

ArcGIS 8.1

By W. Fredrick Limp, director, Center for Advanced Spatial Technologies, 12 Ozark Hall, University of Arkansas, Fayetteville, AR 72701; e-mail: fred@cast.uark.edu.

Price: Contact ESRI for pricing information.

Requirements: Microsoft Windows NT SP6/2000 SP1, 400-plus MHz Pentium or better processor, 128MB RAM (256MB recommended), fast disk, 16MB video, 1.1GB to 1.4GB disk space (not including data).

Company: ESRI Inc., 380 New York St., Redlands CA 92373 [800-447-9778, fax: 909-793-5953, e-mail: info@esri.com, Web: <http://www.esri.com>].

The 8.1 release of ArcGIS, ArcView and ArcInfo represents the mature version of ESRI's flagship product line. The product launch is simultaneously revolutionary and evolutionary, breaking major new ground in its data model, interface, programming language and platform support while maintaining real continuity with its analytical operations, older data models and installed user base.

New Data Model

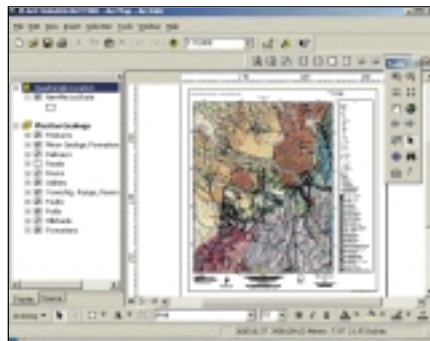
With the 8.x release, ESRI made its most significant break from the past in the new data model that's clearly the "main" model for the future. ESRI calls this model a "geodatabase," which is an object-relational model that uses new terminology. What old "ESRI heads" would call a "layer" (or a "theme" in ArcView), for example, now is a "feature class."

There are feature-class "parcels," and each individual parcel is a feature that's stored in a database table. For single users (and for ArcView), the database is Microsoft Access (used for what ESRI calls "personal geodatabases"). For larger implementations, the database may be Oracle, Microsoft SQL Server, Informix or DB2.

Each feature is a single row in the feature-class table. Various columns store attributes such as owner name, appraised value, etc., while a special column stores the attribute "geometry," which is the set of x, y (and sometimes z) pairs that define an actual parcel. Unlike ArcInfo Coverages, but like ArcView Shapefiles, most features don't store their topological characteristics. In an older ArcInfo coverage, for example, the system would store information about what was to the left and

right of each parcel edge. In "simple-feature" (points, lines and polygons) geodatabases, such areal topological properties are computed on the fly when needed. An exception is for linear networks, which have topological relationships stored as part of the geodatabase.

Adopting the geodatabase model has several implications. The geometrical (previously called graphical) information now is managed within the same database as attributes. Previously, spatial data were maintained in a separate file (e.g., a .shp file in ArcView), while attributes were stored in a table (e.g., a .dbf file in ArcView). Storing all data in the same table



ArcMap provides extensive cartographic capabilities and serves as the gateway to spatial analysis in ArcGIS 8.1.

simplifies maintenance and management.

The geodatabase model is consistent with enterprise-class database management, which means that true multiuser geospatial systems are possible. In fact, ArcGIS takes advantage of these capabilities with features such as versioning. The geodatabase model and nomenclature brings ESRI into conformity with Open GIS Consortium Inc. spatial data models and dramatically increases interoperability.

User Interface

The most visible changes between earlier ESRI versions and 8.x are found in the user interface, which for earlier ArcInfo products consisted of the notorious "command line" in which commands often looked more like text strings of cartoon swearing. ArcView, however, had a graphic user interface (GUI) that was consistent across Unix and Windows platforms. All that is changed in 8.x.

