Summer 2009

ArcUser

The Magazine for ESRI Software Users

GIS in Tough Economic Times

THE ENGINEERING TRIPLE CROWN

Advanced GIS-CENTRIC Power Solutions

For Water and Wastewater Engineers Worldwide

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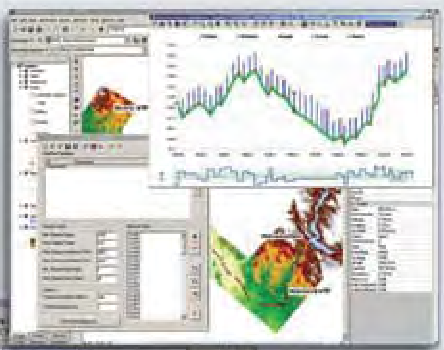

InfoWater PipePlan

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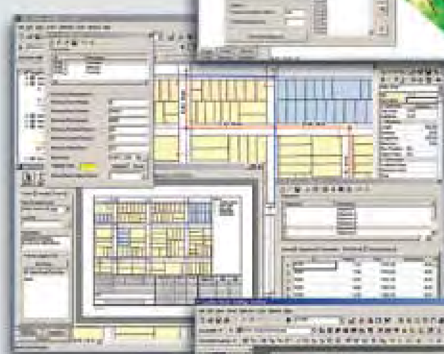

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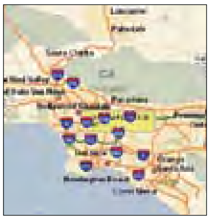
SPECIAL SECTION

Fast Web Mapping Workflows



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The Time *Is* Now

"A crisis is an opportunity riding the dangerous wind."

This Chinese proverb aptly describes both sides of the current situation. With tumbling markets, faltering financial institutions, failing businesses, and high unemployment rates, the word *crisis* is probably not too strong.

There are unhappy similarities to the economic events of 1987, the last time the stock market declined as steeply and rapidly. In 1987, 3.5-inch floppy diskettes were the newest media format and CompuServ had introduced the GIF images to a fledgling Internet world.

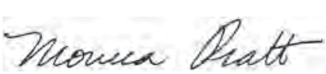
Back in 1987, PC ARC/INFO had just been released and GIS was far from a household word. In this issue's Manager's Corner column, "Embracing Your Passion for GIS," ESRI's Christopher Thomas looks back on the late 1980s and the path that led him to a career centered on exploring and promoting the potential of GIS to improve government.

For many readers, his journey may be evocative. GIS attracted people who wanted the opportunity to make a positive difference—to solve problems, accomplish more, and do it more efficiently. Since the first issue in 1998, the pages of this magazine have contained stories that demonstrate how GIS professionals have done those things.

The technological landscape has changed a great deal since 1987. The use of GIS technology has grown phenomenally by every metric: the number of organizations that have it; the number of industries that use it; and, most importantly, the number of lives it touches every day.

The scope of GIS has changed but not the mission of the people who promote it. As Christopher notes, it still takes a local GIS hero to recognize that GIS is *the* tool for solving problems. "You have acknowledged that this isn't just a job; it's a calling with a mission to make the world a better place with a technology like no other."

See opportunity in the current crisis. There is no time like the present to demonstrate the value of GIS.



Monica Pratt
ArcUser Editor

editor's page

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The Magazine for ESRI Software Users

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DEPARTMENTS

SOFTWARE

MANAGER'S CORNER

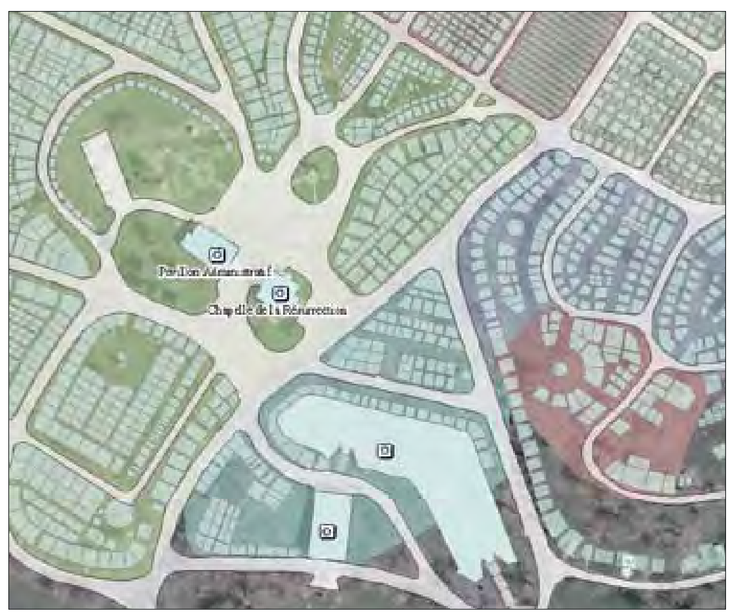
DEVELOPER'S CORNER

HANDS ON

BOOKSHELF

EDUCATION

END NOTES



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More Powerful Tools

For sharing the benefits of GIS with a wider audience

ArcGIS Explorer 900, the newest release of ESRI's freely downloadable GIS viewer, offers an enhanced user experience and many new features that extend how the software can be used to deliver and present geographic information to a broad audience.

ArcGIS Explorer is a great way to share and view GIS information and capabilities. It uses a variety of ready-to-use ArcGIS Online basemaps and layers, so users can immediately begin exploring as soon as they download. ArcGIS Explorer enables users to connect to their own map services or add local data. Users can also add other information, such as photos, reports, and videos, and place them in a geographic context. ArcGIS Explorer can be extended with geoprocessing tools and other capabilities, enabling people to use GIS data and tools without needing to be GIS experts themselves.

Making a Compelling Case

New presentation capabilities make ArcGIS Explorer an outstanding choice for briefings, meetings, and lectures. Users can create dynamic presentations that integrate GIS and other content, such as titles, pop-ups, documents, photos, and videos, and combine these into dynamic presentations that can be easily shared.

Integrated 2D/3D Display

ArcGIS Explorer 900 introduces an integrated 2D/3D display that lets users choose a visualization experience that meets their needs. In 2D mode, ArcGIS Explorer now supports all ArcGIS projections, so data can be used in the same way as in ArcGIS Desktop.

Choice of Basemaps

ArcGIS Explorer 900 includes a basemap gallery that allows users to select from a variety of ArcGIS Online maps, including aerial imagery, streets, hybrid, and topographic maps. The gallery also includes Microsoft Virtual Earth basemaps (imagery, hybrid, streets), and users can easily add their own basemaps to the gallery.

Sharing Is Easier

Layer packages are a new feature in ArcGIS 9.3.1 that makes it easier for GIS professionals to distribute and share information. Layer packages encapsulate ArcGIS Desktop cartography along with data. Because ArcGIS Explorer uses layer packages, desktop cartographic capabilities and data can be used by anyone, not just GIS professionals. Layer packages can be shared via ArcGIS Online, sent as e-mail attachments, or distributed on a network.

Enhancing Data Support

In addition to support for new layer packages, ArcGIS Explorer 900 offers direct connect to an enterprise geodatabase as well as support for personal geodatabases. KML/KMZ support has also been improved, including network-linked KML.

Tailoring the User Experience

Using application configurations, the user experience can be easily tailored, without programming, to support specific user needs or workflows. Multiple configurations can be managed centrally and used throughout an organization.

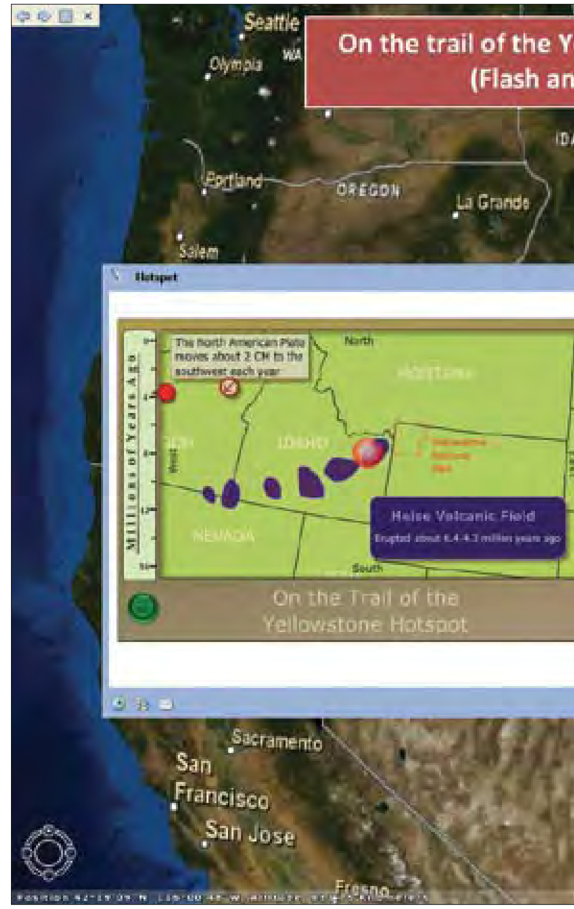
ESRI also offers a freely downloadable ArcGIS Explorer Software Developer Kit (SDK). This SDK provides a powerful object model and lets developers create new tools and add-ins that can extend ArcGIS Explorer's capabilities.

Working with Multiple Languages

ArcGIS Explorer has been localized for French, German, Spanish, Chinese, and Japanese.

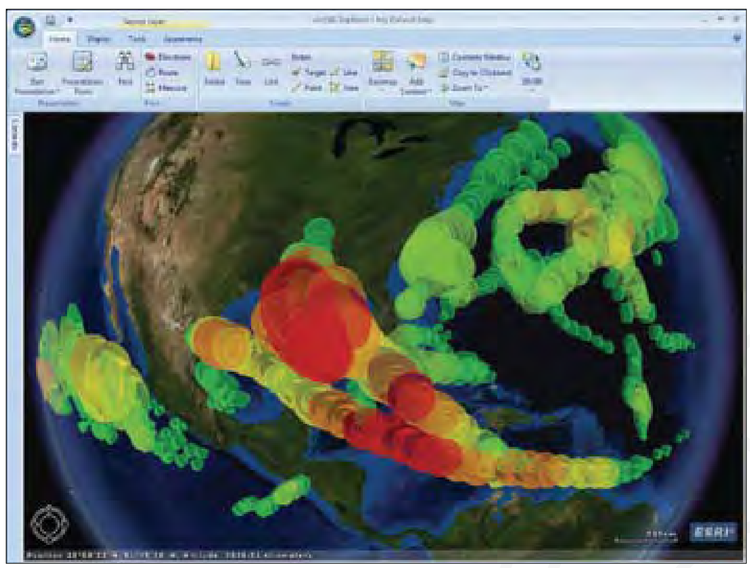
Increasing the Value of GIS

ArcGIS Explorer adds value to any GIS by allowing for broader dissemination of data and greater collaboration, while addressing specific end-user needs. It extends the benefits of GIS to users that need to have access to GIS data and capabilities, but may not be GIS experts themselves. For more information and to download ArcGIS Explorer, visit www.esri.com/arcgisexplorer.

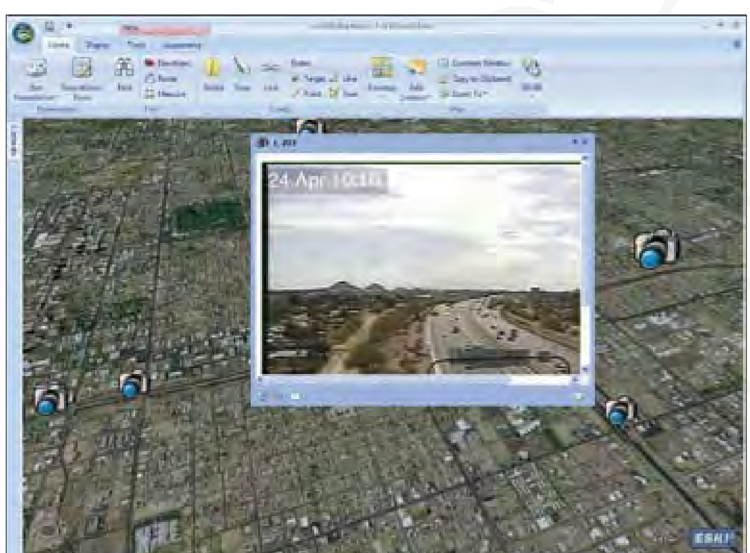


(Upper left) New presentation capabilities make ArcGIS Explorer an outstanding tool for briefings, commission meetings, and lectures. Titles, pop-ups, documents, photos, and videos can be combined with slides and maps in a full-screen display.
(Lower left) Microsoft Virtual Earth imagery, hybrid, and street basemaps are available.

With ArcGIS Explorer 900, it is even easier to find basemaps. They can be selected from the basemap gallery on the new ribbon interface.



The results of GIS analysis can be readily shared with non-GIS end users through ArcGIS Explorer 900.



Geographic information can be linked to other resources such as photos, movies, documents, and Web sites, using Notes. This image shows video feeds from highway cameras linked to an ArcGIS Explorer map.

Manage Geospatial Resources Enterprise-wide

Extension improves efficiency and security

Organizations can publish the location of and metadata for geospatial resources and users can discover and access these resources more efficiently using the ArcGIS Server Geoportal extension (formerly GIS Portal Toolkit).

Geospatial metadata typically documents how, when, where, and by whom the data was collected; information on its availability and distribution; its projection, scale, resolution, and accuracy; and its reliability compared to established standards.

The ArcGIS Server Geoportal extension does not create or duplicate geospatial resources; it collects and publishes metadata in a central catalog that allows users to search and access the associated resources. By enabling the sharing of geospatial resources regardless of GIS platform, it gives organizations an enterprise-level awareness of disparate geospatial resources and activities.

This extension meets the needs of the four groups who use geospatial portals: portal developers, portal administrators, resource publishers, and resource users. Portal developers need simple tools to quickly and easily create and customize GIS portals. Portal administrators, who maintain the integrity of GIS portals, need tools for evaluating new entries before publication, backing up and recovering portals, implementing security, and integrating the GIS portal with other IT systems. Resource publishers need tools for sharing the resources they have authored. Resource users want tools for previewing and accessing datasets easily.

The ESRI portal for the Group on Earth Observations System of Systems (GEOSS) provides scientists with easy access to a wealth of earth observation data and Web mapping services. When new resources become available, users can be alerted by subscribing to a GeoRSS news feed. The ESRI GEOSS GEOPortal was built using ArcGIS Server 9.3 and the ArcGIS Server Geoportal extension.

The Geoportal extension includes an out-of-the-box portal application that helps portal developers get a GIS portal up and running quickly. With a fully functional metadata catalog, this application helps users search,

ArcGIS Server 9.3 Leverages OGC Specifications

Standards support enhances client integration

ArcGIS Server 9.3 adds increased support for Web Coverage Service (WCS) and Transactional Web Feature Service (WFS-T), two Open Geospatial Consortium, Inc. (OGC), specifications, which improves integration with virtually any client application that supports these commonly accepted GIS and IT standards. Support for enhanced Web Map Service (WMS) allows the use of Styled Layer Descriptors (SLD) that define how layers draw.

WCS is a data service that enables multispectral pixel values from a raster dataset to be returned to Web applications. ArcGIS's WCS implementation supports returning data in many formats—GeoTIFF, NITF, HDF, JPEG, JPEG 2000, and PNG. Applications that can connect to WCS services (including ArcGIS and geoprocessing tools) can perform analysis on the pixel values. ArcGIS Server can publish any raster dataset as OGC WMS, WCS, or KML.

Any GIS client that supports WFS-T can carry out transactions against geodatabases using an ArcGIS Server-published WFS-T service. Publishers can also create Web applications that leverage the WFS-T specification by allowing multiple browser-based clients editing access to ESRI geodatabases.

The ArcGIS Server implementation of the OGC WMS standard supports the use of SLD and allows a publisher to advertise multiple user-selectable styles for generating the map. SLD implementation allows greater client-side control of symbology.

Both SLD and the WFS implementation of ArcGIS Server can leverage the OGC Filter Encoding (FE) specification. ArcGIS Server's implementation of FE allows SLD-based WMS workflows to apply spatial and attribute filter logic to selectively style specific features. In the context of the ArcGIS WFS implementation, FE-based spatial and attribute filters can be used in the queries to request a subset of features from the data store.

In the last decade, ESRI has redesigned the architecture of its GIS products in response to emerging IT and GIS trends that promote interoperability. This new architecture enhances GIS data management and information interchange and supports emerging Web services, GIS portals, and spatial data infrastructures (SDIs). For more information, take *Leveraging OGC Capabilities in ArcGIS Server 9.3,* a free Web training seminar, or visit www.esri.com/standards.

preview, and publish resources. The out-of-the-box application is simple to use and customize.

The extension also includes a REST API. With this API, portal developers can integrate GIS portals with external Web applications. The REST API supports GeoRSS, KML, and HTML outputs that allow developers to include dynamic portal feeds in other applications.

An extension to ArcGIS Server, Geoportal provides portal administrators with a fully supported, stable platform for integrating GIS portals with a service-oriented architecture (SOA) environment. Its support for existing standards, including finalized specifications of the Open Geospatial Consortium, Inc. (OGC), makes this possible. OGC certified the ArcGIS Server Geoportal extension as a Catalog Service for the Web (CSW) 2.0.2 compliant interface.

The extension also includes support for single or multiple Lightweight Directory Access Protocol (LDAP) groups for enhanced security. Sensitive data can remain behind the firewall, and access to it can be restricted to authorized employees and business units. Organizations can control record-level metadata access through the use of policy types. The Unrestricted policy allows all users to access all approved documents.

Using the harvesting tool included with this extension, portal administrators can update large volumes of geospatial resources by automatically retrieving and updating metadata from existing catalogs and databases and registering current files with the metadata catalog.

Support for many different metadata profiles and standards makes it easier for resource publishers to register resources with a GIS portal. In addition to a custom metadata service based on ArcGIS Server technology, the extension supports International Organization for Standardization (ISO), Federal Geographic Data Committee (FGDC), and Dublin Core metadata profiles. It also includes support for the North American Profile and Infrastructure for Spatial Information in Europe (INSPIRE) metadata standards. These standards are required for an organization to participate in the North American and European National Spatial Data Infrastructure (NSDI) networks.

Resource publishers can register resources with a GIS portal using the browser-based Web application and either create the metadata directly in the Web application or upload pre-generated metadata. They can also publish resources directly to a GIS portal from ArcCatalog by using the publishing client.

This browser-based Web application provides resource users with an intuitive experience when finding, previewing, and accessing geospatial resources. The Map Viewer, which uses the ArcGIS Server JavaScript API, allow resource users to preview resources, including ArcIMS and KML services, without loading a browser plug-in or launching a desktop GIS application.

In addition, users can search and access resources directly from ArcGIS Desktop and ArcGIS Explorer with the CSW clients for ArcGIS. Using the clip-zip-ship task, a resource user can download just the data needed rather than the entire data resource. Users simply draw a polygon around the desired extent, select the desired layers, and choose an output format and projection. This feature saves both time and IT resources.

With the ArcGIS Server Geoportal extension, organizations can improve the efficiency and effectiveness of geospatial activities both within and between organizations. To learn more about the ArcGIS Server Geoportal extension, visit www.esri.com/gisportal.

Street Data for Geocoding, Routing, and Cartography

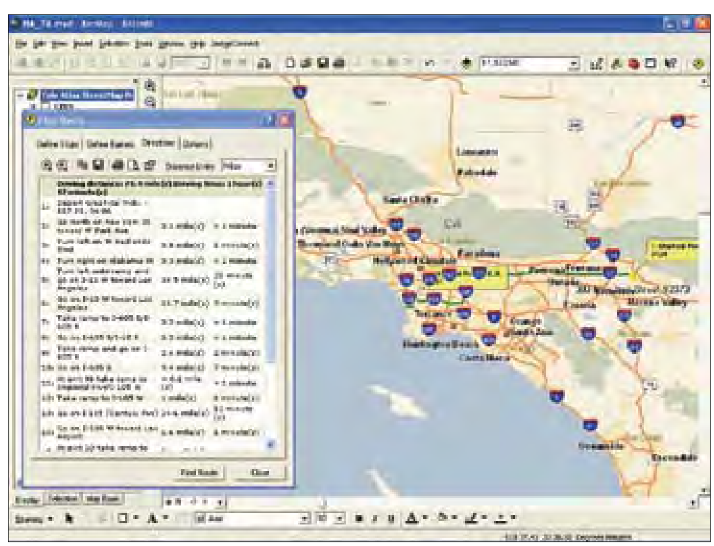
StreetMap Premium provides more licensing options

This enhanced street dataset is designed to work with ESRI's ArcGIS software for geocoding, routing, and high-quality cartographic display of street data for North America (the United States and Canada) and Europe.

This new version of ESRI's StreetMap Premium provides ArcGIS Server and ArcGIS Desktop users access to commercial street data, optimized, structured, and compressed to ensure ease of use and deployment with ESRI software products. The ready-to-use datasets, based on data from NAVTEQ, include streets, road networks, and basemap data.

The standardized data structure of StreetMap Premium enables users to achieve the highest address geocoding match rates and generate the best routes and driving directions as well as produce superior basemaps. StreetMap Premium works seamlessly with cartographic applications that require address information and scheduling applications that require the most updated streets and addresses.

