the earth and large-scale maps are zoomed in to relatively small areas. Distortions are considerable for small-scale maps but negligible for large-scale maps relative to policy, planning, and research applications.

GIS maps are composites of overlaying map layers. For large-scale maps such as in figure 1.2, the bottom layer can be a raster map with one or more vector layers on top, placed in order so that smaller or more important features are on top and not covered up by larger contextual features. Small-scale maps, such as figure 1.1, often consist of all vector map layers. Each vector layer consists of a homogeneous type of feature: points, lines, or polygons.

Digital geospatial data infrastructure

GIS is perhaps the only information technology that requires a major digital infrastructure: namely, a collection of standards, codes, and data designed, built, and maintained by government. We also refer to the map layers of the infrastructure as basemaps. Vendors provide valuable enhancements to the digital map infrastructure, but for the most part, it is a public good financed by tax dollars. Without this infrastructure, GIS would not be a viable technology.

The National Spatial Data Infrastructure (NSDI), developed by the Federal Geographic Data Committee (FGDC), “… encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data.” The U.S. Department of Homeland Security (DHS) has adapted and integrated these policies, standards and procedures into the Geospatial Data Model (GDM) specific to the needs of homeland security planners, analysts, and operations personnel. The GDM is a standards-based, logical data model to be used for
collection, discovery, storage, and sharing of homeland security geospatial data. The model supports development of the department’s services-based geospatial architecture, and serves as an extract, transform, and load (ETL) template for content aggregation.4

FGDC, in conjunction with the National Geospatial-Intelligence Agency (NGA), and the U.S. Geological Survey (USGS), developed minimum essential datasets compliant with the GDM to conduct missions in support of homeland defense and security. These datasets, which will be fully explored in later chapters of this tutorial, draw from a variety of sources to compile geospatial information about places throughout the country. A primary source of basic geospatial data is the TIGER/Line maps provided by the U.S. Census Bureau. These maps are available by states and counties for many classes of layers. These classes and examples of each follow:

- **Political layers**—states, counties, county subdivisions (towns and cities), and voting districts
- **Statistical layers**—census tracts, block groups, and blocks
- **Administrative layers**—ZIP Codes and school districts
- **Physical layers**—highways, streets, rivers, streams, lakes, railroads, and landmarks

You can download TIGER/Line map layers in GIS-ready formats at no cost from a variety of Web sites, including the U.S. Census Bureau’s (www.census.gov) and ESRI’s (www.esri.com). Steps for doing so are found in chapter 3.

Corresponding to TIGER/Line maps of statistical boundaries is census demographic data tabulated by census areas such as tracts and blocks. Data from the decennial census is available at no cost from www.census.gov/geo/www. Steps for downloading census data and preparing it for GIS use are in chapter 5.

The USGS is the “largest water, earth, and biological science and civilian mapping agency ... [and it] collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.”5 Among its products useful for homeland security applications are its 1:24,000-, 1:25,000-, and 1:63,360-scale topographic maps, known as digital raster graphic (DRG) maps in scanned image format, and its digital orthophoto quarter quadrangle (DOQQ) aerial photographs (such as used in figure 1.2). Full national coverage of the most recent DOQQs and 90 percent of DRG maps are available at little to no cost from the National Map Seamless Server (NMSS) at seamless.usgs.gov. Full instructions on viewing and downloading data from this portal are included in chapter 3.