A Windows GUI now is found across the product line—the interface for ArcView and the other products is the same. A related aspect is that the ArcGIS interface only is supported on Windows. The software development environment is Microsoft Common Objects Model, and the development language is Visual Basic

for Applications (included in ArcGIS). With ArcGIS, ESRI is moving away from the multiplatform system, in which Unix was a central element, to a largely Windows world. Legacy versions of ArcInfo 7.x and user-written applications developed in Arc Macro Language (AML) still can be used, and ArcGIS allows integration of larger Unix-based workflows into the Windows environment.

ArcGIS Modules

Previously, the differences between ArcView and ArcInfo were clear. They had different data models (ArcView used Shapefiles, and ArcInfo used Coverages), interfaces and development languages (AML for ArcInfo and Avenue for ArcView). With the 8.1 release, ESRI has created a single, scalable architecture and interface, and the range of functionality provided now differentiates the products. The significance of this can't be overemphasized.

Essentially, the same product now comes in small, medium and large. The small version is ArcView 8.1; ArcEditor 8.1 provides additional capabilities; and ArcInfo 8.1, which includes ArcView, ArcEditor and additional capabilities, provides the full range of functionality. In addition, there are several extensions available for ArcView, ArcEditor and ArcInfo, including ArcGIS Spatial Analyst, ArcGIS 3D Analyst and ArcGIS GeoStatistical Analyst as well as ArcPress for ArcGIS, ArcGIS for StreetMap and MrSID Encoder for ArcGIS. Although not considered "extensions," ArcSDE and ArcIMS are key additional components.

ArcView 8.1

The base product in the 8.1 line is ArcView, which is composed of ArcCatalog, ArcMap and ArcToolbox applications. ArcCatalog is the data organization and management application. It opens in its own window and allows users to view data in "content," "preview" and "metadata" modes. Content view provides a set of icons that quickly show the various components of a particular dataset. Preview provides a map-based snapshot of the geographic dataset as well as a tabular snapshot of the attribute data. The metadata viewer/manager provides a Federal Geographic Data Committee-compliant view as well as ESRI metadata and user-specified views.

ArcCatalog provides easy management access to Shapefiles, Coverages, rasters and several external data formats. The organizational structure is an enhanced Windows file explorer, like a "file tree," with easy-to-identify icons for the various data types and components. ArcMap is the central map viewing, composing and analysis application. Map composition is

powerful but easy to perform in a “what you see is what you get” environment. One of the pleasures of the entire ArcGIS family is the wonderful range of styles, symbolizations and other map composition capabilities.

After a map is composed, it can be saved for future use as an ArcMap document (.mxd) map definition file. A valuable capability in the new ArcGIS world is the “layer,” which is different from the old ArcInfo layer. An ArcGIS layer is a set of rules for displaying a particular dataset. Suppose, for example, a user has a road dataset, but he or she only wants the major roads displayed and wants a particular style associated with them. The user can create a layer, which is simply the “rules” of selection and display, and it’s not necessary to create a new dataset.

Generally, ArcMap is the application in which much of the spatial analysis is performed. All the functionality in ArcView 3.x is present in ArcView 8.1 (e.g., buffering, joins, selects, union, merge, etc.), but there are several new capabilities, including on-the-fly re-projection of vectors and rasters to current viewing projections. Such re-projections are done with a low-order transform, however, and may not always be accurate. There’s also a “permanent” raster re-projection capability that creates new datasets and can use first-, second- and third-order transformations as well as a number of re-sampling options.

Raster display, labeling, legend, margin-alia and data transparency options also are expanded. Other important new capabilities include a structured query language (SQL) verify tool that checks SQL syntax before execution (saving a lot of time) and the ability to import a variety of data formats into the new personal geodatabase structure.

Personal geodatabases can be edited in ArcView’s ArcMap application, and it’s generally comparable to editing Shapefiles, because topology isn’t part of the data. Digitizing tablets are supported as well as map registration. Map creation/editing in ArcMap has several powerful capabilities, including a variety of vector snapping (but no raster snaps or line following). It’s also possible to place edges parallel, perpendicular or tangent to existing lines or at various angles, deflections or distances. In addition to the “traditional” arc-node data structure of nodes and vertices, the new data model supports splines and other geometries. ArcView selection tools have an extensive range of spatial selection criteria, including “are crossed by outline of,” “intersects,” “have center in,” “contain,” “share a segment” and others.