The new licensing model for StreetMap Premium allows users to get data customized by geographic area and mapping use. Geography licensing options include continent (North America or Europe), individual country, or state/province. Usage licensing options include geocoding, routing, and/or cartographic display. For more information on StreetMap Premium, visit www.esri.com/streetmap.



StreetMap Premium is designed to work with ArcGIS software for geocoding and routing.

GIS in Tough Economic Times

A technology for revitalization

An 8.5 percent national unemployment rate (March 2009)

A 6.2 percent decline of the gross domestic product in the fourth quarter of 2008

The failure of thousands of businesses including household names like Circuit City and Lehman Brothers

These numbers make the extent of the current downturn clear. There is an immediate need to deal with effects of job losses and high foreclosure rates on local communities. Revitalizing the United States economy will be a formidable task that will require innovative approaches to challenges such as modernizing energy generation and rebuilding the nation's infrastructure.

Unlike previous recessions, government and business have a powerful technology for dealing with diagnosing and treating the ailing economy on the local, state, and national levels. GIS has evolved beyond the organization level to become a framework for managing and analyzing data, modeling scenarios, supporting decision making, and disseminating information.

Solar Boston generates figures for annual energy output in kilowatts per year, anticipated annual cost savings, and CO_2 savings.

Local Effects

A cascading series of events in the last two years—declines in the housing market, financial institutions in crisis, contracting credit, and business failures—has led to widespread job loss and house foreclosures.

Communities that have experienced high rates of home foreclosure, in addition to the impacts on revenue, have the very practical problem of dealing with neighborhoods with many vacant houses. These houses often are not maintained by the financial institutions that have taken them back and are targets for vandals.

Local governments in two California cities, Chula Vista and Riverside, have GIS applications that address the problems of poor house maintenance and graffiti and minimize the negative impact of vacant houses on neighborhood values. Articles in this issue explain why GIS has been invaluable in enforcing the home maintenance ordinance in Chula Vista and identifying and prosecuting taggers in Riverside.

New Strategies and Sources

Even before the current economic troubles, the effects of the run-up in oil prices in mid-2008 made clear the urgency of managing and using existing energy more efficiently and incorporating new sources of energy, particularly renewable energy.

GIS is contributing significantly to the development of commercially viable renewable energy. Utilization of the two most common renewable energy sources, solar and wind, is more challenging than conventional energy sources. Both energy sources are available intermittently and are typically more geographically dispersed than oil or natural gas. GIS helps evaluate the potential of sites for energy generation and the feasibility of getting energy to users.

The Boston Redevelopment Authority created Solar Boston, an online mapping application developed using the ArcGIS API for Flex, that allows users to see active renewable energy installations within the city and calculate the solar potential of building rooftops. In addition to calculating usable roof area and incoming solar radiation, this application generates figures for annual energy output in kilowatts per year, anticipated annual cost savings, and CO_2 savings.

The site for the wind farm project and the location of individual wind turbines within Iberdrola Renewables' Rugby Wind Project were determined using GIS to assess wind availability, take into account the existing electrical transmission infrastructure, and consider many environmental factors in the surrounding area. The project, currently under construction near Rugby, North Dakota, could produce enough power for 11,000 homes.

technology for revitalization

The Grid Can't Be Smart without GIS

The role of GIS in transforming utilities that use conventional energy sources is substantial. Utilities already use GIS to comprehensively inventory electrical distribution network components. In the future, existing GIS implementations will be the foundation for Smart Grid.

Rather than a specific system, Smart Grid is an approach for intelligently managing the generation and delivery of energy. Not only does it help utilities handle loads more efficiently, it also enables interaction between the providers and consumers of electricity and significantly automates the process of restoring the network after an outage.

Today, most electricity utility systems are passive and unaware of problems in the field. Other than information about main supply substations, these systems have little information on their status.

Spatial technologies offer the breakthrough needed for utilities to operate much more effectively and interactively. Utilities will use GIS as a method for organizing data collected from sensors and smart meters and communicating status information to the utility and its customers.

Utilities will use GIS as a method for organizing data collected from sensors and smart meters and communicating status information to the utility and its customers.

CenterPoint Energy, a Texas company that supplies electricity and gas to approximately three million customers, has a sophisticated enterprise GIS that meets both its engineering and business needs. In 2007, the company deployed Smart Grid technology on a limited basis in Houston, initially installing 10,000 smart electric meters and 500 smart natural gas meters. Following this successful project, the company received approval from the Public Utility Commission of Texas (PUC) to deploy 2.4 million smart electric meters over five years, beginning in 2009.

According to CenterPoint Energy's GIS manager, Cindi Salas, "GIS technology plays a key role in the automation strategy in that it will provide the initial infrastructure data that will fuel the automated analytics."

Spatializing Stimulus Spending

The development of the Smart Grid is just one example of how GIS technology is helping rebuild and expand the nation's infrastructure.

The American Recovery and Reinvestment Act of 2009 (ARRA) dedicated billions of dollars to jump-starting the economy. These funds will be allocated to thousands of projects that will rebuild the nation's physical and technological infrastructure. GIS provides tools for evaluating and prioritizing these projects so ARRA funds are spent in the most beneficial manner.

An article in this issue, "Geographic Insight—A more rational approach to managing stimulus spending," describes how GIS has been used on the local, regional, and state levels for identifying and targeting problems, prioritizing projects and programs, measuring the performance, and ensuring government accountability.

In addition to highlighting existing applications used by the City of Baltimore and the State of Maryland, this article illustrates how GIS can foster government accountability on the national level. ESRI has developed a prototype application called FedStat that can be used for prioritizing and tracking the billions of dollars allocated to the ARRA.

Just as the value of GIS is greatly amplified when it moves from the project or department level to an enterprise-wide implementation, FedStat offers data management, analysis, and visualization capabilities that will assist government in spending stimulus funds in a manner that will truly revitalize the United States economy while promoting government transparency and accountability.

Come for the Savings, Stay for the Quality

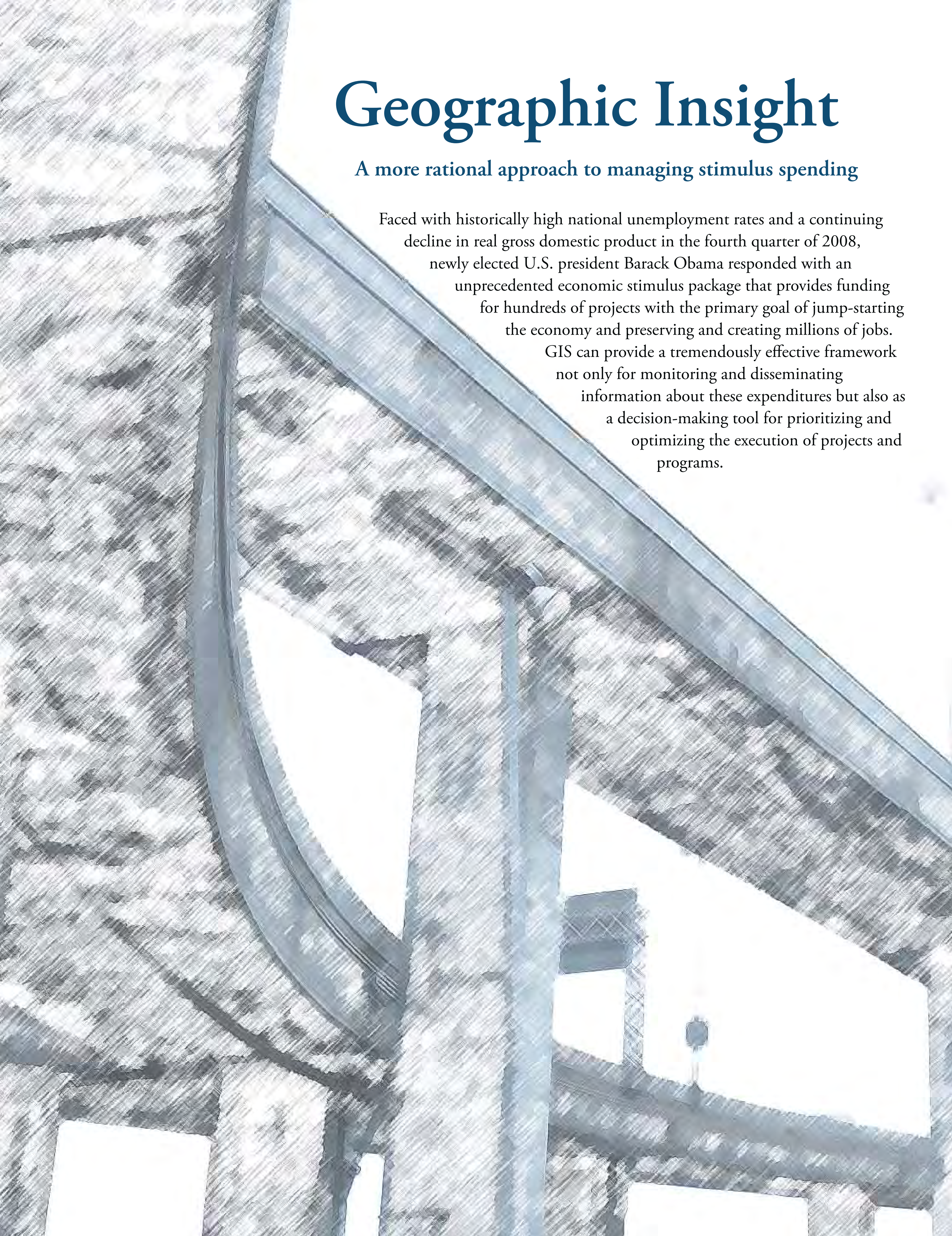
In good economic times, government agencies and businesses were attracted to GIS because of its promise to save time and money. In an economic downturn, the ability to do more for less has become imperative for organizations.

Historically, GIS has done just that by increasing productivity, automating processes, and increasing efficiency. However, the insights provided by viewing data in a spatial context have fostered better resources management and increased collaboration and communication. With the development of Web GIS in recent years, the tools of GIS available to policy makers at all levels of government can enable more informed decision making and performance measurement.

Geographic Insight

A more rational approach to managing stimulus spending

Faced with historically high national unemployment rates and a continuing decline in real gross domestic product in the fourth quarter of 2008, newly elected U.S. president Barack Obama responded with an unprecedented economic stimulus package that provides funding for hundreds of projects with the primary goal of jump-starting the economy and preserving and creating millions of jobs. GIS can provide a tremendously effective framework not only for monitoring and disseminating information about these expenditures but also as a decision-making tool for prioritizing and optimizing the execution of projects and programs.



Work to Be Done

Economic stimulus is an aspect of an economic theory, known as *fiscal policy,* developed by John Maynard Keynes in the 1930s. Fiscal policy advocates the use of government spending and revenue collection to influence the state of a nation's economy. In the absence of spending by individuals and businesses, this theory posits that the government can increase aggregate demand for goods and services by making up the shortfall in private-sector spending through supplying stimulus funding.

The American Recovery and Reinvestment Act of 2009 (ARRA) was based largely on proposals made by President Obama to fulfill promises he made during the presidential election. The wide-ranging provisions of ARRA are nominally worth $787 billion and address both short- and long-term goals. Jump-starting the economy, saving or creating between three and four million jobs, making college more affordable, weatherizing federal building space, and providing tax credits for children and low-wage workers top the list of immediate goals sought by the bill.

Mixed in with these goals are more long-term ones, such as computerizing health records, reviving the renewable energy industry, and modernizing the existing energy infrastructure as well as the physical infrastructure such as bridges, roads, and mass transit construction.

In addition to strategic spending, one of the Obama's avowed goals, as enunciated in the bill, is "unprecedented levels of transparency, oversight, and accountability." The government Web site, Recovery.com, is the centerpiece of this program. It supplies current information on federal grant awards and contracts so taxpayers can directly learn how stimulus funds are being spent.

Monitoring for Better Performance

Ultimately, government tranparency is about getting government to better perform by reducing waste and inefficiency and eliminating unnecessary spending. As Obama stated in his inaugural address, "The question we ask today is not whether our government is too big or too small, but whether it works—whether it helps families find jobs at a decent wage, care they can afford, a retirement that is dignified. Where the answer is yes, we intend to move forward. Where the answer is no, programs will end."

GIS has proved an outstanding tool for performance measurement and management accountability. Maryland governor Martin O'Malley has ably demonstrated the effectiveness of GIS for this purpose. O'Malley, who was then the mayor of Baltimore, Maryland, created an expanded version of a GIS-based program called ComStat. Focused on reducing crime, ComStat was implemented by the New York City Police Department to identify high-crime locations and get resources to those areas.

Maryland governor Martin O'Malley has ably demonstrated the effectiveness of GIS for performance measurement and accountability.

In 2000, O'Malley began using GIS across city departments as a tool for better government. This approach, called CitiStat, initially focused on cracking down on the rampant absenteeism in the city's workforce. After saving the city $13.2 million in its first year, the program was greatly expanded: the city now uses it to manage all city programs from potholes to parks, and it has saved Baltimore hundreds of millions of dollars. The success of CitiStat has also led to the adoption of this approach by 11 other cities, most recently Washington, D.C.

"GIS is an important part of our performance-based approach to government," said Governor O'Malley. "By analyzing our performance in a geographic context, we are able to reduce operating costs, increase revenue streams, and improve the quality of service we deliver to citizens. An efficient government is one that uses resources responsibly and effectively, and this approach to operations helps us achieve that."

When O'Malley moved to the governor's mansion in 2006, he took with him his conviction that GIS could make government better and expanded to another level. As governor, he has developed two programs similar in principle to CitiStat. StateStat monitors the performance of state agencies. BayStat helps rehabilitate the Chesapeake Bay by coordinating various efforts and programs and uses data from the departments of Agriculture, Environment, Natural Resources, and Planning.

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Geographic Insight

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Getting Aid Where It Is Most Needed

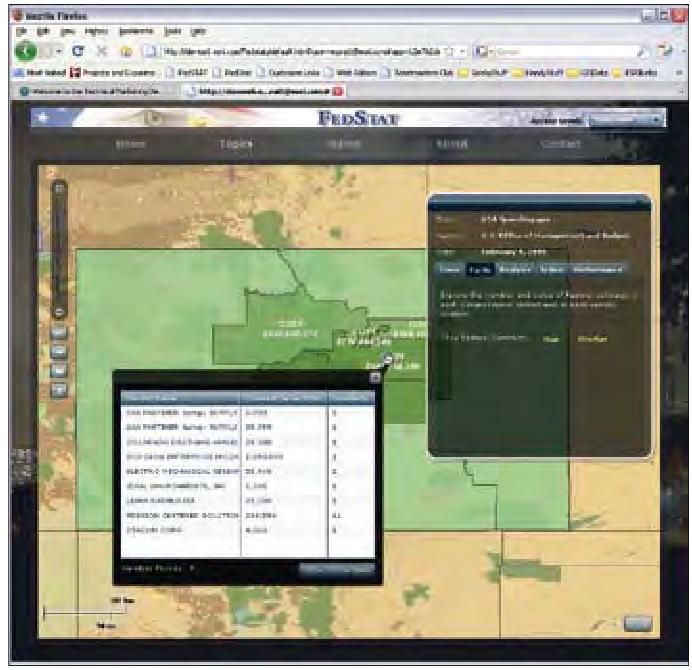
ARRA emphasizes projects that aid short-term recovery and encourage long-term revitalization. The so-called shovel-ready projects included in ARRA are candidates for immediate action that could greatly benefit from GIS. As Jack Dangermond, ESRI's president, has noted, "Lurking in the *[stimulus]* bill are lots of GIS answered questions such as where to build bridges." Analysis of these projects would help prioritize them more effectively to maximize the benefits from these expenditures.

Governments and businesses have been using GIS to streamline processes and improve decision making for decades. This technology was originally developed in 1962 to handle a million-acre Canadian land-use/planning mapping project that would not have otherwise been fiscally feasible.

The capabilities of GIS have expanded greatly in the intervening years. For example, an Australian energy infrastructure management company called Jemena uses GIS to view its assets relative to utility line crossings, land-use zoning, and rights-of-way, as well as critical or sensitive infrastructure such as airports, schools, or hospitals. Jemena uses GIS to manage a system that supplies gas to more than 1.6 million customers in Melbourne and Sydney.

StateStat monitors the performance of state agencies and generates reports and maps.

GIS is more than a visualization tool; it is an information system that provides a geographic framework for managing data, understanding phenomena, and modeling solutions. As GIS technology has matured, more powerful tools have been developed, particularly in the area of appropriately applying statistics to geospatial data. These tools generate insights that could not be obtained by other methods, whether the question being answered is why a wetland area is deteriorating or why a particular area has high rates of foreclosure.



The FedStat prototype takes advantage of the new ArcGIS Server API for Flex in a fast Web mapping application incorporating spatial analysis tools that assist in determining the cost to mitigate or solve the problem, its relationship to other similar issues, and how it should be prioritized.

One of the many ways GIS can better manage organizations is what Dangermond has termed *geoaccounting.* Society needs to account for "everything people really care about," such as infrastructure, social services, and environmental quality—systematically—and really recognize the cost of human actions. GIS helps uncover and analyze these costs. Through GIS, what *should* be done can be addressed.

StateStat on Steroids

ESRI has created a prototype application that supplies geoaccounting for government on the federal level. FedStat demonstrates how GIS can not only visualize Obama's transparent government but also foster informed decision making, accountability, and performance measurement. Through "spatializing" stimulus funds, FedStat offers the next logical step in implementing performance-based governance using GIS to help provide an unprecedented level of government transparency.

Developed as a rapid prototype, FedStat takes advantage of the new ArcGIS Server API for Flex and current strategies for delivering highly responsive and focused Web mapping using the capabilities available in ArcGIS 9.3.1.

Modeled on the previously cited successful GIS-based programs on city, region, and state levels, FedStat not only shares information but also supports dynamic and interactive analysis in a collaborative environment.

FedStat can help government function more effectively by overcoming problems caused by the information silos that result from stand-alone Web applications that cannot share information across agencies. Federal agencies can publish message packets to the FedStat system. Message packets are self-contained dynamic briefings on a topic or issue, complemented by real-time access to Web services that furnish maps and data and provide decision makers with accurate content from domain experts.

FedStat doesn't just deliver visualization and communication capabilities, it integrates decision-support tools for performing analysis using cross-cutting data and content. It also incorporates spatial analysis tools that assist in determining the cost to mitigate or solve the problem, its relationship to other similar issues, and how it should be prioritized. For ongoing projects, it can serve as a performance measurement tool for optimizing expenditures and keeping the public informed.

A More Insightful Approach

More than ever, the rational approach supplied by GIS is needed to bring information resources to bear on seemingly intractable problems. As Dangermond has observed, GIS can make the information more accessible and the process more transparent so "mere mortals can see where is the right place and where is the wrong place. If a picture is worth a 1,000 words, a map is worth 100,000 words" because people see maps and intuitively understand the information presented. In this crisis is an opportunity for creating government transparency by incorporating GIS not only for stimulus funding but for all government spending.

ArcGIS Server-based tool mitigates graffiti

By Matt Keeling, City of Riverside, California

A comprehensive application developed by a Southern California city not only helps identify and prosecute the vandals who produce graffiti but also tracks the entire cost of graffiti to the city.

The Public Works, Police, and Information Technology departments of the City of Riverside have developed the Graffiti Abatement Tool (GAT) to coordinate interdepartmental efforts and address the problem of connecting instances of graffiti to an individual vandal (or tagger). GAT, a custom application, was built using ArcGIS Server, ArcSDE, and several other technologies. It stores and manages images of graffiti with other tabular data useful

Above: Public Works crews that remove graffiti first take a picture of the graffiti using a Ricoh GPS camera and complete a customized digital form on the camera.

Right: The Graffiti Abatement Tool (GAT) helps identify and prosecute the vandals who produce graffiti and also tracks its entire cost to the city.

GAT relates an individual instance of graffiti to other instances nearby and calculates the cost of removing graffiti.

in tracking, prosecuting, and suing taggers for the city's costs in mitigating and removing graffiti.

Documenting Where Taggers Strike

Public Works crews that remove graffiti first take a picture of the graffiti using a Ricoh GPS camera and complete a customized digital form on the camera. This form records basic information about the incident. The images and data are then uploaded onto a server that automatically adds the data to a spatial layer in ArcSDE.

Taggers sign their works with distinctive monikers so identifying the creator of an instance of graffiti is simple. Using an ArcGIS Server application, the Police Department's graffiti task force matches these images with other instances of graffiti by the same tagger.

Having a spatial layer that locates graffiti gives the Police Department many advantages. Taggers will often provide useful information, such as gang affiliation, within the graffiti lettering. The police can perform GIS analyses to find trends in tagging and identify problem areas. Some graffiti is associated with a street gang or a specific tagging crew. If so, this data is entered into the application so police can determine when and where these crews are active and get a general idea of gang territory. All the graffiti data is available to the Police Department in a user-friendly application.

Capturing the Cost of Graffiti

GAT allows the total cost—from an individual event to all graffiti caused by a specific tagger—to be easily calculated. When the Public Works abatement crew removes the graffiti, the cleanup method and materials used are entered as well as how much time was required for removal, and GAT calculates the cost of removing the graffiti. The Public Works Department can determine where money is being spent on graffiti removal and the neighborhoods and wards where tagging most often occurs.