Regional and local governments provide many of the large-scale map layers in the United States, and in this data most features are smaller than a city block. Included are deeded land parcels and corresponding real property data files on land parcels, structures, owners, building roof footprints, utility networks, and pavement digitized from aerial photographs. Often you can obtain such map layers and data for nominal prices from local governments, though they have become increasingly difficult to obtain due to security and privacy issues that have arisen since the attacks on September 11, 2001.
Unique capabilities of GIS

Historically, maps were made for reference purposes. Examples of reference maps are street maps, atlases, and the USGS topographic maps. It wasn’t until GIS, however, that analytic mapping became widely possible. For analytic mapping, an analyst collects and compiles map layers for the problem at hand, builds a database, and then uses GIS functionality to provide information for understanding or solving a problem. Before GIS, analytic mapping was limited to a few kinds of organizations, such as city planning departments. Analysts did not have digital map layers, so they made hard-copy drawings on acetate sheets that could be overlaid and switched in and out, for example, to show before-and-after maps for a new facility such as a baseball stadium. With GIS, however, anyone can easily add, subtract, turn on and off, and modify map layers in an analytic map composition. This capacity has led to a revolution in geography and an entirely new tool for organizations of all kinds.

As figures 1.1 and 1.2 show, maps use symbols that are defined in map legends. Graphical elements of symbols include color fill, pattern, and boundaries for polygons; width, color, and type (solid, dashed, etc.) for lines; and shape, color, and outline for points. A GIS analyst does not apply symbols individually to features, but applies and renders a layer at a time based on attribute values associated with geographic features.

For example, given a code attribute for roads with values primary, secondary, and local, a GIS analyst can choose a yellow, bold line for primary roads; a red, thin line for secondary roads; and an orange dashed line for local roads. Those three steps render all roads in a map layer with different line symbols determined by the road type.

Similarly, the color-shaded state map layer in figure 1.1 is based on an attribute that provides the 2000 population by state. A map that uses color fill in polygons for coding is called a choropleth map. In this case it shows a natural-breaks numeric scale, rendered using a green color scale. The darker the shade of green, the higher the interval of the numeric scale. By making selections and setting parameters, the GIS analyst accomplishes all of this coding and rendering with a simple graphical user interface.

Most organizations generate or collect data that includes street addresses, ZIP Codes, or other georeferences. GIS is able to spatially enable such data, that is, add geographic coordinates or make data records joinable to boundary maps. Geocoding, also known as address matching, uses street addresses as input and assigns point coordinates to address records on or adjacent to street centerlines, such as in the TIGER/Line street maps. Geocoding uses a sophisticated program that has built-in intelligence—similar to a postal delivery person’s when getting your mail to you—that can interpret misspellings, variations in abbreviations, and so on.

Policy, planning, and research activities often require data aggregated over space and time, rather than individual points. For example, in a study to determine the number of on-site incidents within proximity to emergency service locations, it may be desirable to aggregate address data to counts per census tract or ZIP Code boundaries. GIS has the unique capacity to determine the areas in which points lie, using a spatial join or overlay function, and this enables the analyst to count points or summarize their attributes (e.g., using sums or averages) by area.
How does GIS support homeland security planning and operations?

This book has a sampling of homeland security GIS applications. It is prepared as a guide to support the series of homeland security initiatives driving the federal government’s efforts to safeguard the country, primarily the National Preparedness Goal, National Planning Scenarios, Target Capabilities List, and Universal Task. These initiatives combine to provide an “all-threats/all-hazards” guide to local, state, tribal, and federal governments in their efforts to build collaborative and integrated capabilities to secure the homeland.

The National Preparedness Goal (the Goal), a result of Homeland Security Presidential Directive 8, is designed “to achieve and sustain risk-based target levels of capability to prevent, protect against, respond to, and recover from major events, and to minimize their impact on lives, property, and the economy, through systematic and prioritized efforts by Federal, State, local and Tribal entities, their private and nongovernmental partners, and the general public.” The Homeland Security Grant Program (HSGP) is a primary funding mechanism for building and sustaining national preparedness capabilities. The FY2007 Homeland Security Grant Program document is a guide to securing funding available to government agencies through the Department of Homeland Security, which makes available approximately $1.7 billion in grant funding to build capabilities that enhance homeland security. This GIS tutorial parallels the target initiative of the Goal, by providing a sampling of GIS applications that directly support mission area efforts to prevent, protect against, respond to, and recover from major events that impact our national security.