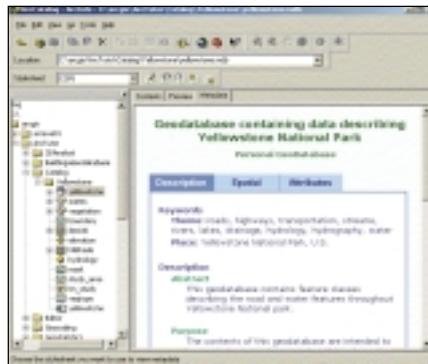
ArcGIS also includes ArcToolbox, which is a set of Windows-based wizards on top of previous command-line ArcInfo tools. Topology building and several coverage manipulations are present as well as access to advanced GRID, coordinate geometry, generalization and other advanced operations. There are two flavors of ArcToolbox: the one provided with ArcView provides access to about 35 tools, and the full version (part of ArcInfo) provides access to more than five times as many tools.

The programming/development environ-

ment to extend ArcView is Visual Basic for Applications, not Avenue, which was used in previous ArcView versions. With the release of ArcView 3.2, a visual-modeling environment was made available, but that environment isn’t provided with 8.1.

ArcEditor 8.1

ArcEditor is the “medium” version of the ArcGIS suite. To all the components of ArcView 8.1, ArcEditor adds extensive “enterprise” database development and management. The geodatabase provided with ArcView is Access, which is a capable single-user system. For larger enterprise implementations, database systems such as Oracle 8i, SQL Server, Informix or DB2 are needed. ArcGIS works with all of these systems, and direct connections are possible between ArcGIS and Oracle 8i and SQL Server. For Informix and DB2, the ArcSDE product is needed. ArcEditor works essentially the same whether using direct con-



ArcCatalog provides an easy-to-use interface for data management as well as map, data and metadata viewing.

nections or ArcSDE, but the data types also can be managed as if they’re geodatabases when using ArcSDE to connect to coverages or layers.

ArcEditor provides several important capabilities that are critical to enterprise/multiuser systems as well as supporting new feature class “dimensions.” An important multiuser capability is versioning, which traditionally deals with problems that can occur when multiple people are adding/deleting or changing the same dataset. Suppose, for example, that one unit in a state highway program is updating information about pavement characteristics for a particular section of road while another section is updating information about signage. Without versioning, access by the first group might lock out the other group. With versioning, both groups can work simultaneously.

A second capability is the development of “relationships,” which are software rules that associate different features into a related entity. For example, a relationship could be used to connect a transformer, light pole and power line. If properly formulated, when the location of the power pole is changed, the location of the transformer and the end of the power line would automatically be updated. This capability provides powerful tools to formally define and manage cross-feature class relationships

that geospatial software previously ignored.

ArcEditor also supports dimensions, which are a special type of annotation in which the actual length of a line or polygon side is placed on a map along with dimension arrows. In addition, powerful geometric network capabilities are provided, which can be used to map and analyze feature classes such as water lines, electric utilities and sewer systems. Geometric networks are a special feature type, “storing” only the “rules” in other feature classes. It’s possible to directly create geometric features with the editing tools or have ArcGIS automatically determine connectivity from the referenced feature classes.

ArcGIS only stores the topological properties in the geometric network feature class. The geographic components are stored in the “original” point and line feature classes. Changes to the original classes will cause automatic updates to the geometric network(s) on which they’re based. Connections at the intersection of two (or more) line segments are called junctions, and it’s possible to create junctions with complex behaviors that can simulate electrical switches or similar real-world switches/valves. After a network of edges and junctions is created, it’s possible to create flows, sinks and weights. These can be used to analyze electrical flows, water systems, etc.