When investigating graffiti-related crimes, the Police Department also enters the cost of each investigation into the GAT system. The documentation of graffiti investigations becomes criminal evidence. Due to the sensitive nature of this information during a criminal investigation, partitions have been made in the system that separate the data for the Police and Public Works departments. The Public Works segment includes the graffiti images, location, and removal costs, while the Police portion appends information on the tagger, moniker, and the victim.

The costs associated with prosecuting and suing a tagger in a civil lawsuit are entered by the city attorney. If the tagger is a minor, the city attorney can sue the parents or legal guardians, giving them a strong incentive to keep their children away from such activities. GAT allows for the construction of a proper chain of evidence for both the prosecution and the civil lawsuit by providing picture evidence with time stamps, costs, digital images, and locations.

Integrating Technologies

GAT was built by integrating a number of technologies. The Ricoh GPS cameras are the primary input devices. Public Works crews complete customized forms that are simple, easy to use, and require minimal training. ArcSDE handles the storage of graffiti data, including geometry, images, and attribute information, while an ArcGIS Server application provides the user interface. Several Microsoft technologies, including SQL Server 2005, SQL Server 2005 Reporting Services, and AJAX, were used for other parts of GAT.

Other features that may be added in the future include more complex analysis built directly into the application and wireless upload from the cameras using the City of Riverside's free wireless Internet service.

A key aspect of GAT is its global architecture. Because vandalism does not respect city boundaries, the City of Riverside hopes GAT will eventually provide a regional graffiti/tagger tracking and abatement system. Other jurisdictions would simply provide their own servers and GPS-enabled cameras to use GAT. The entire region could benefit by sharing data across jurisdictional boundaries.

For More Information

To learn more about GAT, contact Matt Keeling, GIS analyst, City of Riverside, at mkeeling@riversideca.gov. To learn more about creating enterprise-wide applications, the instructor-led course, *Data Management in the Multiuser Geodatabase,* is offered by ESRI. Visit www.esri.com/training to sign up.

Mapping Site for Abandoned Properties

Visualizing the most current data on the Web

By Chris McCoy, City of Chula Vista, California

Dead grass, overgrown bushes, and trash scattered across the front yard—these are the telltale signs of a house in foreclosure. To combat the negative effects of distressed properties on other homes in the neighborhood, the City of Chula Vista, California, passed an ordinance requiring that foreclosed properties be maintained. Code enforcement officers use a Web mapping application to track distressed properties so information is available in the field as well as the office.

During the past decade, the City of Chula Vista has been among the fastest growing cities in the United States. With a current population of about 200,000, Chula Vista experienced a significant increase in the number of single-family homes built during this period. At the height of the 2004–2006 building boom, it was not unusual for the Planning and Building Department to issue more than 2,000 building permits per year.

In recent years, the cooling housing market has led to a decrease in permits issued and an increase in foreclosures. These vacant houses have a negative impact on the surrounding neighborhood and the community as a whole. Many homes in the foreclosure process remain vacant and are not maintained for months. Blighted properties can discourage potential buyers of adjacent properties and reduce property values in a neighborhood by thousands of dollars.

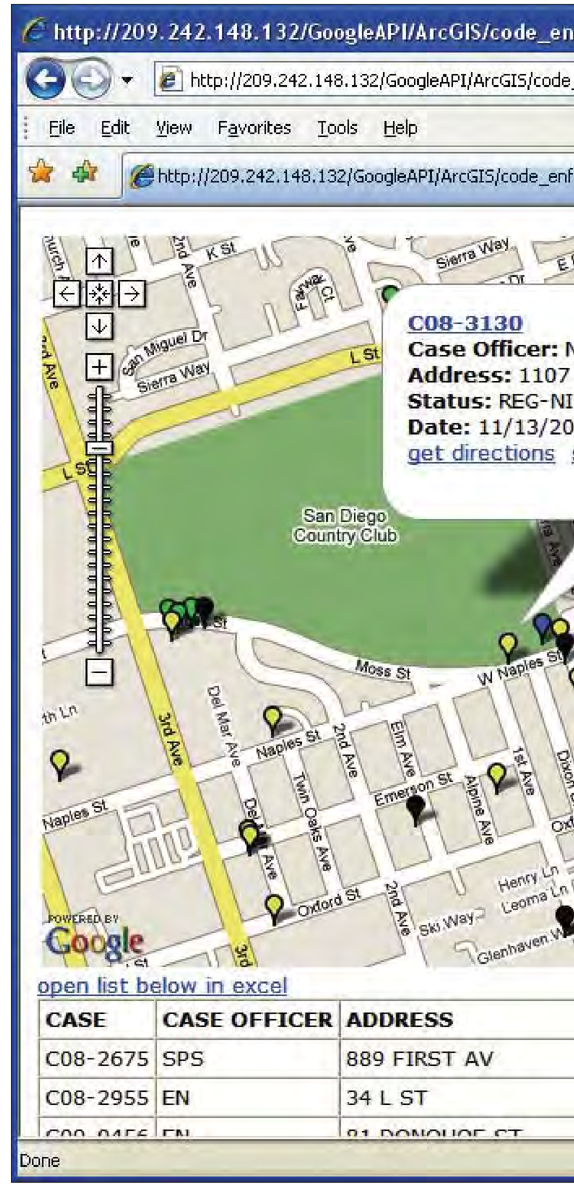
To combat problems associated with unmaintained properties, city leaders approved the Residential Abandoned Property (RAP) ordinance in October 2007. It requires the financial institution foreclosing on a property to maintain the vacant house to neighborhood standards. The Code Enforcement Division is charged with enforcing compliance with this ordinance. To manage more than 2,000 foreclosed properties, enforcement staff must identify where the highest concentration of foreclosure activity is occurring and quickly monitor data both in the office and field.

Although Code Enforcement Division staff maintained RAP data in Permits-Plus, the city's permitting system, they preferred a system that could visualize property locations. Code enforcement staff approached the GIS team and requested a digital map to identify these foreclosure locations. This would allow them to see clusters of foreclosures and help determine where to focus resources.

In 2005, Chula Vista built CVMapper, a custom ArcIMS viewer for city staff to display and query common GIS layers. Initially, the GIS team discussed adding the RAP data directly to the ArcIMS viewer as a separate layer. Although this was a workable solution, code enforcement staff preferred a simple, lightweight map interface that would display up-to-date property locations.

A key component of the project was furnishing current, accurate data. When code enforcement officers returned to the office from field inspections, the Web site would require updating to reflect the latest inspection data and current inspection status of each property. Another key consideration in the Web site design was the sensitivity of the data. The RAP database contains phone numbers, e-mail addresses, and other personal data that should only be available to the Code Enforcement Division.

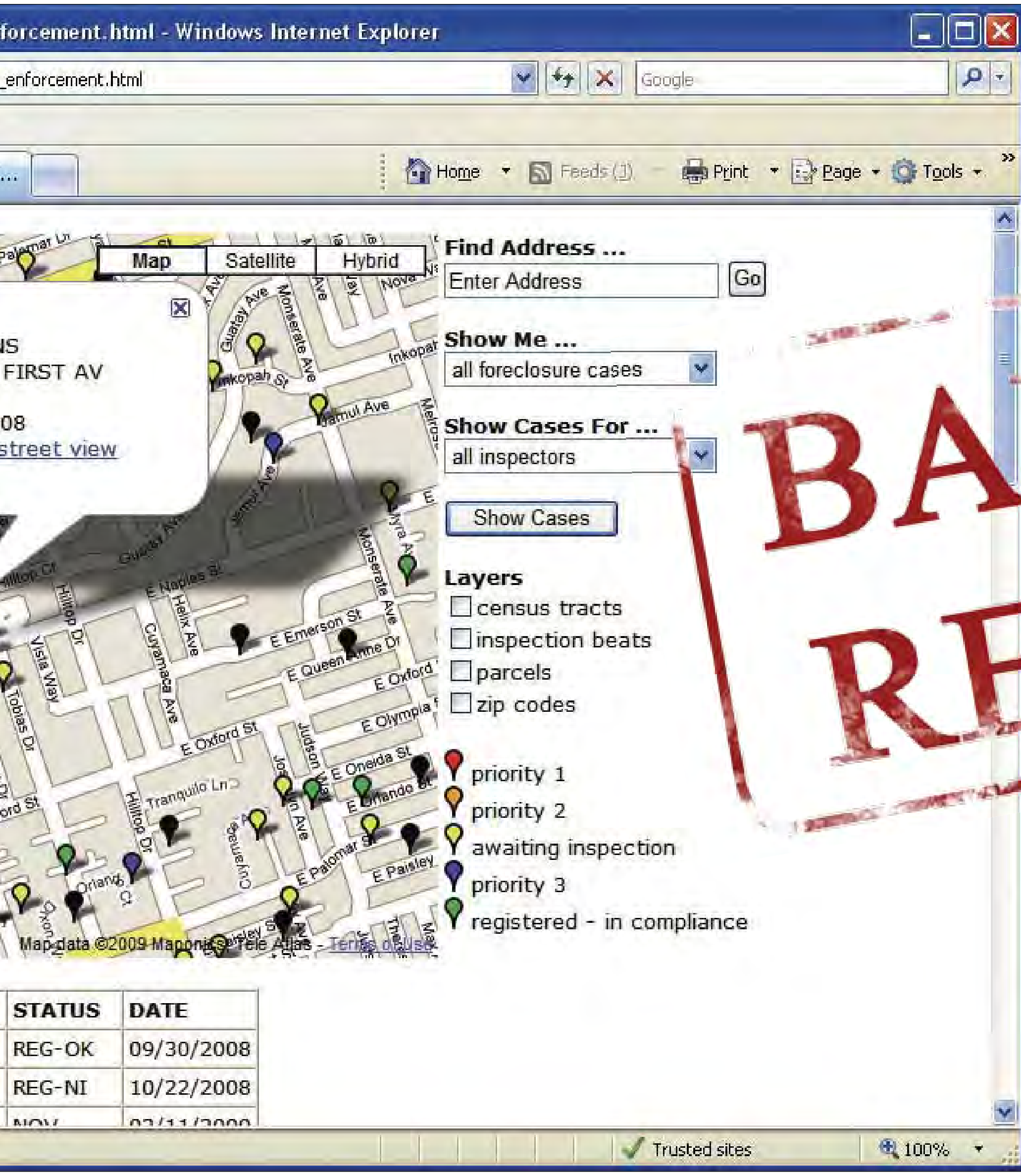
The GIS team ultimately decided to build a Web site based on ArcGIS Server, using ArcGIS JavaScript Extension to the Google API and the ArcGIS API for JavaScript. "We thought this was a great opportunity to take advantage of the mashup capabilities of ArcGIS Server and create a simple Web page that merged the locations of foreclosure properties on top of a Google map," said Bob Blackwelder, the GIS manager for Chula Vista. Since Chula Vista maintains its GIS data in ArcSDE using a Microsoft SQL Server enterprise geodatabase, staff can easily integrate GIS data with other city databases, including the RAP data, which is also stored using Microsoft SQL Server.



The first step in creating the Web site was to spatially enable the RAP data. The GIS staff created a simple ArcSDE database view using the city's parcel layer. Using Microsoft Visual Studio, the view was modified to include the RAP program data. The modified ArcSDE view linked each record in the RAP database to a parcel feature based on the unique assessor parcel number (APN). Since the database view retrieved data directly from the Permits-Plus database, this also ensured the RAP locations and property status were always current on the Web page.

The ArcSDE database view data was added to an ArcMap document along with a few additional GIS layers. These layers, including parcel boundaries, city boundary, census tracts, and ZIP Code boundaries, were added to provide reference and background information for the digital map.

The ArcMap document was then published as a map service and embedded into a Web page. Using the ArcGIS JavaScript Extension



Chula Vista's GIS team built a Web site based on ArcGIS Server using ArcGIS JavaScript Extension to the Google API and the ArcGIS API for JavaScript. Each property is mapped with a Google "balloon" and color coded based on the inspection status.

to the Google API and the ArcGIS API for JavaScript, the GIS team created the Web site and embedded the digital map into the HTML document. "With a basic understanding of HTML and JavaScript, we were able to use some of the sample scripts available on the ESRI site and get the initial site up and running in a few days," said Blackwelder.

With its debut in November 2008, the new mapping site is used in the field on a daily basis by code enforcement staff. Previously, staff had no way of identifying clusters of foreclosure properties. Now, each property is mapped with a standard Google "balloon" and color coded based on the inspection status. Users can click on the balloon to retrieve the case number, status, and program date for the selected property.

Code enforcement officers can open the mapping site prior to field visits, see clusters of properties to inspect, and plan their day accordingly. Using a pull-down list, they can display all RAP data or view just single-family or condominium locations. Another pull-down list allows users to map all properties or just properties assigned to a specific code enforcement officer. As officers in the field collect data about a foreclosed property, the data is fed directly to the Permits-Plus server. This allows office staff and field inspectors with wireless capabilities to immediately view updates to inspection status on the Web page.

Since the initial development of the mapping program, management in the Code Enforcement Division has noticed a significant increase in productivity. Many code enforcement officers report that the productivity increase is a result of having more time to process cases rather than spending time determining property locations or printing driving directions between locations.

Additional tools have also been added based on end-user comments and feedback. One link, added to each property, provides driving directions from city offices to the site. Another link brings up Google street-level images for the selected property. Users can use the mapping site to zoom to an area and export all data within the map extent as a Microsoft Excel file.

With the success of the RAP viewer, Chula Vista is considering other ways to take advantage of ArcGIS Server to create more online maps that would link business data and map services in a simple Web site. The Public Works Department would like to map city assets along with related information from the city's GBA Master Series software *[a work management system]*. Using ArcGIS Server, they could build a project-specific mapping site and allow staff to view recent fieldwork related to these assets.

For more information about this program, contact Bob Blackwelder, GIS manager, City of Chula Vista, at bblackwelder@ci.chula-vista.ca.us or Chris McCoy, development services officer, City of Chula Vista, at cmccoy@ci.chula-vista.ca.us. To learn about creating these types of applications, two instructor-led courses, *Introduction to ArcGIS Server* and *Building Web Maps Using the ArcGIS API for JavaScript,* and a free Web training seminar, *Building Mashups Using the ArcGIS JavaScript APIs,* are offered by ESRI.

TxDOT Maps Texas History

Information for planning transportation and other projects

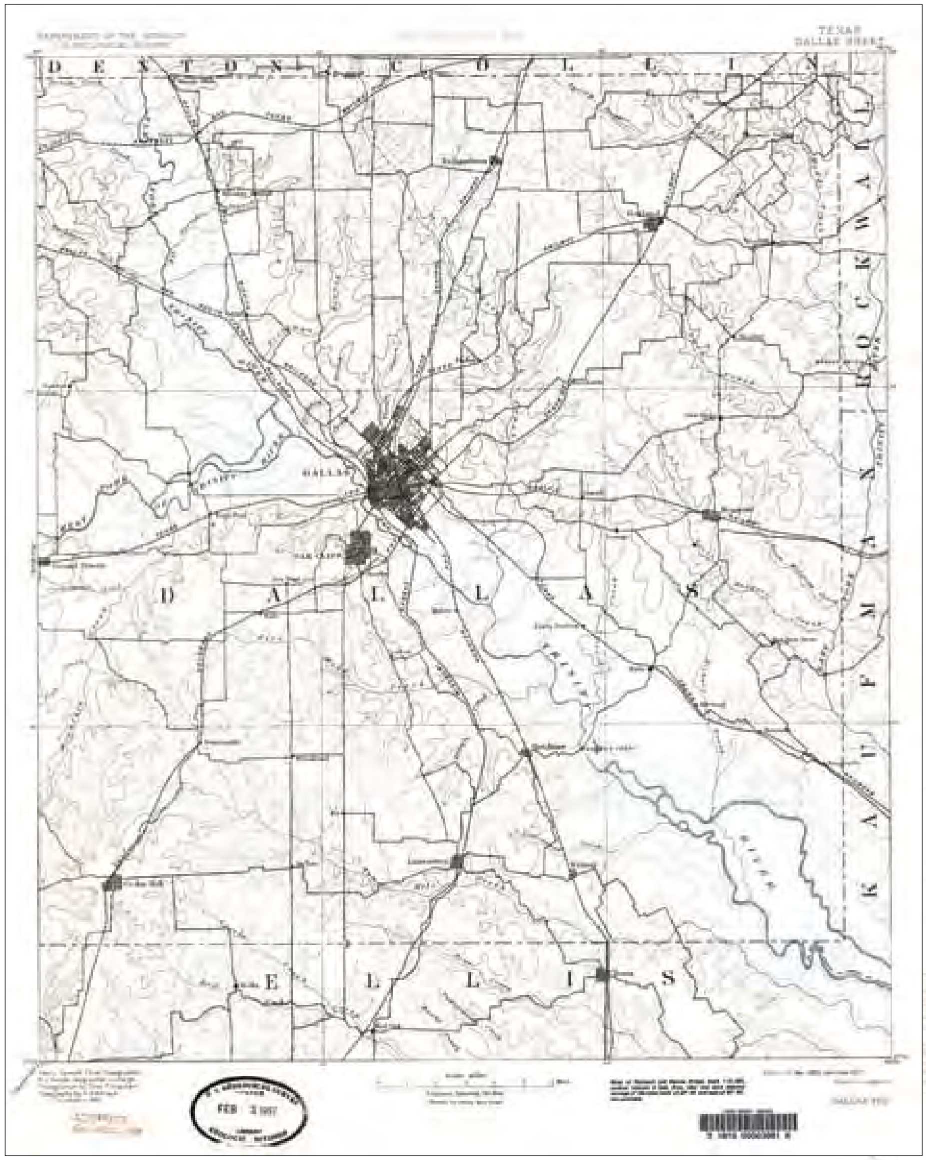
By Ty Summerville, Geospatial Project Manager, PBS&J

Texas Department of Transportation (TxDOT) created a GIS-based historic archaeological resource that helps avoid sensitive archaeological and cultural sites and guide field surveys.

From the long-lost missions built during Spanish rule to the historic cattle drives along the Chisholm Trail, Texas geography tells a varied and diverse story that historians, archaeologists, and cultural resource experts are still trying to write.

It's up to agencies like TxDOT to ensure history is preserved while keeping the current residents moving forward. Second in the nation in both size and population, Texas is home to 23 million people, and cars and trucks are the primary mode of transportation. Currently TxDOT maintains the public highways that crisscross the state's almost 270,000 square mile area. By 2020, road and rail freight moving to, from, and within Texas is expected to increase by 70 percent, while population is expected to increase 52 percent by 2030.

In an effort to more effectively manage cultural resources affected by highway construction and maintenance, archaeologists and historians in TxDOT's Environmental Affairs Division teamed with PBS&J to create a GIS-based historic archaeological resource. The Texas Historic Overlay (THO) would provide important information needed for planning transportation improvements and maintenance projects. The source information for creating the GIS would be historic-era maps. Today, the THO is an integral part of TxDOT's efforts to preserve and protect valuable resources, along with almost 80,000 miles of state highways, while securing rights-of-way for highway widening and new alignments for the future.



The THO project gathered out-of-print historic maps with significant cultural detail such as this map of Dallas, Texas.

Historic Map Collection

The THO project began with an effort to gather out-of-print historic maps with significant cultural detail that were created between 1722 and 1988. The effort focused on the eastern half of Texas, an area that comprises 62 counties covering 145,000 square miles. More than 3,000 historic maps exist for this area. Over a two-year period, the THO team solicited information from 162 libraries, museums, and repositories. Once the information was gathered, the team scanned, processed, georeferenced, and indexed these maps and incorporated them into a single system.

Maps were supplied in a variety of formats including scanned hard copies, photographic reprints, microfilm, digital photography, and tracings of hard-copy maps on vellum. The map images were initially enhanced in Adobe Photoshop to adjust brightness and contrast, replace aged paper color with white, and remove any blemishes present on the maps. Bibliographic and other detailed information regarding source maps was captured in a Microsoft SQL Server database.

Coordinated Connections

One of the greatest challenges in the THO effort was georeferencing all maps to a common coordinate system. Unfortunately, most georeferencing software is designed to transform coordinates for U.S. maps that are created with the North American Datum of 1927 (NAD27) or more recent horizontal datums.

Many maps selected for use in THO use a datum predating NAD27. Of the 3,318 source maps, 745 used an antiquated datum such as the North American Datum (1913), the U.S. Standard Datum (1901), or other datums available prior to development of regional geodetic datums.

Most antiquated datums used by the historic maps selected for the project are actually a datums that use the Clarke 1866 ellipsoid. The exceptions to this generalization are the Walbeck 1820 ellipsoid and the Bessel 1841 ellipsoid. In 1870, the U.S. Coast Survey adopted the Clarke 1866 ellipsoid for use for geodetic purposes including mapping. This ellipsoid was used as a local datum until the adoption of the first geodetic datum of the United States, the U.S. Standard Datum of 1901. In 1913, the U.S. Standard Datum was renamed the North American Datum (NAD) with its adoption by Canada and Mexico.

To transform a coordinate system to the selected common coordinate system, mapping experts developed three-parameter Molodensky transformations for each historic datum encountered. The process works by calculating the shift along the x-, y-, and z-axes from one system to another. To calculate this shift, the team undertook a substantial research effort to find coordinates for features represented in historic and modern form.