The National Planning Scenarios is a set of “15 all-hazards-planning scenarios for use in national, Federal, State, and local homeland security preparedness activities. These scenarios are designed to be the foundational structure for the development of national preparedness standards from which homeland security capabilities can be measured because they represent threats of hazards of national significance with high consequences.” This tutorial employs a sample of these scenarios within the context of the Goal to demonstrate how GIS is applied to the range of possible hazards and attacks, including natural disasters, and biological, chemical radiological, and explosives attack. It is not intended to encompass all potential threats or hazards, but rather a selection of security situations that may be enhanced by the application of GIS tools and analysis.

The Target Capabilities List (TCL) is a set of 36 capabilities to support capabilities-based planning, which is defined as, “planning, under uncertainty, to provide capabilities suitable for a wide range of threats and hazards while working within an economic framework that necessitates prioritization and choice.” The underlying reasoning that drives the application of this TCL is that if a community has met the set of capabilities targeted to address a particular threat or hazard, then it is prepared to prevent, respond to, or recover from that event. Each exercise within this tutorial employs a particular national scenario, and applies selected GIS techniques to demonstrate how they support a particular target capability identified as critical to planning for that threat or hazard. For example, in chapter 6, GIS is used to demonstrate how the target capability of Search and Rescue can be met and enhanced as response personnel geocode an address database to locate missing persons in the aftermath of a natural disaster such as a major hurricane.
The Universal Task List (UTL)\textsuperscript{[11]} is the basis for defining the capabilities found in the TCL that are needed to perform the full range of tasks required to prevent, protect against, respond to, and recover from incidents of national significance.\textsuperscript{[12]} Approximately 300 tasks have been identified as critical to the success of a homeland security mission. Each exercise in this tutorial uses a selected set of these defined critical tasks within the context of a target capability to meet the challenge of a particular homeland security mission. For example, chapter 5 demonstrates how the implementation of protective measures around critical infrastructure can be aided and enhanced by GIS tools and techniques such as 3D visualization and line-of-sight analysis.

The Goal specifically identifies the essential role that geospatial analysis plays in a successful homeland security mission:

“DHS Office of Grants and Training recognizes the important contribution that geospatial information and technology plays in strengthening our Nation's security posture. Federal, State and local organizations have increasingly incorporated geospatial information and technologies as tools for use in emergency management and homeland security applications. Geospatial data and systems improve the overall capability and information technology applications and systems to enhance public security and emergency preparedness and efficient response to all-hazards including both natural and man-made disasters”\textsuperscript{[13]}

The FY 2007 Homeland Security Grant Program Supplemental Resource: Geospatial Guidance document focuses exclusively on GIS with respect to homeland security operations. DHS has developed a standards-based geospatial data model for GIS systems built and used at all levels of government for collection, discovery, storage and sharing of geospatial data.\textsuperscript{[14]} Compliance with this model will ensure an open, interoperable and shareable system, which is a critical imperative at a time of security crisis.

In support of this geospatial model, federal, state, local and tribal governments worked together to create Minimum Essential Data Sets (MEDS) over urbanized and large areas, and for national critical infrastructure to fulfill the Joint Forces Command Common Relevant Operating Picture. The MEDS provide the geospatial foundation necessary for the homeland security community to carry out the key national homeland security strategy objectives, as outlined by the White House on July 16, 2002: 1) preventing terrorist attacks within the United States; 2) reducing the nation's vulnerability to terrorism; and 3) minimizing damage, while speeding recovery from natural or terrorist-caused disasters.\textsuperscript{[15]}

The MEDS data layers include:

- Orthoimagery
- Elevation
- Hydrography
- Transportation
- Boundaries
- Structures
- Land cover
- Geographic names
All of the exercises in this tutorial use selected MEDS data layers to build, process, and analyze geospatial data to support capabilities-based planning for homeland security. The scale of these MEDS data layers is determined by the geographic extent at which the planning effort is focused. For urban areas, the MEDS should have the currency and positional accuracy qualities typically sought by local governments. For larger areas at a smaller scale (states or groups of states), these datasets should have the positional accuracy qualities of the USGS primary topographic map series.\textsuperscript{16}

Beyond the content of the MEDS data itself, the most fundamental issue with respect to homeland security planning and operations is the collaboration and delivery of data and support systems necessary to make critical decisions during a crisis. The use of geospatial data in a homeland security operation can be integrated at the desktop level, multiuser server configuration, multiserver federated enterprise platform, or a geo-Web-distributed server environment managed and accessed via the Internet. The scenarios studied in this tutorial are designed to be managed at any one of these levels of planning and operations. The GIS tools and analysis introduced here can be applied regardless of the platform or environment through which the data is delivered and managed though a desktop environment does contain more "out of the box" capability than a multiserver federated enterprise system or a fused geo-Web environment where much of the geospatial analysis capability requires a great deal of interoperability, collaboration, and applications development to fully function as needed.

Below is an overview of each chapter in this tutorial, providing the context of how GIS supports homeland security planning and operations.

**Chapter 1: Introducing GIS and homeland security planning and operations**
This first chapter introduces the basic parameters and functionality of ArcGIS within the context of homeland security operations. The primary goal of the DHS is to coordinate the creation of homeland security operations from state to state, and urban area to urban area, within an integrated and standardized framework. As noted earlier, the Department of Homeland Security recognizes the critical importance of geospatial data analysis in any effort to protect the nation's communities from hazards and attacks. The chapters with exercises that support and strengthen this geospatial component of homeland security operations are summarized below.

**Chapter 2: Visualizing data for homeland security planning and operations**
Chapter 2 introduces the basic ArcMap components and explores them using the extensive suite of navigation and viewing tools. You will apply these tools to basic point, polyline, and polygon layers that are relevant to homeland security operations. This chapter also explores the link between the map and attribute tables to reveal the capability to manage geospatial data in both a map and tabular format. Attributes of U.S. cities with population greater than 100,000 and U.S. interstate highways are selected, identified, and found to demonstrate how these tools aid the user in viewing and navigating a map display.

**Chapter 3: Preparing data for homeland security planning and operations**
Chapter 3 encompasses the preparation of essential geospatial data layers in a comprehensive dataset critical to the safety and security of the nation. Having such a geospatial dataset in place at the time of a catastrophic event aids and assists emergency operations personnel in protecting, responding to, and recovering from such an event. In this chapter, you will explore and build the components of MEDS, as defined by DHS. The MEDS include data from various Internet portals, and are prepared in a range of formats, including vector shapefiles, raster datasets, tables, and geodatabases. Each of the databases will be downloaded, and
processed for inclusion into the MEDS database using a full suite of ArcMap geoprocessing tools, to include select, buffer, merge, import, export, clip, and adding x,y coordinate data as a data layer. In later exercises, you will use portions of this data to address the prevention, protection, response, and recovery of communities in crisis scenarios.

Chapter 4: Designing map layouts for homeland security planning and operations: Prevent
Chapter 4 extends the basic ArcMap skills learned in earlier exercises to preparing and producing reports and map layouts. The target capability of information sharing and collaboration is met by performing the task of disseminating indications and warnings within the context of National Planning Scenario 5: Chemical attack — blister agent. Map layouts are composed of a suite of elements that define the map information presented. Prepared and custom map templates help create effective warning reports and map layouts that can be printed on paper or exported in a variety of digital formats for electronic distribution. Within the Prevent Mission Area of homeland security planning, this set of skills is essential to disseminating critical information that may actually prevent an attack.