ArcInfo 8.1

ArcInfo 8.1 is the “large” size of the ArcGIS product suite, and it includes all the capabilities of ArcView and ArcEditor as well as added access to the full range of legacy ArcInfo capabilities, including continuing support for pre-existing AMLs. There are about 170 different ArcInfo modules that are accessible through ArcToolbox, and about 35 are accessible through the limited ArcToolbox provided with ArcView. The toolbox allows an architecture in which different capabilities of ArcGIS can be distributed across different systems.

Using ArcGIS architecture, it’s possible to link ArcInfo modules running on Windows servers or Unix systems with desktop applications. Wizard-based interfaces develop formerly command-line arguments that can be submitted to remote systems for later use. Using ArcToolbox, it’s possible to transfer computation of large jobs to a remote server to be run when loads are low.

Full support for legacy operations is provided in ArcInfo 8.1, including support for ArcPLOT, ARCEDIT, ARC COGO and ARCSAN. Functional capabilities accessible via ArcToolbox include conflation, location/allocation, complex routing, dynamic segmentation and multiple data transformations.

Analyst Extensions

Previously, ArcInfo’s raster analysis capabilities were provided within ArcGRID. For ArcView, a limited set of raster capabilities was provided with the ArcView Spatial Analyst extension. Within the new ArcGIS environment, there’s only a single Spatial Analyst extension, but the capabilities are expanded

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over the earlier version.

Other GRID operations still are accessible via ArcToolbox. Spatial Analyst provides surface creation via interpolation, including inverse distance weighting, polynomial trend surfaces, splining, and ordinary and universal kriging. Other capabilities include slope, aspect, hill shade, viewshed, curvature and contour generation. Supported operations include distance and allocation, cost surfaces, and shortest paths. Local, neighborhood and zonal functions include majority, minority, variety, etc., and neighborhoods can be rectangles, circles, wedges or annulus (donut). The raster calculator includes a broad range of mathematical and logical operators, including access to map algebra functions.

ArcGIS 3D Analyst offers a broad range of 3-D visualizations and analyses. The functionalities essentially are the same as those in the ArcView 3.x 3D extension, and data from rasters and TINs can be used. Interpolation options are available, and it's also possible to create TINs from vector as well as raster data. Within 3D Analyst, it's possible to create 3-D vector features, and, in visualization mode, it's possible to extrude 3-D features (e.g., buildings). There are many controls for viewing, including viewpoint, sun angle, etc. It's also possible to create an animation rotation, but "camera path" and similar predefined tools aren't supported.

ArcGIS GeoStatistical Analyst is a new extension that provides a useful suite of geographically oriented statistical analysis capabilities. It's not a comprehensive statistical package, but it focuses on geostatistics. Like Spatial Analyst and 3D Analyst, GeoStatistical Analyst provides new interpolation capabilities, including thin-plate splines, splines with tension, regularized splines, multiquadratic functions, inverse quadratic functions and inverse distance weighting with several options.

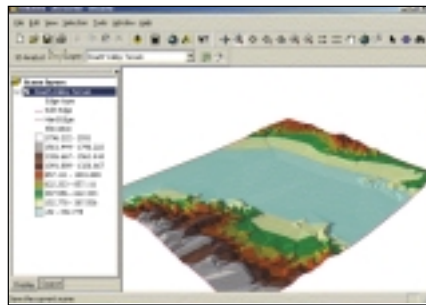
The package provides an extensive suite of 2-D kriging and co-kriging with ordinary, simple, universal and indicator options. The extension provides for data de-trending, cross-covariance models, bivariate distribution plotting, optimal searching, neighborhood selection, Qplots, histograms, semivariograms, covariance clouds and Voroni maps. An exploratory spatial data analysis function links map views with statistical plots so that selecting a data point on a graph will highlight it on a map or vice versa.