Resource Ready

Completed in early 2007, the THO is integrated into TxDOT's existing statewide GIS, which is built on ArcGIS. All selected historic maps were georeferenced using vector registration overlays representing historic coordinate systems or geographic features with resulting images in GeoTIFF and MrSID formats.

Once the maps were registered and resampled, PBS&J used the Positional Accuracy Assessment Generator (PAAG), an ArcObjects application created by PBS&J, to calculate the accuracy of the spatially referenced historic maps. Source map extents were digitized as polygons in geodatabase

Continued on page 22

The Texas Historic Overlay is integrated into the existing statewide GIS of the Texas Department of Transportation (TxDOT) for ready access by staff and approved consultants.

TxDOT Maps Texas History

Continued from page 21

For more than two years, the THO team solicited information from libraries, museums, and repositories and obtained maps. Maps were supplied in a variety of formats including scanned hard copies, photographic reprints, microfilm, digital photography, and tracings of hard-copy maps on vellum.

feature classes to serve as an index joined to the source map information in SQL Server. The team also created the Metadata Miner, another ArcObjects-based application, to automate the generation of historic map-image-specific metadata in Federal Geographic Data Committee (FGDC) format using information mined from a SQL Server database.

The resource information developed from the THO project is available to TxDOT and approved consultants to develop historic trends in land use, development, and vegetation and manage the state's cultural resources while planning state road and highway projects.

"Just about every project we do for TxDOT includes use of the Texas Historic Overlay in the early stages to identify likely locations for resources that once existed in the landscape," said Eugene Foster, senior scientist at PBS&J and project manager for the THO project. "We typically use that information early on to compare and refine project alternatives."

The data is used to develop scopes and budgets for field surveys. It also guides historians and archeologists in field surveys and right-of-way acquisitions. For instance, PBS&J was contracted by TxDOT to evaluate the possibility of unmarked graves in the area surrounding a proposed bridge on State Highway 130 over State Highway 71 near Austin. PBS&J planners needed to survey about 15.7 acres of land located adjacent to the proposed bridge site.

The team pulled area maps from THO to locate cemeteries. Then they overlaid remotely sensed data to find unmarked graves at the site. While no unmarked graves were located, the team was able to help TxDOT see the old State Highway 71 alignment as well as some potential historic sites. The entire site analysis took three days.

Jim Abbott, project manager for the TxDOT Environmental Division, said, "The ability to access and compare historic maps at the desktop provides us with a powerful

Querying the Texas Historic Overlay prior to any major highway construction or reconstruction project allows TxDOT and its consultants to ensure the preservation of historical and cultural resources.

tool for cultural resource planning. With the Texas Historic Overlay, we can quickly and consistently locate and avoid possible historic archaeological sites that otherwise might be missed in planning for highway projects."

The resource proved particularly valuable to a project in San Antonio, Texas. As part of the redevelopment of downtown San Antonio, the city wanted to renovate the historic Main Plaza located about a mile from the Alamo *[the site of the most famous battle of the Texas Revolution]* into a pedestrian-friendly plaza for residents and the millions of tourists who visit annually.

First established in 1731 by Spanish settlers as the Villa de San Fernando, the Main Plaza has always been the center of San Antonio's municipal government. Soldiers killed during the 1810–1820 War for Mexican Independence are buried at the church along with the remains of the defenders of the Alamo. The Main Plaza also links to the historic San Fernando Cathedral and the nearby San Antonio River.

PBS&J used the THO geodatabase to identify and avoid sensitive archaeological and cultural resource sites during construction activities as mandated by the Antiquities Code of Texas.

Historical consultants laud the new resource because of its value in projects like the renovation of San Antonio's Main Plaza. Abbott said, "They say it has saved them so much time because we've been able to gather these resources, which have heretofore been scattered all over the state and were not being used, and bring them into one place where they are readily accessible."

THO data is available to TxDOT and approved consultants to manage the state's cultural resources and develop historic trends in land use, development, and vegetation. Although some maps are restricted as a result of agreements between TxDOT and the individual libraries and repositories that own the paper copies, the rest of the maps are available to the public through the Texas Natural Resource Information System Web site at www.tnris.org.

About the Author

Ty Summerville is the geospatial project manager for PBS&J. He has more than 11 years of experience in this area. He can be reached at tdsummerville@pbsj.com.

For More Information

Understanding Map Projections and Coordinate Systems and *Georeferencing Rasters in ArcGIS,* both Web courses, are available from www.esri.com/training.

Shifting Shorelines

Modeling the 20,000-year history of the Great Lakes

By James A. Clark and Kevin M. Befus, Wheaton College, Wheaton, Illinois

Shorelines of the North American Great Lakes during the past 20,000 years were modeled using ArcGIS predictions of earth deformation and the hydrology tools in the ArcGIS Spatial Analyst extension.

During historical times, water levels of the modern Great Lakes have fluctuated by more than a meter. This is largely caused by changing weather patterns and the associated rates of evaporation and discharge of rivers and groundwater entering and leaving the lakes. However, when one considers changes in the Great Lakes over the past 20,000 years, the level of the lakes has changed even more dramatically—by more than 100 meters.

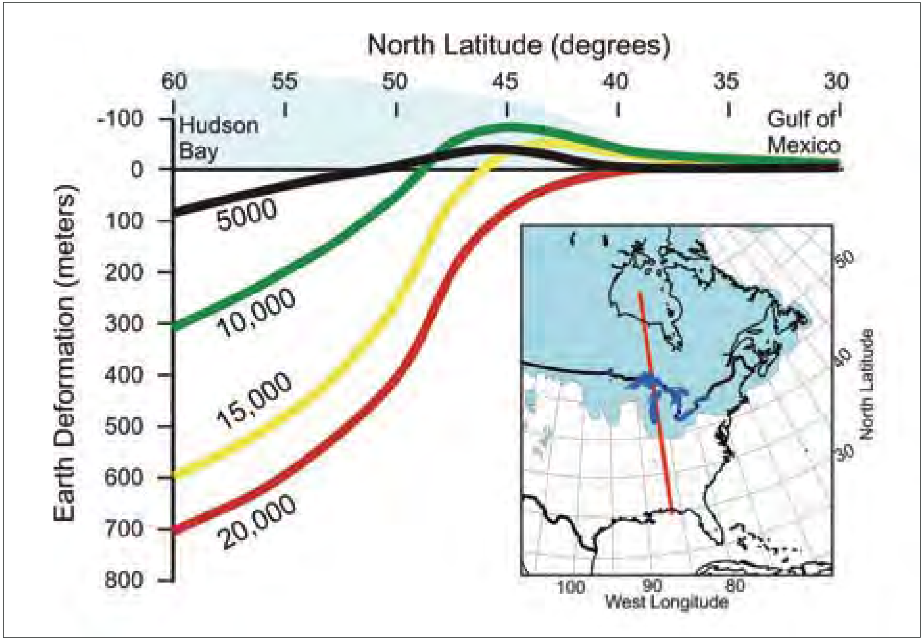
These changes were caused not only by climate effects, but (more importantly) because the great ice sheet that covered half of the North American continent 20,000 years ago blocked the modern outlets of the Great Lakes, other outlets had to be used. The earth was deformed under the huge weight of the ice sheet, a further complicating factor. The Great Lakes region is between 41 and 49 degrees north latitude, and the ice sheet extended south to about 40 degrees.

As the ice sheet retreated northward, outlets became ice free and controlled the level of the lakes. But these outlets were also changing in elevation because the earth was slowly rising to the undeformed position it held in the pre-Ice Age.

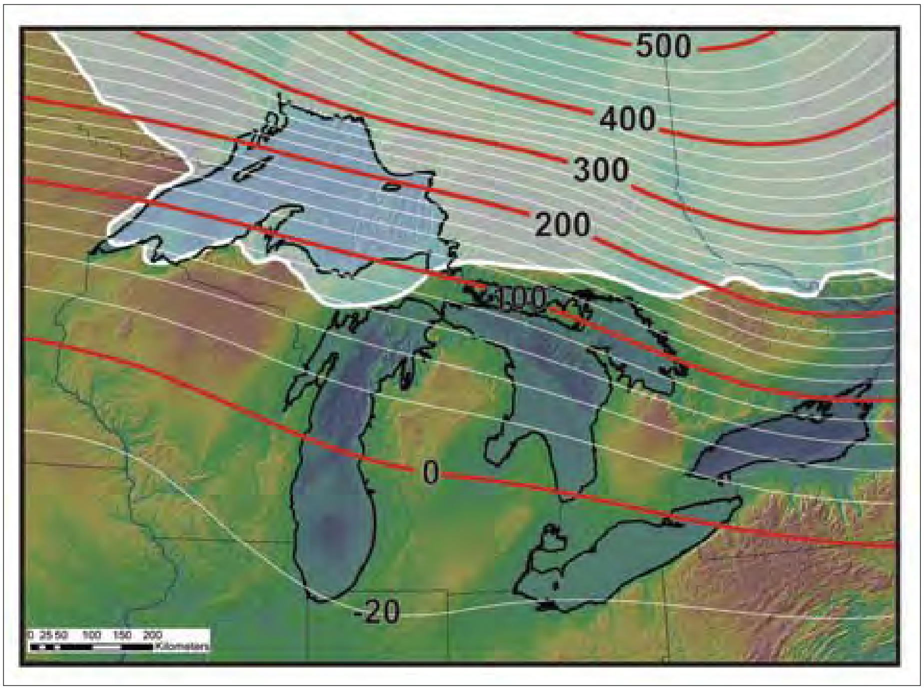
Creating Paleo-DEMs

Based on geophysical theory, it is possible to predict how the viscous mantle of the earth moves under surface loads. In this inquiry, the surface loads included changes in ice sheet thickness over Hudson Bay that were probably in excess of 3,000 meters and accompanied by changes in ocean loads as the melting ice sheets caused the ocean level to rise by approximately 100 meters.

Taking all time-dependent loads and the viscosity structure of the mantle into account, numerical geophysical models can predict the vertical deformation anywhere on the earth at any time during the past 20,000 years. As ice advanced over the Great Lakes region, the earth surface under the ice subsided, while the region beyond the ice bulged upward. In general, as the ice retreated, the process occurred in reverse. The land rose under the melting ice but subsided in regions near the ice sheet margin.



This diagram shows the deformation of the earth's surface along a transect from Hudson Bay to the Gulf of Mexico. The transect is shown as a red line on the locator map. Curved lines are labeled with the age in years before present. Where the earth was deformed the most by the thickest portion of the ice sheet, the land rises gradually. Near the margin of the ice sheet, the land first rises and then subsides.



Contours of deformation at a time 13,000 years ago relative to the present (shown in meters). In the northern part of the map, land was more than 500 meters lower than present-day elevations. South of the zero contour line, land was actually higher than current elevations. The position of the ice sheet and a shaded relief Paleo-DEM are included.

For any time period, the geophysical model can predict deformation at hundreds of discrete points over the Great Lakes region. These discrete predictions can be interpolated using the spline interpolation methods, available in the ArcGIS Spatial Analyst extension, to yield a deformation raster at each time of interest.

Just as the locations of modern rivers and lakes are a result of topography, so too did topography in past ages control surface hydrology. To determine past topography, the deformation raster map was subtracted from a modern digital elevation model (DEM). The Shuttle Radar Topography Mission (SRTM) DEM was used over the land areas and combined with Great Lakes bathymetry data from the National Geophysical Data Center of the U.S. National Oceanic and Atmospheric Administration (NOAA).

Because the bathymetry dataset was not complete, it was supplemented with Lake Superior bathymetry provided by the Large Lakes Observatory of the University of Minnesota. To speed calculations, the raster resolution was changed from 90 meters to 200 meters. The result was a series of Paleo-DEMs that spanned the last 20,000 years.

Mapping Great Lakes History

Through extensive fieldwork, geologists have determined the extent of the ice sheet as it retreated from the Midwest. Maps of the ice sheet extent were digitized. The ice sheet north of the margin was assigned an arbitrary thickness of 1,000 meters. By adding ice sheet raster maps to the Paleo-DEMs, the actual topography during late-glacial and post-glacial times was re-created.

With this topography, the hydrology tools in ArcGIS Spatial Analyst were used to determine paleohydrology. A first step in modeling modern hydrology, given a DEM, is usually to fill any closed depressions in the topography to correct for any small imperfections in the DEM that would incorrectly serve as sinks for water. In the present application, these filled depressions are critical to the solution because the lakes that formed on the ancient landscape are exactly those that result from filling the Paleo-DEM. Subtraction of the Paleo-DEM from the filled Paleo-DEM yields a raster of Paleo-lakes and their bathymetries.

Not only can the ancient distribution of lakes and shorelines be predicted but so can the volumes of those lakes. Using the Hydrology Flow Accumulation tool, which determines the number of raster cells above a given cell that would contribute overland water to that cell, the locations of ancient stream channels could be predicted on the filled Paleo-DEM. In addition, the outlet of each lake was located. It was identified as the single raster cell on the margin of each lake with the highest flow accumulation value.

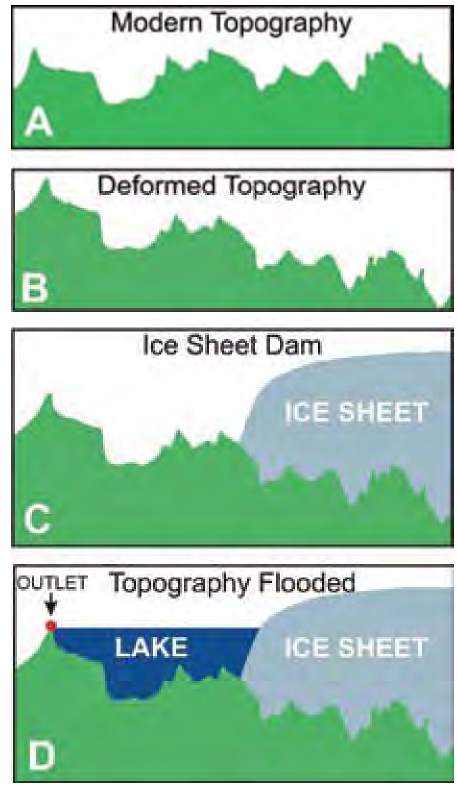
While the locations of hundreds of lakes are predicted for each time period, most of these lakes are very small. To limit the analyses to the largest lakes, the paleolakes raster was searched for all lakes with contiguous areas larger than a specific minimum area. These steps were automated using a Python script. A record of the 20,000-year history of the Great Lakes was produced after only about three days of computational time on a PC.

Modeling Results

When ice covered much of the Great Lakes basin, water flowed out through Chicago, down the Illinois River, and into the Mississippi River. When ice had retreated north of the Great Lakes, an outlet in Canada that had been depressed under the weight of the ice became the lowest outlet. It captured the drainage as soon as the outlet became ice free. This caused the lakes to drain rapidly. Lake Michigan, which experienced a 125-meter drop in lake level, became separated from Lake Huron. Subsequently the northern controlling outlet rose as the earth readjusted to the reduced load of the melting ice until the outlet reached the same elevation as the more southern outlets. When that happened, drainage of the Great Lakes shifted to the south and the modern outlets. Lake Erie, which almost drained completely because its northern outlet was low, gradually filled as its outlet slowly rose to its present position.

Conclusion

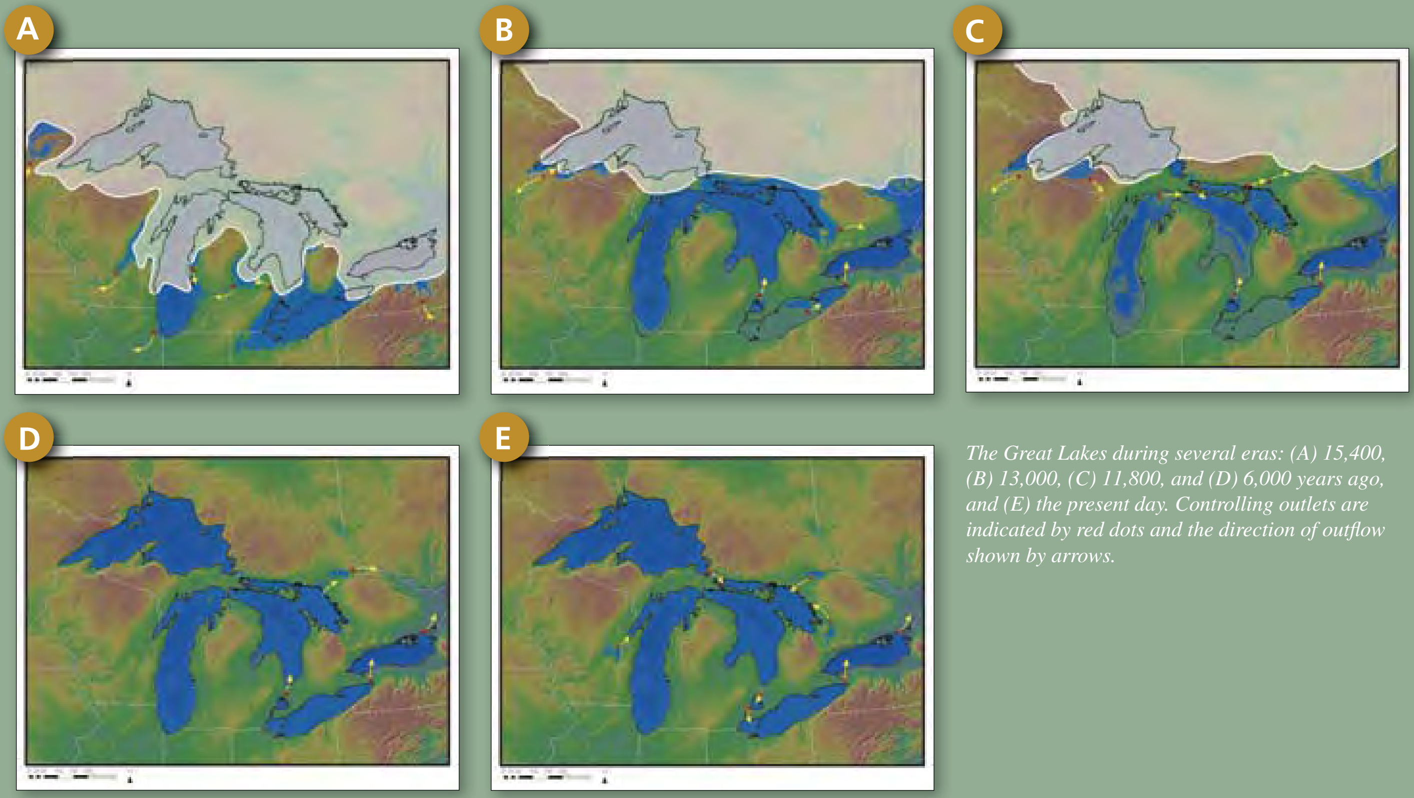
These lake-level predictions were suggested by a century of fieldwork by geologists mapping old shorelines of the Great Lakes. (This work is summarized in Jack L. Hough's classic work, *Geology of the Great Lakes.*) These geologists observed that ancient shorelines were tilted relative to modern shorelines and attributed the tilting to earth deformation forced by ice sheet loading. The results of this analysis demonstrated that when the physics of viscous mantle flow is combined with ArcGIS methods, these ancient shorelines can be reproduced.



GIS methodology: The present topography (A) is warped vertically by the predicted deformation to yield the Paleo-DEM (B). The ice sheet is added (C) to form the actual surface landscape at given times in the past. The Paleo-DEM is filled to eliminate closed depressions (D) and the difference between the filled Paleo-DEM and the Paleo-DEM (C) is the predicted lake. Outlet location is on the lake margin where the greatest flow accumulation value occurs.

Using this GIS methodology makes it possible to verify shoreline positions by uploading shapefiles of the predicted shoreline to ArcPad installed on GPS units and locating shorelines in the field. Differences between the observed and predicted locations suggest how the geophysical model should be improved ,either by altering the viscosity structure of the earth model or adjusting the ice sheet thickness chronology.

Continued on page 26



The Great Lakes during several eras: (A) 15,400, (B) 13,000, (C) 11,800, and (D) 6,000 years ago, and (E) the present day. Controlling outlets are indicated by red dots and the direction of outflow shown by arrows.

Shifting Shorelines

Continued from page 25

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Acknowledgments

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About the Authors

James Clark is a professor of geology in the geology and environmental science department at Wheaton College in Wheaton, Illinois. In addition to the Great Lakes studies, his research interests include global sea level changes and water supply problems in developing nations. His Ph.D. is from the University of Colorado.

Kevin Befus is now using shallow surface geophysical methods to characterize the Boulder Creek Critical Zone Observatory while pursuing a master's degree at the University of Colorado in Boulder, Colorado.

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Navigating Canada's Largest Cemetery

Custom applications provide guidance and information

The largest cemetery in Canada combines an impressive historical legacy with cutting-edge modern technology to increase the efficiency of internal operations and provide visitors with a truly unique experience.

Located in Montreal, Quebec, Cimetière Notre-Dame-des-Neiges contains a delicate mix of heritage resources, artwork, and ecological marvels. Founded more than 150 years ago, the cemetery is home to notable institutional buildings and historical artifacts that are protected as part of Quebec's architectural heritage. A few examples include the Resurrection Chapel built in 1856, the Jarry-Henrichon House that dates to 1751, and a life-sized marble reproduction of Michelangelo's *Pietà* sculpture.