Chapter 5: Analyzing data for homeland security planning and operations: Protect
Chapter 5 applies the suite of ArcMap tools and geospatial analysis to the Protect Mission Area of homeland security planning and operations. This chapter focuses on two national planning scenarios to demonstrate how GIS tools and analysis protect the nation’s people and places.

The target capability of critical infrastructure protection (CIP) is met by performing the task of implementing protection measures within the context of National Planning Scenario 12: Explosive attack — bombing using improvised explosive devices. Buffering, selection, and intersect tools are employed to identify critical infrastructure within an area of a potential threat. Additional 3D spatial tools, such as viewshed and line of sight, are applied to optimize positioning of surveillance sites around targeted facilities.

The target capability of citizen protection: evacuation and/or in-place protection is met by performing the task of providing public safety-develop protection plans for special needs populations within the context of National Planning Scenario 6: Chemical attack — toxic industrial chemicals. Incorporating census data into the GIS, homeland security planners and operations personnel can effectively locate and identify how many people, including those with special needs, may be affected by an emergency event. This assists in allocating necessary relief and evacuation resources before an event to ensure the safety of those affected. Spatial selection tools are also employed to identify the location of assembly points for evacuation outside an affected area.

Chapter 6: Analyzing data for homeland security planning and operations: Respond
Chapter 6 brings you to the aftermath of Hurricane Katrina as emergency response workers converge on the Gulf Coast to locate and rescue missing persons. The target capability of search and rescue is met by performing the task of conducting search and rescue within the context of National Planning Scenario 10: Natural disaster — major hurricane.

The exercises in this chapter include geocoding a set of street addresses of the last known location of missing persons; and then preparing a suitability map to identify available sites for helicopter landing zones in the affected areas near the geocoded locations of missing persons. The geoprocessing steps are then programmed into a model to automate the sequence of operations involved in the analysis so that it can be executed each time inundation conditions change along the coast. When the analysis is complete, the U.S. National Grid is draped
over the map layout to provide a nationally defined coordinate system for spatial referencing, mapping, and reporting, as required by DHS.

Chapter 7: Analyzing data for homeland security planning and operations: Recover
In the final chapter of this tutorial, GIS tools and analysis are applied to the Recover Mission Area of homeland security planning and operations. The target capability of restoration of lifelines is met by performing the task of providing energy-related support. Recovery includes immediately restoring essential services to a community after a major disaster or event. Using National Planning Scenario 9, focusing on a major earthquake in an urban area, the USGS ShakeMaps are studied to determine San Francisco Bay Area locations expected to experience the greatest impact. Within these areas, GIS is used to identify segments of high-pressure gas-transmission lines most susceptible to rupture during a major catastrophic earthquake. You will also trace power disruptions sustained along a fault line and identify knock-on effects of these outages on infrastructure, such as other public utilities, hospitals, churches, and schools that are critical to a recovery effort. Reports and maps of parcels and services experiencing outages are prepared for distribution. This information is essential to emergency operations personnel as they coordinate efforts with utility workers to restore service to impacted residents.

Once lifeline restoration is under way, focus shifts to the assessment of damage to private property incurred by individual property owners. The target capability of structural damage assessment and mitigation is met by performing the task of post-incident assessment of structures, public works, and infrastructure. Industry-standard damage assessment tools are integrated into the GIS to enable rapid and efficient evaluation of properties located in the greatest hazard potential zones. Hyperlinking photos enhances GIS functionality by providing a visual record of assessed properties, and reports and maps are generated to track the restoration effort for planning and operations purposes.

Chapter 1: Data dictionary

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<th>Layer Description</th>
<th>Attribute</th>
<th>Attribute Description</th>
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</thead>
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<td>Shapefile</td>
<td>USA Cities points</td>
<td></td>
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<td>USA Interstate highway polylines</td>
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<tr>
<td>USA_States.shp</td>
<td>Shapefile</td>
<td>USA State polygons</td>
<td>POP2000</td>
<td>2000 Census state population</td>
</tr>
</tbody>
</table>
Introduction to ArcGIS components

ArcGIS Desktop consists of ArcView, ArcEditor, and ArcInfo software. All three of the ArcGIS Desktop products look and work the same, though they differ in how much they can do.