Some Problems

Although ArcGIS is a superb product, there are some limitations that can't be eliminated given such an ambitious software suite. One of

the most frustrating aspects of the new structure is that various capabilities are located within different applications, and users have to remember which application allows them to access particular tools. To add to the confusion, particular operations can be performed in several different modules.

For example, kriging can be performed in Spatial Analyst, 3D Analyst or GeoStatistical Analyst. Fortunately, the kriging interface in Spatial Analyst and 3D Analyst is the same, but the one in GeoStatistical Analyst is quite different. To make this easier, however, all the ArcGIS modules have an extensive "right



ArcGIS has several useful extensions, including 3D Analyst, Spatial Analyst and GeoStatistical Analyst.

click" option that allows users to open a menu with a set of options applicable to that object.

Similar SQL operations require different syntax depending on the database they're using. For example, a SQL query to a personal geodatabase (e.g., Access) would have a field syntax requirement of "field_name" (with quotes), while the same query submitted to an ArcInfo or .dbf table would require [field_name] (with square brackets), but the same query to a enterprise geodatabase would require just field_name (no quotes or brackets). Given the complex links, it probably isn't feasible to create a uniform preprocessor, but the differences can be maddening.

In addition, the multiple product structure creates some confusion in the documentation. Various levels of capabilities are found in ArcCatalog, depending on whether users have ArcView or ArcEditor, but the documentation doesn't reflect this. Users can be reading about an editing option in the manual, for example, only to find that it's not accessible in the configuration they purchased. Although these issues are frustrating, they're basically minor impediments.

Superb Documentation

The basic ArcGIS packages come with nine different books that range from concept

discussions to tutorials and total more than 2,300 pages. The concept books *Modeling Our World*, *ESRI Guide to GIS Analysis* and *Understanding Map Projections* are excellent introductions to the general concepts that underlie the new ESRI data models and spatial analysis operations. I was particularly impressed with how the *Modeling Our World* book explained the complex new ideas underlying the new data model and how it corresponds with earlier Coverages and Shapefiles.

An additional manual comes with each extension. All the books have excellent, full-color illustrations throughout, and they're written in a clear style. ESRI's hard-copy documentation is the best in the industry and dramatically improves the ease with which new users can learn this complex software. The document accompanying GeoStatistical Analyst provides a clear and accessible introduction to often-complex statistical operations. Bibliography and algorithm documentation also is included.

The hard-copy documents primarily are written in tutorial format, but they can serve, to a somewhat lesser degree, as reference manuals. The online documentation provides the industrial-strength reference materials.

ArcGIS 8.1 is a powerful, extensive product. ESRI has balanced the need to move forward into new data and interface models while continuing to support legacy sites. The division into ArcView, ArcEditor and ArcInfo allows users to purchase only the product capabilities needed. The Windows interface and well-designed wizards make complex spatial applications easy to operate, and the distribution of functions on desktops and servers allows systems to be "right sized" for each situation. In addition, the use of personal and enterprise geodatabases means that the same interface and data model supports a fully scalable solution, as does integration of older data models (e.g., Coverages, Shapefiles) and external data types. ☺

ArcGIS 8.1

Strengths: Powerful, accessible interface, scalable, modern data model, superb map composition and excellent documentation.

Weaknesses: Complex distribution of operations in different modules, different SQL syntax depending on data source, substantial hardware configuration needed for adequate performance, and installation may require advanced system-administration skills.



For more than 30 years ESRI has been helping people manage and analyze geographic information. ESRI offers a framework for implementing GIS in any organization with a seamless link from personal GIS on the desktop to enterprisewide GIS client/server and data management systems. ESRI GIS solutions are flexible and can be customized to meet the needs of our users. ESRI is a full-service GIS company, ready to help you begin, grow, and build success with GIS.

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ESRI
380 New York Street
Redlands, California
92373-8100, USA
Telephone: 909-793-2853
Fax: 909-793-5953

For more information
call ESRI at

1-800-447-9778

(1-800-GIS-XPRT)

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