For the past 12 years, Cimetière Notre-Dame-des-Neiges has been leveraging GIS technology through customized applications including an interactive information desk, an internal mapping application, and a Web mapping application.

Improving the Visitor Experience

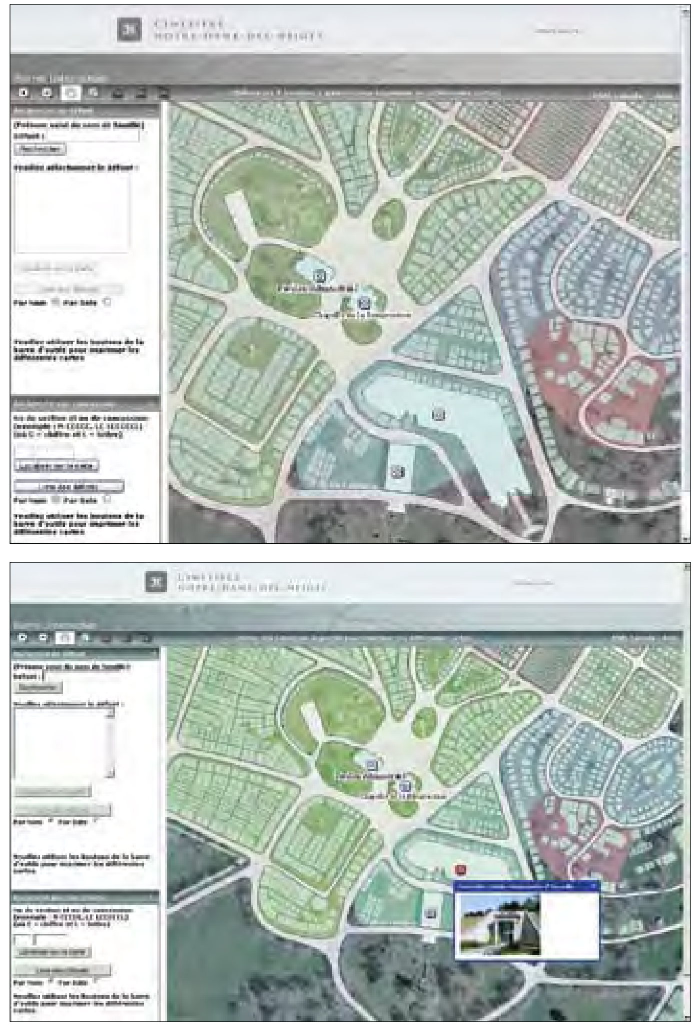
In the late 1990s, the cemetery began receiving phone calls and on-site requests from visitors trying to locate the graves of deceased loved ones. Cimetière Notre-Dame-des-Neiges is 55 kilometers in length and is the final resting place for almost one million people. Visitors can easily become lost or fail to locate the section of the cemetery for which they are searching.

For many years, visitors navigated cemetery grounds using a map printed in a brochure. The map was based on plans that were developed in 1854, when the cemetery first opened, and then updated with the help of a surveyor. A lost or frustrated visitor appealed to a cemetery staff member who searched databases to locate the grave site. Once a plot was located, the staff member marked the brochure with the location. This process was time consuming for both the visitor (who often had to wait in line) and the cemetery staff member.

The cemetery sought a solution that would enable visitors to easily locate loved ones on a map. This would improve the visitor's experience and reduce the number of requests for assistance. With the help of cemetery staff, ESRI Canada Limited, ESRI's distributor in Canada, developed a customized ArcGIS Engine application that met this objective. The application is housed in interactive terminals placed in two locations. Each terminal consists of an HP computer, a touch screen, and a printer. A visitors simply types in the name of the deceased person and receives a map that marks the location of that plot in the cemetery. Visitors can print this map and take it along.

"With the addition of the interactive terminals, we have greatly increased the satisfaction of our visitors," explains Diane St. Pierre, IT manager at Cimetière Notre-Dame-des-Neiges. "Visitors can now be self-sufficient, and they no longer need to wait in line for someone to help them find the plot site they are looking for."

Based on the success of the ArcGIS Engine application, Cimetière Notre-Dame-des-Neiges decided to leverage ArcGIS Server to make its entire database available on the Web so visitors could look up the location of their deceased loved ones prior to arriving at the cemetery. Visitors to the site (www.cimetierenotredamedesneiges.ca) type in the name of the deceased or the section in which they are buried to obtain a printable map showing the location of the grave site. This Web mapping application also provides public access to the cemetery's database so people can conduct research on individuals who are buried there. Maurice Richard, Louis-Hippolyte Lafontaine, and Robert Bourassa are some of the famous Quebecois who are buried at Cimetière Notre-Dame-des-Neiges.



In addition to an on-site application for visitors, information about the location of gravesites is also available from the Cimetière Notre-Dame-des-Neiges Web site.

Effective Planning and Inventory Control

In addition to an application for visitors, Cimetière Notre-Dame-des-Neiges created a desktop-based application to better manage cemetery grounds. GPS units were used to collect waypoints. That information was then uploaded into ArcMap in ArcGIS Desktop. Previously, staff members sketched approximations of the cemetery's new sections in Microsoft Excel. The new GIS-based system provides a more accurate representation of the layout, is easily updated, and integrates data from GPS receivers, Excel, and other sources used to develop plans.

Conclusion

In constant evolution, Cimetière Notre-Dame-des-Neiges is now planning to integrate all infrastructure—wastewater and the gas, fiber-optic, and electrical networks—located on the property. This integration would make critical information readily available and reinforce the cemetery's primary mission: offering professional, high quality service to customers. For more information, visit www.cimetierenotredamedesneiges.ca.

Setting a New Standard

Coral mapping advances conservation efforts

By Barbara J. Brunnick and Stefan E. Harzen

The first full fledged coral mapping project carried out in the Bahama archipelago has resulted in a highly precise map of the marine area that identifies different habitat types and locates individual species.

Considered among the most complex and diverse environments on earth, coral reefs play a key role in the health of our planet's oceans. Pollutants, algae blooms, overfishing, damage due to development, and mooring are well-known threats to the health of reefs. Recent changes in the global climate are causing additional stresses including a rise in water temperature and acidity. The result is further decimation of existing reefs and the creatures that live in them and underpin the ocean's food web.

Most knowledge of coral reefs and benthic habitats is based on monitoring data gathered through a range of methods, mostly reef surveys, varying from rapid monitoring by trained volunteers to highly detailed, species-level observations. *[*Benthic *refers to the ecological region that is at the lowest level of a body of water.]*

However, these surveys provide little, if any, information on adjacent benthic habitats, such as sea grass beds or hard bottom, and, more importantly, fail to appropriately address and document the spatial component of the marine ecosystem. While coral reef mapping in itself is not new, most of these maps may differentiate shallow from mixed reef areas, but they do not provide further detail nor do they include adjacent areas of sea grass beds or other benthic habitats.

Caring for coral reefs is dependent on knowing far more about these extraordinary benthic environments, the associated ecosystems they host, and the establishment of baseline data against which future assessments of ocean health can be measured.

With these goals in mind, the Taras Oceanographic Foundation has embarked on a multiyear program to generate highly accurate maps of coral reefs that will set a new standard in the field of marine science and provide an invaluable tool for the monitoring, management, and preservation of these fragile environments worldwide.

After refining analytical skills and ground-truthing methodology over the last two years, the foundation chose the coral reef adjacent to Peterson Cay National Park off the southern shore of Grand Bahama Island as the site for the first full-fledged coral mapping project.

The site was selected because the coral reefs of the Bahama archipelago are in a near-crisis situation, like many other coral reefs around the world. Mapping this reef complex provides tangible benefits to those responsible for managing the marine resources. In addition, the reef complex was large enough to be significant, yet small enough to be charted in the available time.

The reef map of Peterson Cay integrates aerial and satellite imagery with GPS data and onsite field surveys in ArcGIS. Spatial information was combined with the marine habitat classification framework defined by the Ecological Society of America (ESA) and the National Oceanic and Atmospheric Administration (NOAA) Office of Habitat Conservation. This framework provides for the distinction of community types and density variations therein.

The delineation of these benthic community types resulted in a highly precise map of the marine area surrounding Peterson Cay. The map distinguishes between different habitat types that range from bare ocean floor to algae, sea grass, and coral reef and highlights density variations in each type. The map also pinpoints the exact location of individual species of interest such as the endangered elkhorn coral.

Furthermore, with ArcGIS, it was possible to determine with impressive precision the spatial expansion of each marine habitat across the study site. The coral reef, in its various expressions of density, covers 208 acres, and the sandy bottom—with various degrees of sea grass, spreads out over 263 acres. Areas of hard pad with algae (generally red and brown algae) covers 209 acres, although the density of algae coverage in two-thirds of these areas is less than 10 percent.

The ability to accurately locate individual corals or territorial fish species is essential for successful management and conservation programs. For instance, observations of the invasive Indo-Pacific lionfish *(Pterois volitans)*, which poses a significant risk to native species, can be charted on the map, facilitating its capture and eradication. Having a visual representation of the entire reef, or a number of reefs stretched out across a larger area, is the best means of determining where to install fixed monitoring devices such as sedimentation traps.

The comprehensive understanding of spatial features across the reef will also facilitate the identification of additional dive sites suitable for commercial scuba operators. Increasing the number of dive sites will alleviate the pressure on those currently used every day by multiple groups. Marking mooring sites adjacent to shallow reefs will help avoid reef damage caused by boat traffic and anchors.

Last, but not least, knowing the exact location, dimensions, and composition of the reefs will help develop sustainable land-use plans for coastal projects so they can benefit from these natural jewels rather than harming or destroying them.

By documenting the actual environmental conditions, the relationship between different habitat types and the larger reef ecosystem is better understood. In addition, it will monitor the expansion or decline of certain habitats. Conducting similar studies on adjacent reefs will eventually lead to a larger-scale map and a deeper understanding of both local and regional reef ecosystems and their processes.

Although this new mapping technology doesn't necessarily represent the natural state of any ecosystem, it can at least provide a baseline against which we can compare future observations, thus establishing a powerful framework for conservation and management. And that's what the map of Peterson Cay's coral reef will do. By combining traditional observational recordings with precise spatial information, it provides new insight into the fascinating world just below the water's surface.

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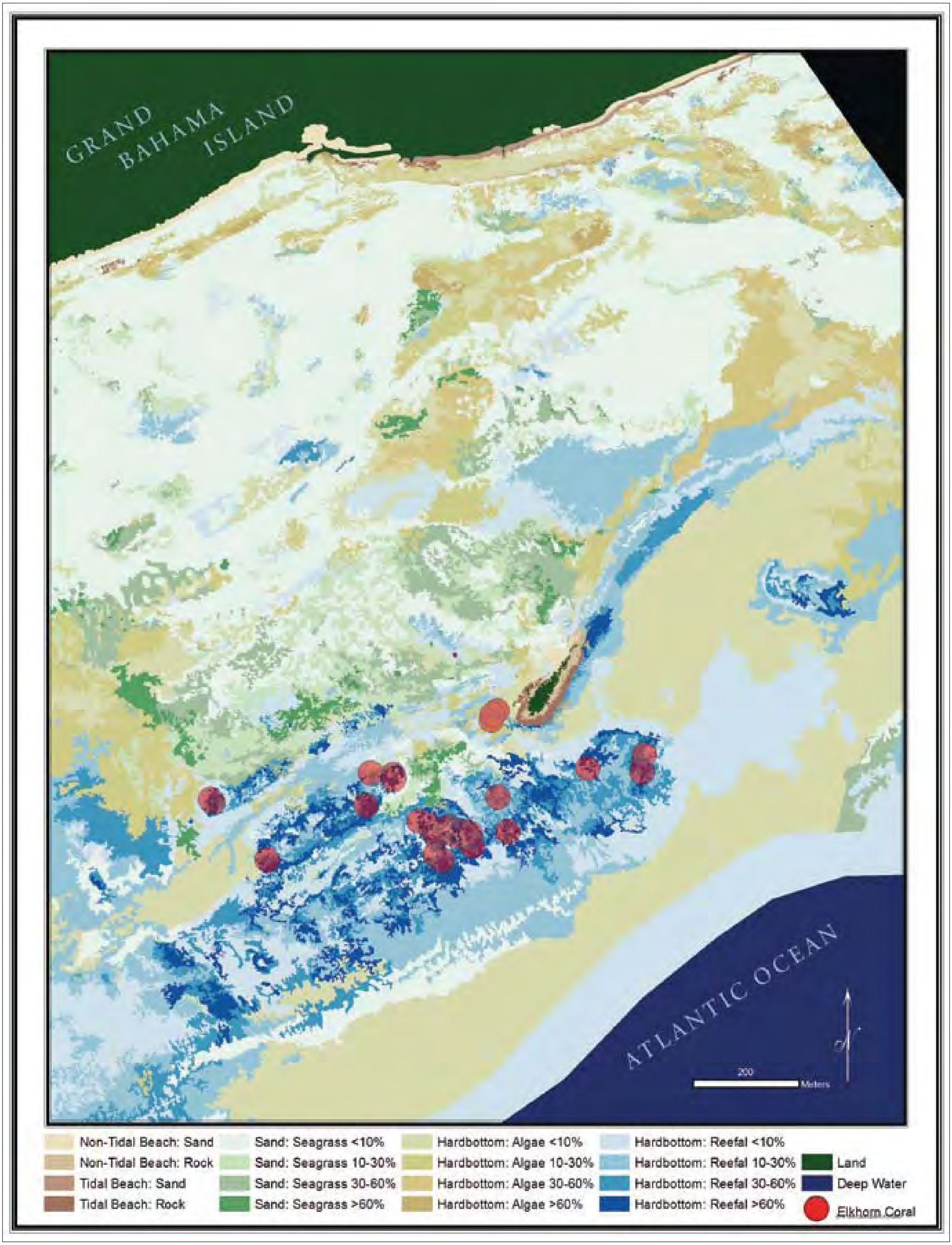

Map created by Barbara J. Brunnick

A mapping project of the coral reef and other benthic communities surrounding Peterson Cay, Grand Bahama, resulted in a highly precise map of habitat types and individual species location, such as the endangered elkhorn coral.

Setting a New Standard

Continued from page 28

Density variations of reefal hard bottom

Photos by Stefan E Harzen

For more information, contact Barbara Brunnick at brunnick@taras.org or Stefan Harzen at harzen@taras.org.

Acknowledgments

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This expedition would not have been possible without the support of Graham Torode, president and CEO of the Grand Bahama Development Company, who hosted the expedition and underwrote all of the expedition's finances. Thanks also go to the shareholders of Grand Bahama Port Authority, Limited (GBPA), and Grand Bahama Development Company (GB Devco) and especially to Sir Jack Hayward. Additional support came from Linda Osborne of International Underwater Explorers Society Ltd. (UNEXSO); Nakira Wilchcombe, environmental manager of the Grand Bahama Port Authority; and the Ministry of Tourism.

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Barbara J. Brunnick

Stefan E. Harzen

Barbara Brunnick serves as the director of the Research and Conservation Program of the Taras Oceanographic Foundation. She is well known for her groundbreaking research on Atlantic spotted dolphins in the Bahamas and her instrumental role in pioneering the use of georectified maps in conservation of marine and wetland habitats throughout the Bahama archipelago. Brunnick holds a doctorate in biology from Union Institute & University, Cincinnati, Ohio.

Stefan Harzen is a scientist, consultant, and entrepreneur who serves as the executive director of Blue Dolphin Research and Consulting, Inc., a distinguished science consulting firm working at the frontier of sustainability. Harzen's expertise includes marine mammals, coral reefs, and wetlands as well as natural resource management and sustainable business practices. He holds a doctorate in natural sciences from the University of Bielefeld, Germany.

Brunnick and Harzen, a husband and wife team, have been included in *Adventurous Dreams, Adventurous Lives,* a Who's Who of international exploration.

For more information on this topic, visit www.esri.com/training to learn more about *Creating and Integrating Data for Natural Resource Applications,* a Web course.

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Productivity, Accuracy, and Timeliness

Automating water crossing calculations benefits company's forest operations

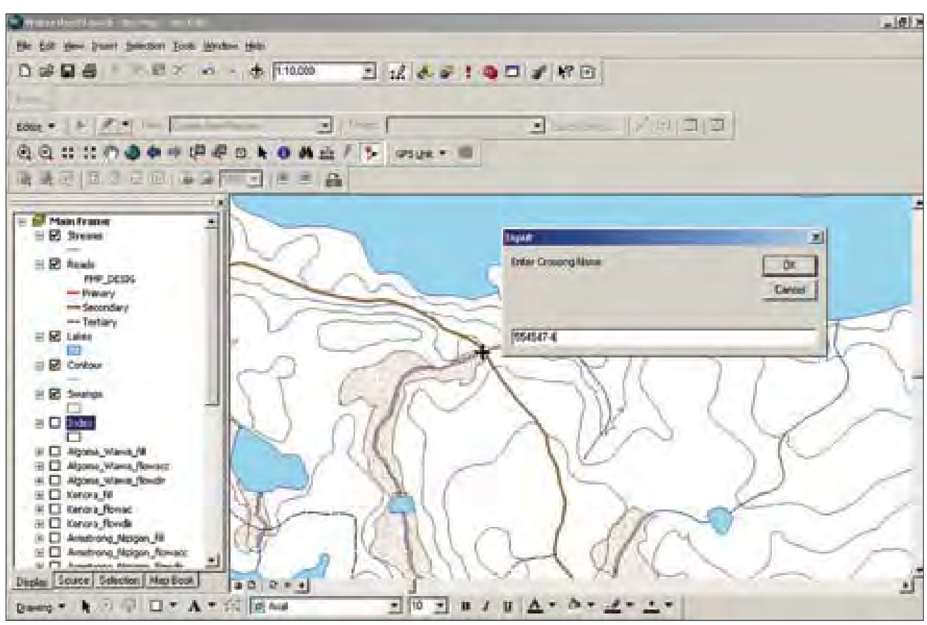
A large manufacturer of paper and wood pulp in North America has experienced a 75 percent increase in productivity since it incorporated GIS into its operations.

Domtar Corporation is the largest integrated producer of uncoated freesheet paper and one of the largest manufacturers of paper-grade market pulp in North America. *[Freesheet paper does not contain groundwood pulp and is a brighter white than paper made from groundwood.]* The company also operates Domtar Distribution Group, an extensive network of strategically located paper distribution facilities. The company also owns and manages more than half of the 15 million hectares of forestlands located in the province of Ontario, Canada.

Accessing forest resources in northern Ontario quite often necessitates building access roads and crossings for the many streams common in these areas—an expensive undertaking. Building stream crossings requires in-depth planning to determine the proper type of crossing (e.g., culvert or bridge) and proper size of crossing to be installed.

Prior to using GIS, forest operations staff members determined the drainage basin associated with each corresponding water crossing based on 1:50,000-scale maps. They used a dot grid overlay to determine the area of each corresponding drainage basin and associated area of lakes and swamps. This information was used with a formula that determined the proper size and type of crossing. Next, they produced a paper map showing the location of the proposed water crossing and its associated drainage basin to accompany the required paperwork. Depending on the location of a water crossing, the size of the drainage basin, and the experience of the person doing the calculations, it took one to several hours to complete calculations.

Domtar set out to improve the accuracy and timeliness of its road building activities by using GIS as a framework. The company created an application using both ArcObjects and the ArcGIS Spatial Analyst extension that automates the process of performing water crossing calculations. A proposed crossing location is identified by clicking on a map, and the application determines the associated drainage basin by analyzing raster layer data from Ontario Ministry of Natural Resources (OMNR). This layer includes hydrologically corrected digital elevation models (DEM) data, flow accumulation, and flow direction along with Domtar's forest resources data.



Foresters and forest technicians can click on a proposed crossing location, and the application determines the associated drainage basin by analyzing raster layer data. The data includes hydrologically corrected digital elevation model (DEM) data, flow accumulation, and flow direction along with Domtar's forest resources data.

Calculations for each water crossing now take as little as 10 to 20 minutes to process. The old manual approach usually required about an hour to perform the same calculations. This represents a 75 percent increase in productivity.

The resulting information is used to populate a Microsoft Excel spreadsheet that is used to predict crossing type and size. A page layout in ArcMap is exported as a PDF. Shapefiles of drainage basins and crossing location results can also be produced for future analysis.

The core users of the application are forest operations staff. They access the application through the ArcMap interface to identify proposed crossing locations. The results of their analyses are packaged up and submitted to OMNR for approval on an annual basis. Using GIS as a framework, forest companies are required to submit all operations information by December 31 to obtain approval to continue operations for the following fiscal year, which begins on April 1.

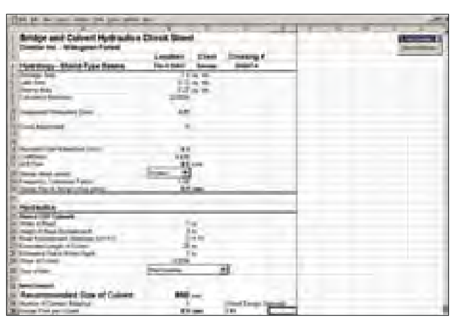
OMNR considers this information when deciding to grant approval for the construction of roads and harvesting of resources. The ministry also examines ways to safeguard forest areas against the negative impacts of roads, both in terms of creating increased access and contributing to forest fragmentation.