This book is designed for use with ArcView 9.3 software. ArcView, the most popular member of this collection and most widely used GIS package in the world, is a full-featured GIS software application for visualizing, managing, creating, and analyzing geographic data. ArcEditor adds more GIS editing tools to ArcView. ArcInfo is the most comprehensive GIS package, adding advanced data conversion and geoprocessing capabilities to ArcEditor. While this book was written for ArcView, you can use it with ArcEditor and ArcInfo as well.

Also available as part of ArcGIS is the free ArcReader mapping application, which allows users to view, explore, and print maps. Finally, ArcGIS has numerous extensions to ArcView, ArcEditor, and ArcInfo. Some major extensions include ArcGIS 3D Analyst for 3D rendering of surfaces, ArcGIS Network Analyst for routing and other street network applications, and ArcGIS Spatial Analyst for generating and working with raster maps.

ArcView consists of two application programs, ArcCatalog and ArcMap. ArcCatalog is a utility program that has file browsing, data importing and converting, and file maintenance functions (such as create, copy, and delete)—all with special features for GIS source data. For managing GIS source data, you will use ArcCatalog instead of the Windows utilities My Computer or Windows Explorer.

GIS analysts use ArcMap to compose a map from basemap layers, and then can carry out many kinds of analyses and produce several GIS outputs. A map composition is saved in a map document file with a name chosen by the user and the .mxd file extension. For example, in this chapter you will open GISHS_C1E1.mxd, a map document already created for use in this tutorial.

A map document stores pointers (paths) to map layers, data tables, and other data sources for use in a map composition, but does not store a copy of any data source. Consequently, map layers can be stored anywhere on your computer, local area network, or even on an Internet server, and be part of your map document. In this tutorial, you will use data sources available from the data DVD accompanying the book, as well as data prepared by you from datasets downloaded from various Web portals. Both types of data will be stored on your desktop computer's hard drive for use in the tutorial exercises.

Installing ArcView and the homeland security tutorial data DVD

This book includes a DVD with the 180-day trial version of ArcView. See appendix B for instructions on installing ArcView and the data DVD also accompanying the book. You must successfully install ArcView and the data to complete the exercises in this tutorial.
Exercise 1.1
Introducing the ArcGIS user interface

The following steps will acquaint you with the functionality and user interfaces of ArcMap and ArcCatalog. You will start by using ArcCatalog to browse the data sources used in figure 1.1, and then examine the completed project itself. You will learn how to build, modify, and query data in the remaining chapters.

In the exercises that follow, you need to be at your computer to carry out the numbered steps. Screenshots accompanying the steps show you important dialog boxes and output. Occasionally we have added “Your turn” exercises after a series of steps. It’s critical that you do these exercises, which do not take much time, to start internalizing the processes covered.

Launch ArcCatalog

ArcCatalog is the program you use to organize and manage various geospatial datasets and documents that you use in ArcMap. This program allows you to connect to your data source locations, browse through your workspaces, examine or explore the data, manage data, tables and metadata, and search for data and maps.

1. From the Windows taskbar, click Start, All Programs, ArcGIS, ArcCatalog.

Depending on how ArcGIS and ArcMap have been installed, you may have a different navigation menu or a name other than ArcGIS.

2. Navigate to the \ESRIPress\GISTHS folder.

All of the tutorial materials are contained in this folder. Each chapter contains a labeled subfolder where the map documents and tutorial data are located (e.g. \ESRIPress\GISTHS\GISTHS_C1). All of the work that you will do in this tutorial will be saved in the \ESRIPress\GISTHS\MYGISTHS_Work folder, and named using your first and last initials to uniquely identify all of your work.