"Our water crossing analysis application has streamlined the approval process," said Paul Tremblay, manager of Information Technology at Domtar Corporation. "The Ontario Ministry of Natural Resources now receives a standard, computer-generated package for each water crossing application from the various Domtar locations across Ontario."

The process of determining the most suitable drainage basin and associated water crossing is now completed much more accurately. Using GIS in conjunction with the water crossing application, Domtar has been able to capture data at a scale of 1:20,000 or better.

The company has also been able to quickly test different scenarios when identifying preferred crossing locations. Often, there are several possible locations for every proposed major road. GIS helps analysts consider factors such as topography, geology, and proximity to harvest blocks. The water crossing tool allows them to easily check what culvert sizes are required at each location. This allows better planning and helps construct roads more effectively and has significantly reduced operating costs by allowing the selection of smaller water crossings when building forest access roads.

After processing the data about a proposed crossing, a page layout in ArcMap is created and exported as a PDF. Shapefiles of drainage basins and crossing location results can also be produced for additional analysis.



The results of crossing calculations can be used to populate a Microsoft Excel spreadsheet that is used to predict crossing type and size.

During two years of use, the application has undergone a number of improvements. Calculations for each water crossing now take as little as 10 to 20 minutes to process. The old manual approach usually required about an hour to perform the same calculations. This represents a 75 percent increase in productivity. Another important benefit is the ability to perform calculations on multiple crossings using batch processing. The forester or forest technician clicks a button to start the process and then is free to perform other duties while the computer performs the calculations.

Other benefits include more consistent results, fewer errors, and greater productivity. When users were asked to interpret information on individual maps, they often found that results would vary from one person to the next. For example, the drawn outline of a drainage basin based on contour lines on a map often differed from one to another. Factors such as user experience and time of day (or day of the week) often affected the interpretation of information. (e.g., results from Monday's work differed from Friday's work). This automated process has reduced incorrect information that results from misinterpretation of drainage basins and/or calculations of retention areas (i.e., water bodies and swamps), and these calculations can be generated in minutes rather than hours.

Future Plans

Eventually Domtar would like to provide this service to other forestry users by hosting the application on a GIS server and making it available via the Internet. The company expects the application will be popular with forestry companies in Ontario that use a manual approach to calculating water crossings. Although some forestry companies currently use GIS to assist in these calculations, they must manually digitize drainage basins and perform geoprocessing tasks that feed information into an Excel worksheet to determine appropriate culvert sizes. Because Domtar's application is fully automated, the company believes it can be applied to all forests in Ontario, regardless of who manages them.

"We hope to make this tool available to other forest companies and are confident that it will increase their operational efficiencies and reduce costs while at the same time minimize their impact on fish habitat and water quality," said Tremblay. For more information, please contact Paul Tremblay, Information Technology, Domtar Corporation, at Paul.Tremblay@domtar.com or visit www.domtar.com.

Acknowledgments

Tremblay acknowledges the work of Claude Joannette, business systems analyst at Domtar, in developing the tool and improving it over the years. "It's people like Claude that really make a difference to the continued success of this tool throughout our operations," said Tremblay.

Graduation Day, May 1984!

First office at Dupont & Young

First GIS project
Mineral Resources, 1985

First GIS Conference
1986

Late nights at the office

First copy of GIS Software

GIS training class
1988

City Planning Meeting

Celebrating the completion of the city project

EMBRACING YOUR PASSION FOR GIS

By Christopher Thomas, ESRI State and Local Government Industry Manager

I wrote this column for those of you who see GIS as your passion. Like many people, I was drawn to technology. In the mid-1980s, I was in my first job out of college. It was an okay job, but I was looking for something more. The company I worked for decided to use computers to improve their business, and in the corner of my office was a single "shared" HP computer that was hardly ever used.

This computer kept taunting me. One day when no one was looking, I turned it on. A blank screen with a single blinking DOS prompt greeted me—and dared me. Next to the computer was a stack of VHS tapes labeled "Learn dBASE." I took the tapes home and began teaching myself how to use a computer. Finding corporate America unfulfilling, I left that job a year later—but now I was intrigued with technology and what it had to offer.

After some soul searching, I decided I was destined to work in government. I wasn't quite sure of the particulars, but I knew it was the right thing to do. I began applying for government jobs and landed one in the planning department of Riverside County, California. On my first day, I looked in the corner of the office and saw a computer and that familiar DOS prompt taunting me. Next to the computer were several software boxes: dBASE and Symphony. A suite of products, including a word processing package, an electronic spreadsheet, and some other applications, was at my disposal along with some floppy disks containing 1980 decennial census data.

I was lucky to have a boss who encouraged me to use this computer. It was the only personal computer in an agency of more than 300 employees. I worked with it whenever I could. My boss was heading an initiative that was simply referred to as "the pilot project." It began as a county initiative to revolutionize the automation of mapping projects. This undertaking piqued my curiosity. On two floors of the county building, dozens of draftspersons were manually drawing maps. Eventually, I used the software to build statistical information for the pilot project.

After a short time, I left that county job and began to work for a Southern California city as a demographic planner. Primarily I worked on long-range planning, supported preliminary work for the 1990 Census, and helped establish the city's computer mapping system. Once again, in a corner of the office sat a lonely computer that was hardly ever used. It was the city's attempt to move into the computer age. It was the only computer in the department, and it was all mine.

> "...IT'S A CALLING WITH A MISSION TO MAKE THE WORLD A BETTER PLACE WITH A TECHNOLOGY LIKE NO OTHER."

Once again, a collection of software program disks were accumulating dust in a pile next to the computer. This time there were more gadgets including an electrostatic plotter for printing maps (a big piece of furniture no one ever turned on) and a digitizing table. I learned that we also had a machine called a minicomputer that was as large as two folding tables, and it ran just one piece of software called ArcInfo.

Finally, here was a mapping system that looked just like the pilot project I had worked on at the county. All this stuff was calling to me. I began exploring the software and equipment. I applied these technologies to the work on the preliminary 1990 Census that I was hired to do. I had to determine how to canvass more than 48 square miles by myself and report errors to the U.S. Census Bureau. In the end, I figured out how to use the computer mapping system to identify discrepancies that would eventually bring $2 million back into the city through federal funds.

I had found my calling in what I eventually learned was a geographic information system or GIS. Of all the technological paths I could have followed, GIS was the one that kept drawing me. It solidified my love of government work and kept me looking for problems that I could solve using GIS.

Do You See Yourself? By now, many of you may recognize yourselves in this story. The places, times, and projects might be different, but you were intrigued by GIS. Information technology got under your skin. Instinctively, you knew you could make a difference in people's lives with this software.

You may be one of the unsung heroes—those who produce GIS events for schools and the ones who get a glimmer in their eyes when they share what they know about GIS technology. You are the ones who cannot wait for GIS Day or the next opportunity to get together with like-minded individuals. You are the people who make a difference in delivering better government daily—and you wonder if the world knows you even exist.

Today, GIS technology is more prevalent. There is a computer on every desk in the workplace. ArcInfo runs concurrently with many other programs on much smaller, more powerful machines. Yet it still takes a local GIS hero to recognize that GIS is a tool that can solve many problems.

In the midst of a recession, opportunity knocks. GIS technology can and will help governments deal with reduced resources and the need to deliver the services constituents demand. You will figure out how to do more with less using GIS technology. You'll learn how to add to revenue streams in your jurisdiction, increase productivity and efficiency, and evolve business processes with GIS technology. Those of you who see yourselves in this article know that this is an opportunity to showcase your skills. You have acknowledged that this isn't just a job; it's a calling with a mission to make the world a better place with a technology like no other.

YOU KNOW WHO YOU ARE. YOU KNOW WHAT CAN BE DONE. LET'S KEEP GOVERNMENT MOVING WITH GIS!

Illustration by Fred Estrada, ESRI

Less Chatter, More Work

RESTful architectures and heavy lifting with ArcGIS Server

By David Bouwman and Brian Noyle, DTSAgile

Representational State Transfer (REST) has become one of the darling architectural principles of the technology community of late. The central principles of a RESTful architecture focus on the use of addressable resources in standard resource formats. The HTTP protocol provides the interface for interacting with those resources (via the four HTTP verbs: GET, PUT, POST, DELETE).

There is no greater argument for the success and appeal of REST architectural principles for the geodeveloper than ESRI's embracing of REST in its release of the ArcGIS Server REST API at version 9.3. While the ArcGIS Server REST API provides a concise and intuitive API for use in the construction of high-performance, client-focused GeoWeb applications, there are times when the use of this API either doesn't offer the functionality needed to accomplish a required function or the REST API is not optimal for accomplishing that function.

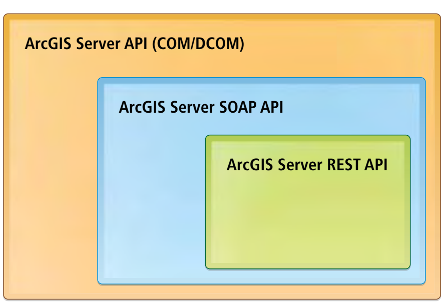


Figure 1: The functional hierarchy of the ArcGIS Server-side APIs

What You Can't Do and What You Can Do Better

An examination of the functionalities exposed by the ArcGIS Server-side APIs reveals the hierarchy of relative functional richness illustrated in Figure 1.

The ArcGIS Server SOAP API offers a subset (albeit a very large one) of the aggregate functionality offered by ArcGIS Server, while the ArcGIS Server REST API offers a subset (and still a pretty impressive one) of the functionality exposed by the SOAP API.

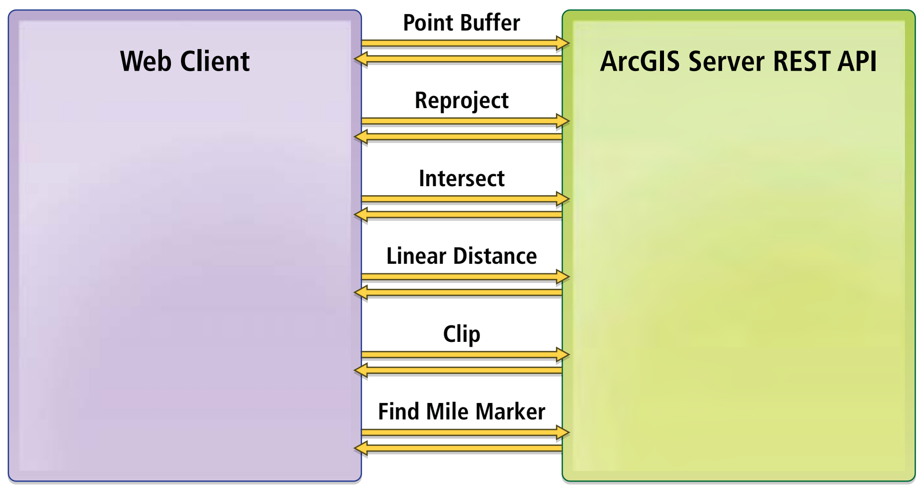


Figure 2: A classic example of calls to server-side resources in a "chatty REST" application

Not surprisingly, there are simply some tasks the developer cannot accomplish via the REST API. Geodevelopers frequently need an alternative solution that will keep their RESTful architecture intact while still allowing them to meet system functional requirements.

In addition, consider the following scenario: a developer needs to implement functions that allow a non-GIS user to locate a point along a linear feature by clicking on a Web map with a minimum of friction and limited exposure to GIS operations. The actual GIS involved in this theoretical operation might look something like this:

1. Take a user-specified point and buffer it.
2. Reproject the buffer to a different spatial reference and hold on to the geometry.
3. Use the reprojected buffer geometry to intersect a roads layer and get a road.
4. Use the road polyline geometry and find the distance along the road where the buffer first touches it.
5. Use the distance to clip the road polyline to produce a new polyline feature describing the affected road feature up to the point of intersection.
6. Return the polyline geometry and the distance along the polyline to the client for rendering.

This is just an example to make a point, but it makes that point well. The RESTful calls to server-side resources are represented in the diagram in Figure 2.

This is the classic example of "chatty REST." Why is this an issue? Non-GIS users (a transportation manager in this scenario) do not care about the specific operations involved in helping them do their job. They want to click the map, have a portion of a road segment become highlighted, and see a mile marker value.

With so much going on in the client, business logic is bound to slip in:

When the client gets one of these individual responses back, how does the response get validated before continuing along the operation chain?

How will this code be unit tested if it resides in the client?

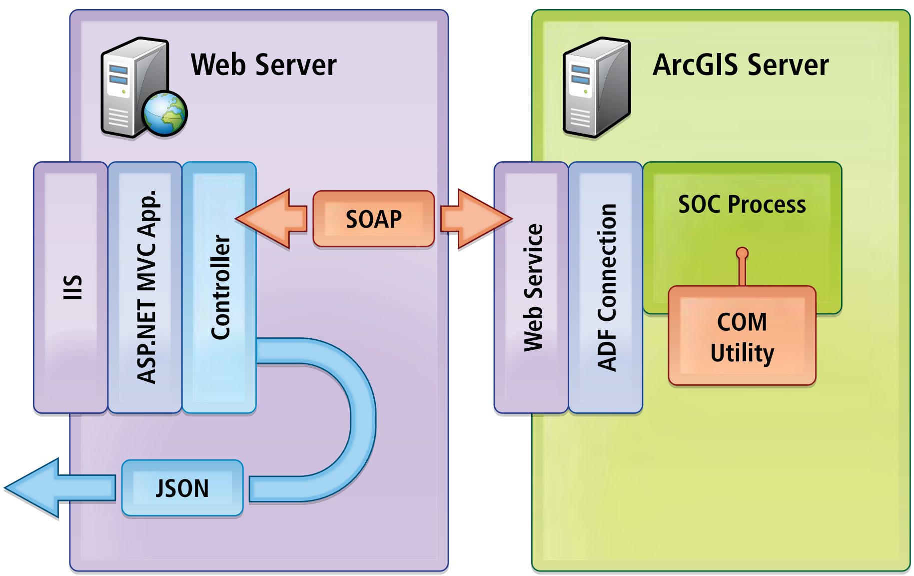


Figure 3: An alternative solution to the developer's functional problem that remains RESTful to the consuming client

Not surprisingly, there are simply some tasks the developer cannot accomplish via the REST API. Geodevelopers frequently need an alternative solution that will keep their RESTful architecture intact while still allowing them to meet system functional requirements.

In addition, while RESTful architectures are definitely high performing (usually), all this chatter on the wire suffers from latency—latency in transfer and latency in serialization/deserialization at the endpoints. There is a better way.

Getting Your REST, and Still Getting Something Done

Consider the diagram in Figure 3. It shows an alternative solution to the developer's functional problem previously described while remaining RESTful to the consuming client.

Let's take a closer look at what's going on.

1. In this architecture, the user map click initiates a call to a well-known resource URI (http://mysamplewebsite/roadInfo/get or http://mywebsite/lineclipper, etc.) on the Web server.
2. Microsoft IIS hands off the map coordinates (x,y) to ASP.NET MVC. The Routing engine within MVC in turn directs the request to the GET method on the RoadPoints controller. (By the way, an MVC Controller method is just a convenient and cogent example; any REST resource will do; Windows Communication Foundation [WCF] provides another option. The point is to make this first hop look RESTful to a client application.)
3. The MVC Controller class uses SOAP to call a traditional WS-* Web service on the ArcGIS Server box.

   The Web service on the ArcGIS Server box uses an Application Developer Framework (ADF) 4 connection to access a COM utility or server object extension (SOE) running inside an ArcGIS Server server object container (SOC) process.
4. The custom COM utility or SOE does all the buffering, reprojecting, and intersecting (all the GIS "stuff" we're hiding from the user) using ArcObjects.
5. The result is returned to the Web server, converted to JavaScript Object Notation (JSON) by the Controller class, and sent back over the wire as JSON for rendering in the client.

What It Gets You

In short, the six-step GIS process described at the beginning of this article has been abridged to "Here's a point, hand me a road segment and a mile marker." The architecture has transferred what would have been client workload into an MVC Controller class and a Web service on the server side, reducing chatter on the wire and increasing performance. GIS operations have been turned over to custom ArcObjects code (read: fast). In addition, two other important things have been achieved through this architecture:

- It encapsulated business logic where it belongs.
- It increased the testability of the application by keeping complex functionality out of the client.

Continued on page 38

Less Chatter, More Work

Continued from page 37

Conclusion

The presence of SOAP, WS-*, and ADF in an architectural diagram for a REST article may raise some eyebrows, but recall that all that matters is how the original resource request looks to the client application. REST prescribes access to information via addressable resources; it does not dictate internal implementation. The client sees a REST resource and gets the answer the user wants quickly.

Much has been written in the ESRI realm about the power and usefulness of COM utilities and SOEs. Developers and architects need to remember that the RESTful nature of application architecture need not stop where the ESRI REST API toolbox does. That's the beauty of REST: it allows developers to bolt together high-performance, URI-based services and application components that may or may not be of their own making.

That's the beauty of REST: it allows developers to bolt together high-performance, URI-based services and application components that may or may not be of their own making.

Providing server-side components, accessible via a REST resource, in this way is an excellent means of developing focused, user-friendly applications with advanced capabilities not currently available in the ArcGIS Server SOAP and REST APIs. Furthermore, this approach hides complexity from the user, delivers high performance, and represents a simple reorganization of ESRI technologies most GeoWeb developers are already used to using. For more information, contact

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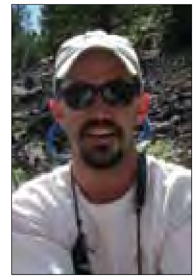

Brian Noyle

About the Authors

David Bouwman has been designing and developing GIS software for the last 12 years. His projects have ranged from small Web sites to statewide enterprise forest management systems. Over the last few years, he has been leading a team of developers in the pursuit of great software built in a sane manner. The combination of an agile process with pragmatic development practices taken from extreme programming has led his firm to develop a highly optimized methodology for creating solid software. When he is not attached to a computer, Bouwman is often found mountain biking on the trails around Fort Collins.

Brian Noyle originally trained as a global change biologist and tundra botanist. He has nearly 10 years' experience as a GIS software developer and architect. His professional and technical interests are primarily focused on moving clients toward more standard architecture and development practices and patterns to facilitate a closer integration of GIS with the standard IT enterprise. Noyle has extensive experience in full software life cycle management with a focus on delivering through agile project management methods. When he's not in the office, he can be found on his mountain bike, picking a bluegrass lick on the guitar, or standing in a river waving a stick (at trout).

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Report from the Development Frontlines

Developers present at DevSummit

Created for Developers by Developers, the tagline for the ESRI Developer Summit (DevSummit) was even more applicable at the 2009 event. In addition to the opportunities for networking with ESRI staff and each other, developers attending the conference gave presentations for the first time.

The conference, in its third year, was held in Palm Springs, California, from March 23 to 26 and drew nearly 1,100 developers. In addition to presentations by ESRI developers and management, developers attending the conference gave presentations that not only showcased successes but promoted better development processes. Brian Noyles of DTSAgile had the distinction of giving the very first developer/user presentation. *[See the accompanying article, "Pleasing Bosses and Customers—A compelling case for ASP.NET MVC."]*

Dave Bouwman, also from DTSAgile (davebouman.net blog) covered the key ideas underlying unit testing and the design patterns that facilitate testing in his presentation "Unit Testing 101." Bouwman's presentation extended Brian Noyle's customer-centric theme, detailing best practices for a thorough, sensible, and incremental approach to creating bombproof software before its release.

Rally Software CTO Chris Spagnuolo offered a similar perspective with his presentation on agile software development. His session supplied a brief history of agile and illustrated how agile practices trump other software development methodologies. Bouwman, Noyle, and Spagnuolo all advocated more intelligent software testing and highlighted tools and best practices that make testing easier than ever.

Several presenters showcased their work with ArcGIS Server and the APIs now available from ESRI. Sreejith Parthasarathy from the City of Philadelphia used ESRI's Flex Viewer to create Map Plugin, a program that lets departments throughout the city share Web services and various data resources on an enterprise level. Vish Uma from Timmons Group showed how he used server object extensions (SOEs) to provide developers with a fast, reliable, and scalable way of building GIS solutions using ArcGIS Server.

Continuing the API theme, RSP Architects' James Fee (James Fee GIS Blog) presented on OpenLayers. Fee advocated the use of the ArcGIS Server REST API to access the OpenLayers library and walked the audience through the process of creating an OpenLayers Web application from scratch.

On the mobile solutions front, Bill Bott from Telvent Miner and Miner presented on his use of the Microsoft Composite Application Library (CAL), a freely available framework for building Windows Presentation Foundation (WPF) applications. His presentation covered the primary components of CAL and how they can be easily combined with the ArcGIS Mobile Application Development Framework (ADF) to create an extensible and powerful mobile application.

A new feature to the ESRI Developer Summit, this year's 12 user presentations were a launching point for discussion and collaboration. Lively question and answer sessions followed these presentations. Many attendees stayed after each presentation to meet the speakers and converse with peers.

"It was great to see how people were using ESRI technology to solve their real-world problems with innovative solutions," said Fee. "So much of what we were shown was about delivering value to our users and how we can change workflows to improve our responsiveness to them." Plans are already under way to expand the user presentations at next year's DevSummit.

Pleasing Bosses and Customers

A compelling case for ASP.NET MVC

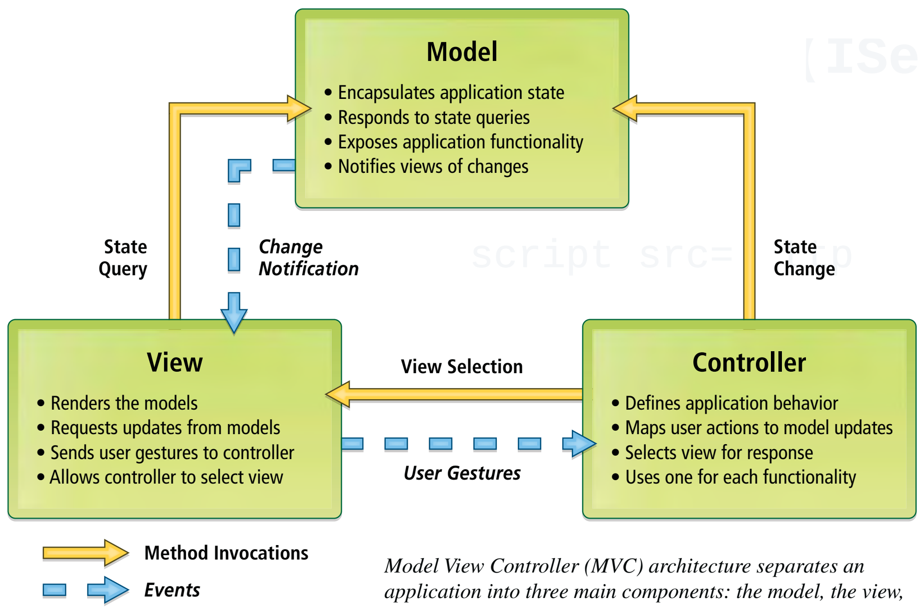
By Matthew DeMeritt, ESRI Writer

Although it was called "RESTful Apps with Microsoft ASP.NET MVC," the first user presentation at an ESRI Developer Summit (DevSummit) could have just as easily been titled "Pleasing Your Bosses and Customers." Given the importance of bosses and customers in dictating developer decisions, it's little wonder that more than half the slides in DTSAgile developer Brian Noyle's presentation at the 2009 DevSummit contained images of, you guessed it, bosses and customers.

Noyle's presentation demonstrated DTSAgile's efforts to increase the quality of its GeoWeb applications using a RESTful architecture with ASP.NET MVC. *[MVC refers to Model View Controller, an architectural pattern that separates an application into three main components: the model, the view, and the controller.]* According to Noyle, the Web 2.0 tools that ESRI and Microsoft have produced eliminate much of the noise that can complicate development and the user's Web mapping experience. In the last year, ArcGIS Server, ASP.NET MVC, and a handful of other advances in API technology have combined to facilitate the creation of fast, focused Web mapping applications, simplifying the developer's toolbox and greatly speeding the development process.

> "The beauty of a Model View Controller architecture in general is that it enforces from project inception a compartmentalization of data, logic, and UI without compromising the functionality end users require."

A preconfigured development approach eliminates common (and ultimately unnecessary) design decisions from the outset. "ESRI and Microsoft have created technology that allows us to develop very rapidly in a predefined architectural paradigm that makes a lot of the decisions for us," said Noyle. "This helps move development forward very quickly."



Model View Controller (MVC) architecture separates an application into three main components: the model, the view, and the controller, and upholds the "separation of concerns" programming paradigm.

Solving a Classic Problem

To demonstrate the clarity that an MVC architecture offers developers, Noyle compared the classic Active Server Pages (ASP) and ASP.NET Web Forms programming models to the ASP.NET MVC model. Classic ASP and Web Forms applications tend to violate the programming paradigm known as the "separation of concerns." As a code base evolves in classic ASP programming or Web Forms, business logic becomes mixed with presentation logic in the user interface, data access bleeds into the business layer, and so forth. Markup for these applications can get messy and noncompliant in a hurry since the developer does not exercise full control over the emitted HTML. There are as many flavors of browsers as flavors of ice cream these days, so what's the likelihood that page will render on everyone's desktop? Not likely.

"The beauty of a Model View Controller architecture in general is that it enforces from project inception a compartmentalization of data, logic, and UI without compromising the functionality end users require. MVC separates typical developer concerns, isolating them into buckets of information within the application where they should be," Noyle said. Application data provided by a data access layer stays within the domain layer (or the M of MVC). User interface elements for rendering and presentation are explicitly isolated in one to many views (the V). And a suite of controller classes orchestrates the trip from database to view and back again (the C). Because humans like HTML, but machines like binary, JSON (JavaScript Object Notation), XML, or code on demand supporting multiple representations of data or features is no problem with ASP.NET MVC because it separates concerns while giving the developer full control over the HTML.

Noyle acknowledged that not all projects benefit from an ASP.NET MVC solution (a static content site with simple mapping, for instance). However, many applications are data driven and require advanced mapping functionality. Tackling those applications in ASP.NET MVC makes the most sense.

Better Bombproofing

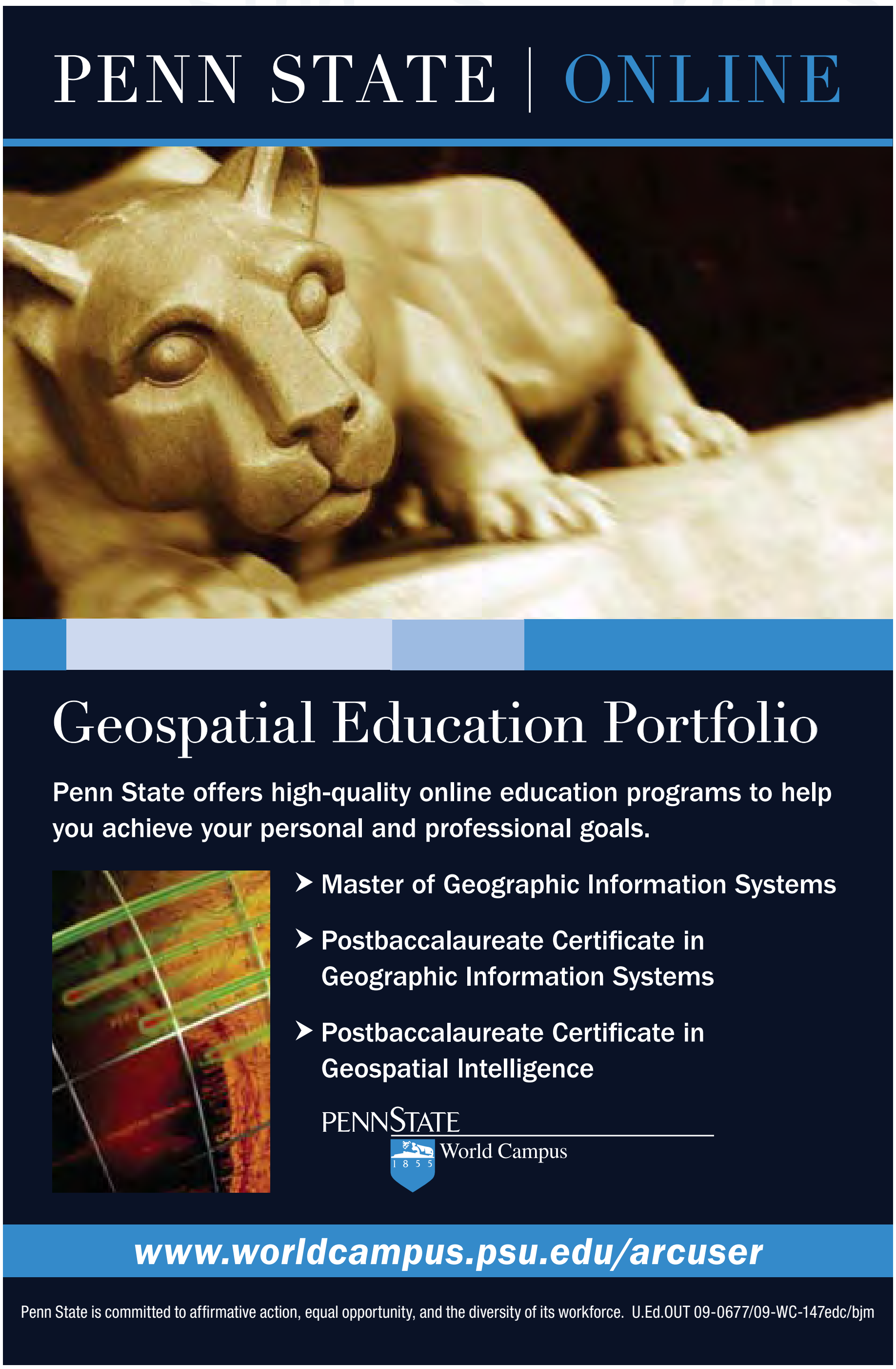
According to Noyle, MVC facilitates much more robust and reliable unit testing than Web Forms or classic ASP programming typically allow. "Plain and simple, ASP.NET MVC was designed and built to produce testable software. If Microsoft thinks it's important, then developers should think it's important."

Typically, DTSAgile will create points of entry (separate C# projects) in its code base for the automated testing of application components. Application models, controllers, and all supporting services get tested a lot. MVC allows developers to set up automation in which a simple mouse click can run nightly tests that answer questions such as

Does the application code function as it is supposed to today?

Did I fix something that broke something else?

"If I run it at five o'clock again tomorrow and something fails, I know something that I have written today has broken the application and I need to hunt it down," Noyle said. "Automated monitoring and regression practically ensures code quality from start to finish."



What About the Maps?

While this was a GIS developer conference, Noyle's message was not primarily mapcentric, and with good reason. "DTSAgile tries to follow the KISS *[Keep It Simple Stupid]* principle when choosing a map canvas for its applications," said Noyle. "What is the simplest technology I can use to satisfy the user's requirements? DTSAgile builds very focused, high-performance applications for clients so the map canvas, and nearly all associated code that drives it, usually winds up in an ASP.NET MVC view, specifically as JavaScript code.

"Very rarely will I use server controls when building mapping applications," continued Noyle. "We code against the ArcGIS Server REST API wherever possible, and if we need to build advanced spatial functionality, we will typically surface it as a REST resource—not surprisingly as an ASP.NET MVC Controller method—that calls a custom server object extension or COM utility." Near the end of his presentation, Noyle showed an abundance of mapping applications that used ArcGIS Server APIs for REST and JavaScript, and the ArcGIS Extension for Microsoft Virtual Earth API, and OpenLayers. "ESRI and other vendors have made mapping so easy for us that we can now focus on tailoring applications to customers' specific needs."

Should Noyle's customers care about the MVC architecture, compliant HTML, RESTful access to mapping resources, or all the unit testing that go into producing one of his applications? Not according to Noyle.

"The bottom line is that we have seen a paradigm shift in expectations since Google Maps shipped in 2005. As an industry collective, we need to realize that our bosses, our clients, and our users expect fast, robust, focused apps that provide relevant information right now. They don't care about the bits and bytes that do it." Perhaps it is appropriate, then, that Noyle's presentation, focusing on technology examples and architectural patterns and practices to increase development velocity and code quality, brought developer focus back where it belongs: to users and clients.

Mashups and Mobile Solutions

Code challenge contest expands

By Matthew DeMeritt, ESRI Writer

This year developers could impress and inform their peers and compete for cash prizes by submitting original code samples in not one, but two, contests.

The ArcGIS Code Challenge has been part of the ESRI Developer Summit since the conference began in 2006. This year's contest was split into the ArcGIS Server Mashup Code Challenge (using the ArcGIS Server APIs) and the ArcGIS Mobile Code Challenge (using the ArcGIS Mobile Software Development Kit [SDK]) to better represent the multiple development environments available to developers on the ArcGIS platform.

The ESRI developer community—ESRI Developer Network (EDN) subscribers, business partners, and selected current and past attendees of the Developer Summit—selected the two winners for each contest from a total of more than 30 entries. The winners were announced at the 2009 ESRI Developer Summit.

See Alper Dincer's first place ArcGIS Server Mashup Code Challenge entry, Summit ExtMap—Mashup Framework, in action on YouTube (/www.youtube.com/watch?v=kVc3RR2KDZY).

ArcGIS Server Mashup Code Challenge

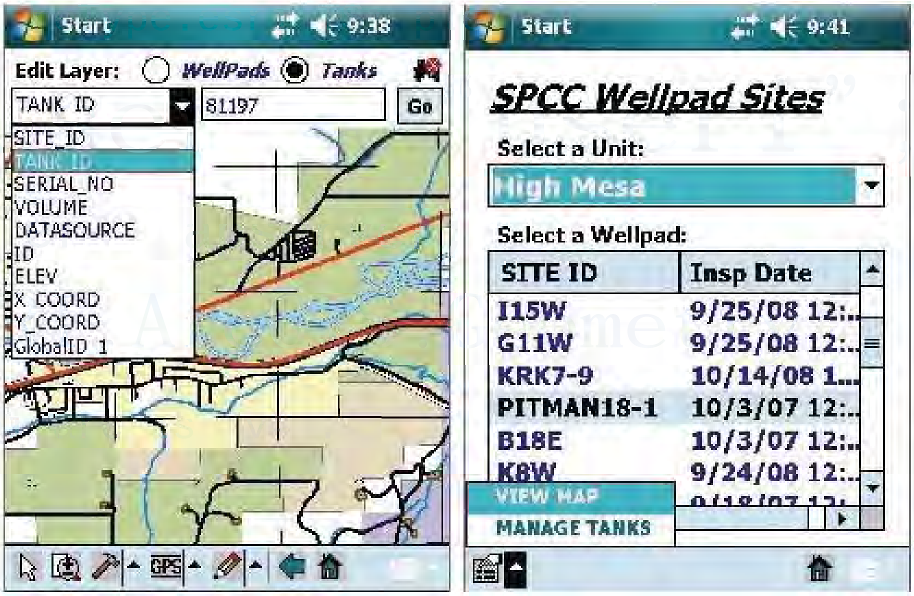
Alper Dincer, a Web developer at the Ministry of Environment and Forestry in Ankara, Turkey, won first place and the $7,000 award for his entry, Summit ExtMap—Mashup Framework. His application is a mashup framework based on Ext JS Framework, Google Maps API, and the ArcGIS API for JavaScript Extension to the Google Maps API.

With this application, users can add and remove layers supplied by ArcGIS Online and select basemaps from Google and Microsoft Virtual Earth. The application's well-designed user interface offers tools that perform geocoding and reverse geocoding, find altitude by clicking on the map, add data/services, query layers by attributes, and configure map settings.

"The main goal of our mashup is usability rather than performance, and the inspiration point was ArcGIS Desktop ArcView," says Dinçer. "We wanted to make a primitive Web version of ArcView. I hope both developers and users download the source code, use it in their projects, and share their ideas about it with us."

Matthew Petre, a software developer at Petris Technology in Houston, Texas, won the second prize and $3,000 for his Flex Viewer Dice Job Searcher Widget. He created this application in eight hours using the ArcGIS API for Flex. It allows users to search for job postings using

Matthew Petre, a software developer at Petris Technology in Houston, Texas, won second place in the ArcGIS Server Mashup Code Challenge.



Lisa Tunnel's Environmental Compliance Field application can be used to perform inspections for environmental compliance for mining, oil, and gas sites.

Lisa Tunnel won first place in the ArcGIS Mobile Code Challenge.

Dice and visualize this information on ArcGIS Online basemaps.

"I was eager to work with the ArcGIS Flex API *[so]* the code challenge was a perfect excuse to try some creative things with Adobe Flex and the ArcGIS API for Flex," said Petre. "I believe I created an application that showcases the power of Flex, the performance of the ArcGIS API for Flex, and ease of development for both. We are now evaluating the ArcGIS APIs for JavaScript, Flex, and Silverlight as possible solutions to create richer user experiences for future *[product]* releases."

Chad Yoder took second place in the ArcGIS Mobile Code Challenge with the ArcGIS Mobile Backup and Restore Utility. It provides a way to export and import changes from an ArcGIS Mobile map cache.

ArcGIS Mobile Code Challenge

Lisa Tunnel, software developer at Digital Cartographic Services in Denver, Colorado, won first place in the ArcGIS Mobile Code Challenge for her Environmental Compliance Field application and received the $4,000 prize.

"My organization entered the ArcGIS Mobile Code Challenge because we felt it would be an opportunity to showcase some of the mobile tools we've developed using ArcGIS Mobile 9.3," said Tunnel. "The code challenge is a great idea because it allows the mobile developer community to see what others are implementing and how it can be accomplished."

Tunnel's application can be used to perform inspections for environmental compliance for mining, oil, and gas sites. Users can turn layers on and off; select which layer to edit; sketch geometry; walk (GPS) geometry; search a layer based on attributes; select a feature to delete or modify; and pan, zoom, and identify.

Chad Yoder, software developer at GeoCove in Orlando, Florida, received the $2,000 second place award for his ArcGIS Mobile Backup and Restore Utility.

"We found a serious need for all mobile application users to be able to recover their work, should something happen to their original cache," said Yoder. "There are no out-of-the-box tools for data recovery from an unsyncable cache, so we built one and decided to share it with the developer community via the code challenge. I think the code challenge is a great way to inspire developers to share their ideas and tools."

Better Tools for Developers

ESRI's ArcGIS platform continues to evolve and provide the APIs and tools to build next-generation GIS Web and mobile applications that are specifically designed for different deployment scenarios.

The ArcGIS Code Challenge illustrated the technological leaps made since last year's Developer Summit. With the beta release of the ArcGIS API for Microsoft Silverlight, the developer community will continue to produce many GIS applications with compelling graphics, tighter data integration, and streaming audio and video.

"It's inspiring to see so many creative and useful applications come from the challenge," said Jim Barry, program manager of the ESRI Developer Network (EDN). "The code challenges are a great way to incentivize developers to share tools, ideas, creativity, and code with the community. Over the past year, there has been an increase in the exchange of code among our community, and we encourage developers to continue this trend."

Effective Web maps have a specific focus and are designed so users can interact with them to accomplish meaningful tasks.

Five Steps to Better Performance

Sample methodology for creating a great Web map

By Bronwyn Agrios, ESRI Education Services

Optimized Map Service, a new map service type available beginning with ArcGIS 9.3.1, significantly boosts the performance of dynamic operational layers in Web maps. This article steps through a new recommended workflow for Web map design that takes advantage of the performance improvements in ArcGIS 9.3.1 and introduces the new Map Service Publishing toolbar.

The sample workflow described in this article goes through the stages leading up to and including application development. The workflow is summarized in the following five steps:

Step 1: Think about the application and its users.

Step 2: Design maps for Web applications.

Step 3: Tune maps to optimize request performance.

Step 4: Save maps and publishing layers.

Step 5: Visualize basemap and operational services in a Web application.

These steps use publicly available data from the ArcGIS Online servers. Readers who have their own data and an installation of ArcGIS Desktop and ArcGIS Server with the permissions to create services can follow these steps. For more information on the application design process, see the ArcGIS Desktop help topic "Steps for implementing GIS map applications" located in the book *GIS servers and services > Creating and publishing Web maps for ArcGIS Server.*

Step One

Think about the application and its users

As any good project manager knows, projects should be planned before they are started. Before developing a map-based Web application, spend some time thinking about the application users and how they can best be served by this application. Consider the following questions:

What is the business need/purpose of the Web mapping application?

Who are the end users?

Is this an internal or external Web site?

What data will be included in the application?

How will the data be used? Visualization? Spatial query? Attribute query?

Will the data be used with other services to create a mashup?

Answering these questions will help narrow the focus of the application and develop maps and tools for specific tasks. These will also serve as a guide through the process of envisioning the project and will lead more quickly to a successful result.

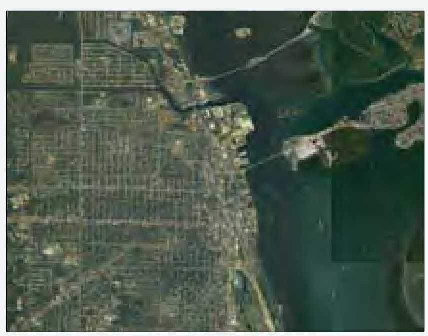
Step Two

Design maps for Web applications

Following best practices for Web map design, the maps used in this application will be divided into a single cached base layer and multiple operational layers, both cached and dynamic. All content should

- Employ strong cartography.
- Use scale dependency to enhance performance and improve clarity.
- Maintain the identical coordinate systems for all map layers used in the application.

Cached NGS_Topo_World_2D basemap from ArcGIS Online



Cached ESRI_Imagery_World_2D basemap from ArcGIS Online

Cached ESRI_StreetMap_World_2D basemap from ArcGIS Online

Separating data into basemap and operational layers is the most important step in establishing a well-performing Web mapping application. Basemaps provide a spatial context for an application by supplying general supporting information. Prebuilt basemap layers from ArcGIS Online are used in this example.

Building basemaps and operational layers

Basemaps provide a spatial context for an application by supplying general supporting information. Typically this information does not change frequently. With the exception of imagery basemaps (which may also be served dynamically using ArcGIS Image Services), basemap services are always cached.

These maps are either developed in-house or accessed from public GIS servers such as ArcGIS Online. Imagery, a collection of hydrography layers, or a collection of street map layers are examples of basemap layers.