3. Click the small plus sign next to the GISTHS folder to expand it to see its contents.

The left panel of ArcCatalog is called the Catalog Tree. It is used to navigate to the data on your computer or network server, much like Windows Explorer.
4 Expand the GISTHS_C1 folder and click on the folder name.

The right panel, called the Catalog Display, contains three tabs: Contents, Preview, and Metadata. When you choose the Contents tab, the datasets in the current folder are listed. The datasets currently listed represent spatial data, and the icon next to each file name indicates what type of geometry the data is built with: point, line, or polygon.

5 In the Catalog Display, click USA_States.shp, then click the Preview tab at the top of the right panel.

Previewing data this way allows you to get a quick glimpse of the data without actually loading it into a map. You can also use this tab to preview the contents of a table.
At the bottom of the Catalog Display, click the Preview drop-down arrow and click Table. Use the horizontal scroll bar to view the attribute fields in the table.

Each record in the table corresponds to one of the state polygons you previewed in the previous step, and as you can see, there are quite a few attributes stored for each state, most of which are demographic. For example, by reading across the table, you could identify that the State of Washington is in the Pacific subregion and has a population of 5,894,121 in 2000. The State_Name attribute was used to label the states in figure 1.1.

Click the Metadata tab at the top of the Catalog Display, and click the Spatial tab in the resulting display. (If the Spatial tab does not display, make sure the Stylesheet drop-down list is set to FGDC ESRI.)

Metadata describes data; it is data about data. For example, you can see that States has a geographic coordinate system (latitude and longitude) with certain bounding coordinates for the rectangle framing the map layer. Also available are descriptions of the data and a list of attributes with their data types, under the Description and Attributes buttons.
Review data layer types

You will do most GIS file maintenance work in ArcCatalog, though it is instructive to view GIS files in a conventional browser. Next you will examine two common ESRI file formats used in GIS: a shapefile and a file geodatabase. A shapefile map layer has three or more files with the same name but different file extensions, all stored in the same folder. A file geodatabase is a collection of geographic datasets of various types stored as relational database tables. Both of these data types are very common in the GIS industry, with the geodatabase being a more modern form.

1. From the Windows taskbar, click Start, My Computer. (The path to My Computer may differ depending on which operating system you are using.)

2. Browse to \ESRIPress\GISTHS\GISTHS_C1.
Let's review the USA_Cities shapefile, which actually consists of seven files, all with the name USA_Cities.

- The USA_Cities file with .shp extension has the feature’s geometry and coordinates. In this case, each record has a point and an x,y location. For line and polygon layers, each shape record has coordinates of a line segment or a polygon.

- The USA_Cities file with the .dbf extension has the feature attribute table in dBASE format. This file can be opened and edited in Microsoft Excel and Access, but such work must be done carefully and without deleting or adding records or changing the order of rows. This could result in corrupted data. The relationship between the .shp and .dbf files of a shapefile depends on one-to-one physical arrangement of records in both files.

- The .sbx, .sbn, and .shx files contain indexes for speeding up searches and queries.

- The .prj file is a simple text file that has the map projection parameters of the layer.

- Finally, the .shp.xml file contains the layer’s metadata and can be opened in a Web browser for reading.

3 Click Up One Level in My Computer.

4 Double-click GISTHS_C6 to view the contents of this folder.

The folder JacksonCo_MEDS.gdb, is a geodatabase of features stored in a relational database.
5 Double-click JacksonCo_MEDS.gdb to view the file contents of this geodatabase.

This set of files defines the features in the database. The features are stored in point, line, and polygon format here, as in the shapefile, but this database can also contain additional information that defines the relationship these features have to each other. It can also contain raster files. This geodatabase format is a more versatile data structure, and is the preferred format for future geospatial data development, maintenance, and transfer. You will use the conventional shapefile and raster image formats, as well as the geodatabase format throughout this tutorial.

6 Close the file explorer window

7 Return to ArcCatalog and view this geodatabase in the catalog display.

The geodatabase is labeled with a cylinder icon in the Catalog Tree, and each feature is labeled with a feature type icon, either point, line, polygon, or raster in the Catalog Display. While it is possible to view all of these data formats using your operating systems file manager, never open any of them up in anything other than ArcCatalog or ArcMap to avoid corrupting the layers.
Launch ArcMap and open a new empty map document

ArcMap is where you display and explore the datasets for your study area, where you assign symbols, and where you create map layouts for printing or publication. ArcMap is also the application you use to create and edit datasets.

1. From the Windows taskbar, click Start, All Programs, ArcGIS, ArcMap.

Depending on how ArcGIS and ArcMap have been installed, you may have a different navigation menu or a name other than ArcGIS. Alternately, if ArcCatalog is still open, you can also open ArcMap by clicking the ArcMap button on the ArcCatalog standard toolbar.

2. The first time you start ArcMap, the Startup dialog box appears. Click the “A new empty map” radio button.

3. Click OK.

A new untitled empty ArcMap document opens.
Review ArcMap menus, buttons, and tools

Let’s review the major components of the ArcMap application window.

- The Menu Bar has some items common to most window application packages, plus some unique to GIS.
- The Standard Toolbar most typically appears at the top of the ArcMap application window and is used for map printing, creating a new map, opening an existing map, saving your map, and starting related ArcGIS applications.
- The Tools Toolbar has frequently used mapping tools and can be undocked by dragging and dropping it to the desired location.
- The Map Display is where the datasets loaded into the map are drawn.
- The Table of Contents lists all the data in the map document and allows you to toggle their visibility and access their properties.
- The Status Bar shows the map coordinates of the cursor location in the map display.

Open an existing map document

You will now open a map document that is already created. It contains the map of the United States with the U.S. interstate highways, and cities with greater than 100,000 population that you viewed earlier in this exercise.

1 From the Standard toolbar, click the Open button.
2. Browse to `ESRIPress\GISTHS\GISTHS_C1` and select `GISTHS_C1E1.mxd`.

3. Click OK.
In Table of Contents, click the checkbox next to the USA_Interstates data layer to uncheck it.

Notice how this data layer disappears from the map display.

Close the ArcMap document without saving changes.

This ArcMap document has already been prepared for you for use in this exercise. In the next chapter you will use the same data layers to build a map from an empty untitled map document and learn how to navigate around the map and define the properties of the data layers.

**Summary**

In this chapter, you were introduced to the basic principles of geographic information systems, and how data used in a GIS can be managed and viewed to enhance geospatial analysis of homeland security scenarios. The Department of Homeland Security directives and initiatives were reviewed to ascertain how geospatial analysis can be used to help emergency operations planners and personnel prevent, protect, respond, and recover from events that threaten our national security.

This introductory chapter acquainted you with the primary components of ArcGIS. ArcCatalog was reviewed to demonstrate how to view and manage the different data layer formats to include shapefile, raster, and geodatabase formats. You were introduced to the ArcMap interface, including the various menu and button bars, as well as the map display and table of contents components. You opened a preexisting ArcMap map document showing point, line, and polygon data layers symbolized to best display the data.
As you move on in this tutorial, you will discover that GIS is a fascinating and valuable information technology. It enables spatial processing and visualization of data in ways never before possible. At the most basic level, GIS makes it easy to quickly compose and render maps from base layers. You can easily turn map layers on and off to study spatial patterns and correlations to enhance situational awareness. On a more advanced level, as explored in later chapters, you can use GIS to perform complex analysis to determine how many people are impacted by a major disaster, or what critical facilities are located in proximity to a threatened site.

Notes

2. Ibid., pp. 42-44.
3. www.fgdc.gov
5. www.usgs.gov/aboutusgs
6. FY 2006 Homeland Security Grant Program Guidance and Application Kit, p. 1
12. Ibid., p. 2