Operational layers supply the specific data that is queried to perform both decision-making and task-based functions. Because the data supporting operational layers may change frequently, operational layers are often served dynamically.

Customers and customer locations, sensor feeds, and work orders are examples of operational layers. Operational layers may also contain the results from analysis, features that require editing, or new data that needs to be made available to map application users.

Separating data into basemap and operational layers is the most important step in establishing a well-performing Web mapping application. It allows the majority of the map layers that provide base data to be cached. Only a small percentage of the data will be served as dynamic, operational layers.

Continued on page 46

Five Steps to Better Performance

Continued from page 45

For more information on designing basemap and operational layers in ArcMap, see the ArcGIS Desktop help topics "How to build online basemaps" and "Building operational map layers" located in *GIS servers and services > Creating and publishing Web maps for ArcGIS Server.*

Step Three

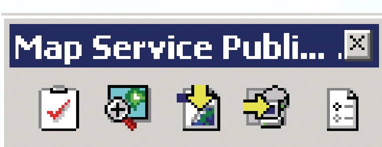
Tune maps to optimize request performance

The next step is analyzing the performance of the layers in the map document using the Map Service Publishing toolbar. This toolbar, introduced with the ArcGIS 9.3.1 release, adds new functionality. The general workflow for optimizing request performance is

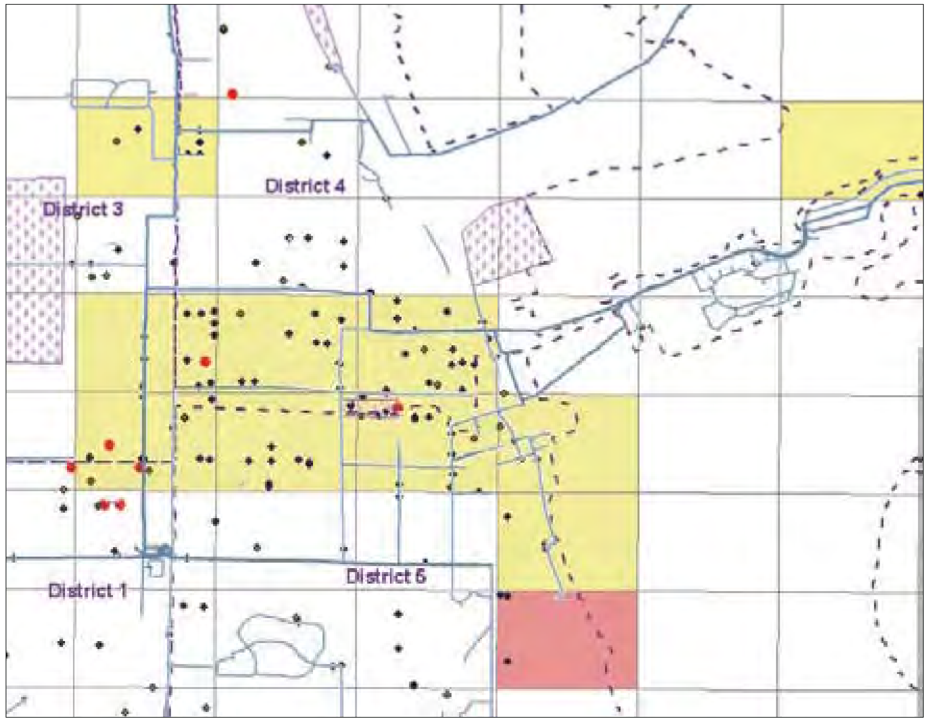
1. Analyzing the document and identifying performance improvements
2. Implementing the recommended changes
3. Saving the map document (.mxd) file and publishing it to ArcGIS Server or saving a new optimized map service definition (.msd) file and publishing the .msd file to ArcGIS Server

Examine the Map Service Publishing toolbar

Before optimizing map layers, start ArcMap and open the Map Service Publishing toolbar. The tools in this toolbar are described in the accompanying table.



The Map Service Publishing toolbar



An example of an optimized operational layer served dynamically. The water district operational layers are updated daily so users can access current information and toggle the visibility of layers.

Name	Function
Analyze Map	Examines the map contents, provides suggestions for improving performance, and returns errors for layers and properties incompatible with the optimized drawing engine
Preview	Draws the map using the new ArcGIS 9.3.1 optimized drawing engine; provides an idea of how fast the map will draw and whether the new drawing engine has changed the look of any layers
Save Map Service Definition	Saves map document (.mxd) as an optimized map service definition (.msd) file
Publish To ArcGIS Server	Creates map service definition file (.msd) on the server (arcgisserver\arcgisinput folder) and publishes the .msd file to ArcGIS Server; requires the same administrative privileges as other publishing methods
Options	Options for improving the quality of text and line work in the map

Tools on the Map Service Publishing toolbar

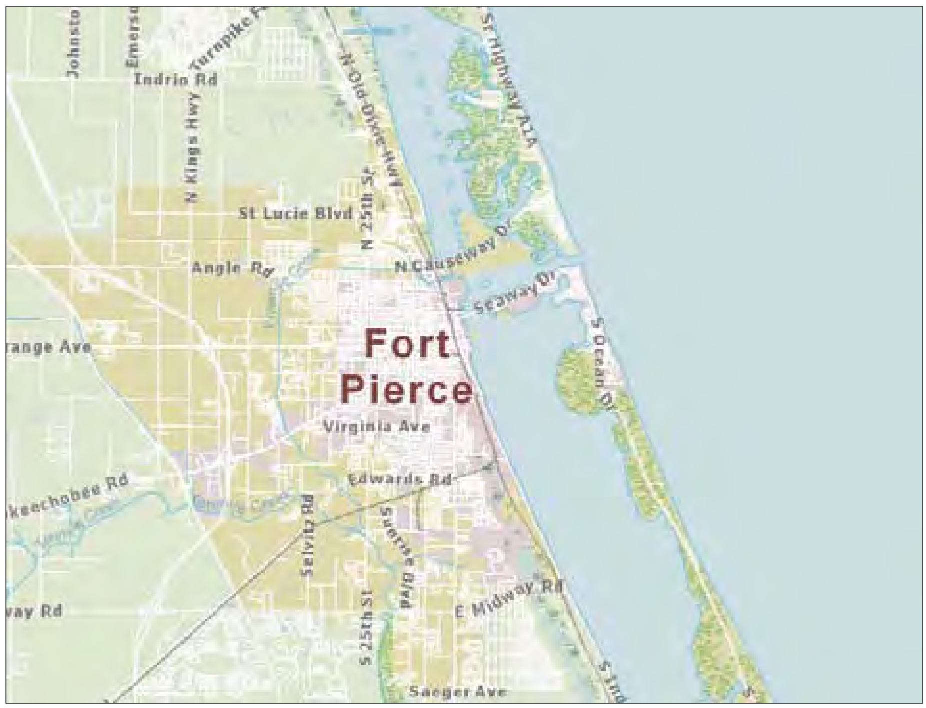
Analyze and preview the map

First optimize the basemap layers using the Analyze tool.

1. Click Analyze and notice that a dialog box opens at the bottom of the ArcMap session. This dialog box, called Prepare, contains errors, warnings, and messages. All errors must be fixed before saving an MSD (map service definition) file.
2. Right-click on any errors and examine the options available in the context menu to fix the error. Right-click on warnings and messages to view suggestions.
3. Click Preview. The Preview window tests the draw time of the map at various scales. An optimized map should draw in less than one second. The image type can be changed (e.g., JPEG, PNG32) and the quality of the display examined.
4. Repeat these steps for all maps containing operational layers. Optimized operational layers will be published to ArcGIS Server and served dynamically. Optimized basemap layers will be published to ArcGIS Server and cached.

Error	Warning	Message
Data is not accessible.	Layer is being projected on the fly.	No scale dependencies set
Map does not contain a spatial reference.	There is a missing spatial index.	Notification of possible symbol appearance differences

Common results of map performance analysis for each of the three categories



Optimized basemap layers that will be published to ArcGIS Server and cached

Step Four

Save maps and publishing layers

How the map will be used and the type of data it contains will determine whether to save the map as an MSD or MXD.

Save as an MSD if

- The published map service will be served dynamically and only have capability requirements of mapping, KML, or Web Map Service (WMS).

Save as an MXD if

- The map uses layers that are not supported by the 9.3.1 optimized rendering engine, such as Maplex labels or cartographic representations, or the published map service needs to support analytic capabilities such as geoprocessing.

Dynamic services published from an MSD provide an alternative to cached map services. MSD-based dynamic maps have drawing performance equal to or better than an equivalent ArcIMS map service and provide users with the flexibility to toggle the visibility of map layers and access updates on demand. To achieve the best map rendering performance, take the time to cache map services.

Saving and publishing an optimized map service from ArcMap

Although the basemap will be cached, the service will be published from an MSD to support faster initial cache creation and tile updates. Use the information in this section with map service requirements to save, publish, and optionally cache operational layers.

1. In the ArcMap session that contains the optimized basemap from the previous step, click the Publish to ArcGIS Server button on the Map Service Publishing toolbar. *[Note: Before publishing a map service directly from ArcMap, there must be an administrative connection to the GIS Server present in the ArcCatalog GIS Servers node.]*

2. Publish the map service by completing the steps in the publishing wizard. At the end of this process, an MSD is created automatically on the GIS server and is available as a Web service through ArcGIS Server.

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Five Steps to Better Performance

Continued from page 47

3. Where was the MSD automatically saved on the GIS server? Open Windows Explorer on the GIS server machine (the machine where the server object manager [SOM] component is installed) and navigate to ..\arcgisserver\arcgisinput. Notice an MSD file, with the same name as the ArcMap document used to publish it, is present. The MSD located in the arcgisinput folder is automatically accessible to the server object container (SOC) account and is linked to the published map service. If the service is deleted, so is the MSD.

4. Open ArcCatalog and expand the administrative connection to the GIS server. Preview the new map service and note how fast it displays.

5. Before building a cache for the map service, it is important to understand how the image format property of the cache impacts the quality of cached tiles. Read the ArcGIS Server help topic “Publishing services” under *Caching services > Map Caches (2D) > The caching process > Choosing cache properties* to gain a better understanding of image formats.

6. The steps to design and create a cache are beyond the scope of this article. For information on designing a cached map service, see “Providing the Best User Experience: Answers to questions about map caching for ArcGIS Server” in the Winter 2009 issue of *ArcUser* magazine, which is available online at www.esri.com/news/arcuser/0109/map_caching.html.

7. Publishing a map service directly from ArcMap is only one option. Traditional publishing workflows can also be used for both MSD- and MXD-based services. The only difference is that with an MSD-based service, the MSD is saved using the Save Map Service Definition tool on the Map Service Publishing toolbar before using ArcCatalog or ArcGIS Server Manager to publish the file to ArcGIS Server.

The steps in this section yield a basemap service that has been cached and is based on an optimized MSD and at least one operational service that is either served dynamically or cached.

If the operational service is

- Served dynamically and only used for mapping, the service will be based on an MSD

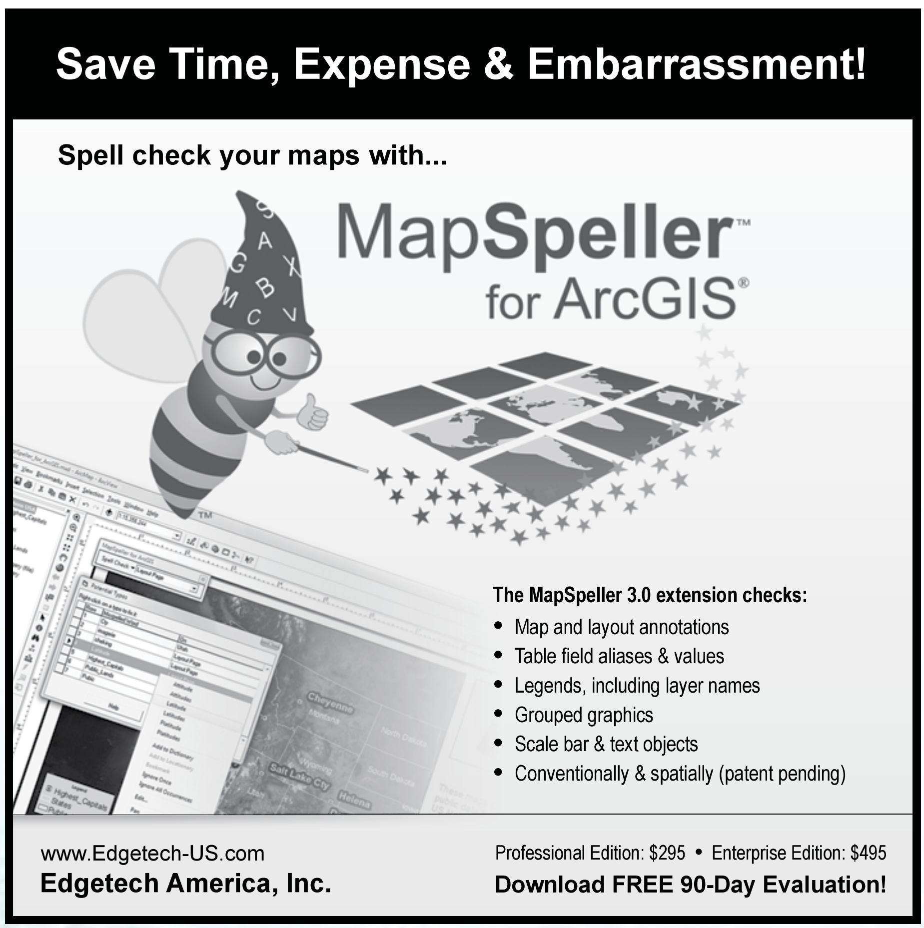
- Served dynamically and used for analyical capabilities, the service will be based on an MXD

Typically, the cached data behind the operational service will change infrequently. Although data can be served dynamically with acceptable performance using tools and configuration new to ArcGIS 9.3.1, best performance will still be reliably achieved from cached map services.

Step Five

Visualize basemap and operational services in a Web application

By organizing the map services into base and operational layers and optimizing the layers prior to and after publishing (caching), the maps in the Web application will be intuitive for the audience and exhibit acceptable performance. To appreciate how this works, assemble the services in a Web mapping application created using the ArcGIS API for JavaScript. Follow the steps in the article “Add a Map to a Web Page in Three Simple Steps—Getting started with the ArcGIS API for JavaScript” from the Winter 2009 issue of *ArcUser* (available online at www.esri.com/news/arcuser/0109/files/3steps.pdf). The steps in this article will



show you how to use a code sample from the ArcGIS API for JavaScript Resource Center to combine two cached map services into a single application.

Replace the cached basemap service

The following steps demonstrate how to change the cached basemap service and add an additional dynamic operational service. When using services from your own GIS server, use your own Services Directory in the instructions below rather than the Services Directory for ESRI Sample Server 1.

1. Change the cached basemap service: Open a new browser window and navigate to resources.esri.com/javascript. Under Services Directory, click the link for Sample Server 1. Using the skills gained from the article, "Add a Map to a Web Page in Three Simple Steps—Getting started with the ArcGIS API for JavaScript," replace the ESRI Street map base data with the WaterTemplate/LocalGovernmentInfrastructureBasemap (MapServer) cached map service at

   http://sampleserver1.arcgisonline.com/ArcGIS/rest/services/WaterTemplate/LocalGovernmentInfrastructureBasemap/MapServer

2. Add a new reference to an optimized dynamic service: Repeat the process in the previous step to add the dynamic operational layer. Activate the text document containing the application code and locate the lines of JavaScript beginning at line 18, as shown in Listing 1.

```
var Portland = new esri.layers.ArcGISTiledMapServiceLayer ("http://
sampleserver1.arcgisonline.com/ArcGIS/rest/services/Portland/
Portland_ESRI_Neighborhoods_AGO/MapServer");
myMap.addLayer(Portland);
```

Listing 1

3. Replace the Portland_ESRI_Neighborhoods_AGO service with the WaterTemplate/WaterDistributionOperations (MapServer) service

   http://sampleserver1.arcgisonline.com/ArcGIS/rest/services/WaterTemplate/WaterDistributionOperations/MapServer.

The WaterTemplate/Water Distribution Operations (MapServer) service is a dynamic map service created from an MSD. Change the reference to a cached map service to a reference to a dynamic map service by deleting the text ArcGISTiledMapServiceLayer located at line 18 to ArcGISDynamicMapServiceLayer. Finally, change the name of the variable referencing the service to WaterDynamic. The code referencing the dynamic operational layer should look like Listing 2. Save and close the HTML file. Test this updated HTML page locally by opening it in a browser.

```
var WaterDynamic = new esri.layers.ArcGISDynamicMapServiceLayer("htt
p://sampleserver1.arcgisonline.com/ArcGIS/rest/services/WaterTemplate/
WaterDistributionOperations/MapServer");
        myMap.addLayer(WaterDynamic);
```

Listing 2

Keeping Web mapping applications performing well

An important part of creating high-performance Web mapping applications is to monitor the performance of map services and stay in tune with the needs of the application users. For more information on monitoring performance, see the ArcGIS Server help topic "Administering the server" under *Tuning and configuring ArcGIS Server > Monitoring performance.*

Learn more

ESRI offers both instructor-led and online courses on ArcGIS Server, optimizing Web map performance, and using ArcGIS APIs in addition to a three-day ESRI instructor-led course *ArcGIS Server: Web Administration Using the Microsoft .NET Framework* which covers many aspects of ArcGIS Server administration, including monitoring and tuning the server. Visit the ESRI Mapping Center at mappingcenter.esri.com for more resources on creating effective maps.

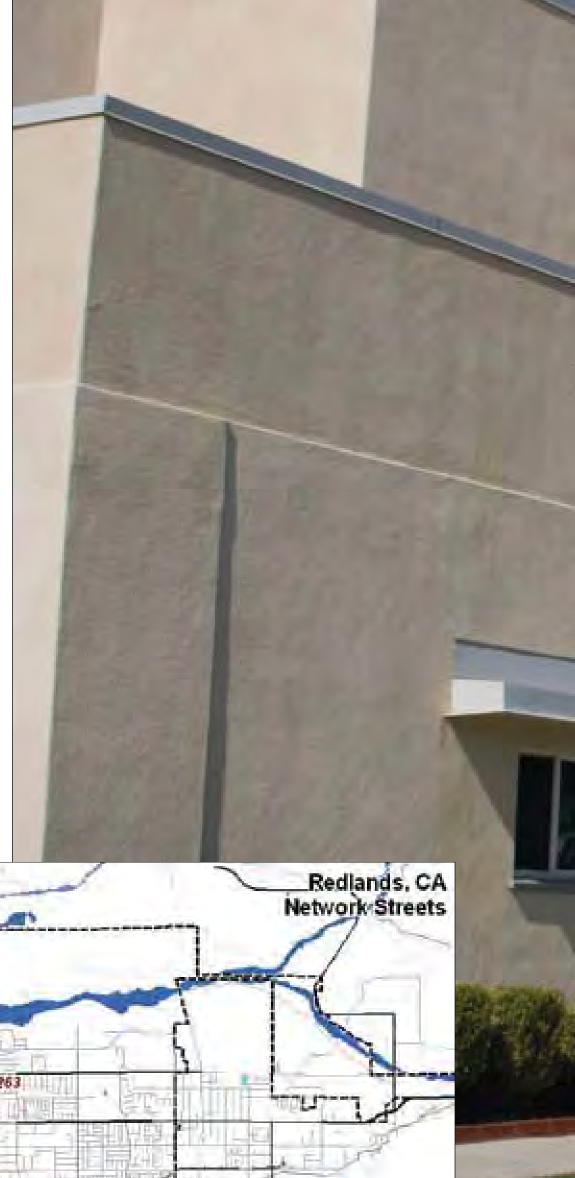
Course	Type
Introduction to ArcGIS Server	Instructor-Led Course
ArcGIS Server: Web Administration Using the Microsoft .NET Framework	Instructor-Led Course
Implementing and Optimizing ArcGIS Server Map Caches	Free Web Training Seminar
Building Mashups Using the ArcGIS JavaScript APIs	Free Web Training Seminar
Building Rich Internet Applications with ArcGIS API for Flex	Free Web Training Seminar
Building Web Maps Using the ArcGIS API for JavaScript	Instructor-Led Course
Authoring and Deploying Fast Web Maps	Free Web Training Seminar

Educational resources available from ESRI

Do It Yourself!

Building a network dataset from local agency data

By Mike Price, Entrada/San Juan, Inc.



Tutorials in recent issues of *ArcUser* magazine have showed how to create mapped time- and distance-based travel network models for emergency response applications. Building these models required carefully prepared agency or commercial street data that had been tuned for network modeling.

Many local agencies build and maintain quality street datasets, often designed to support highly reliable geocoding. While these streets can be very current and have great positional accuracy, they are often not built to support time- and distance-based networking. However, in many cases, it is possible to modify these street datasets to support a network model.

This exercise uses a street dataset for Redlands, California, where ESRI is headquartered. The Redlands City GIS streets data was designed and is maintained for address geocoding. After inspecting the data, the exercise explores several methods for modifying a copy of the data for time-based networking. This exercise involves careful heads-up editing. The Redlands street data in the sample dataset has been modified only slightly so exercise tasks can be accomplished more quickly. It is very similar to the original Redlands street dataset.

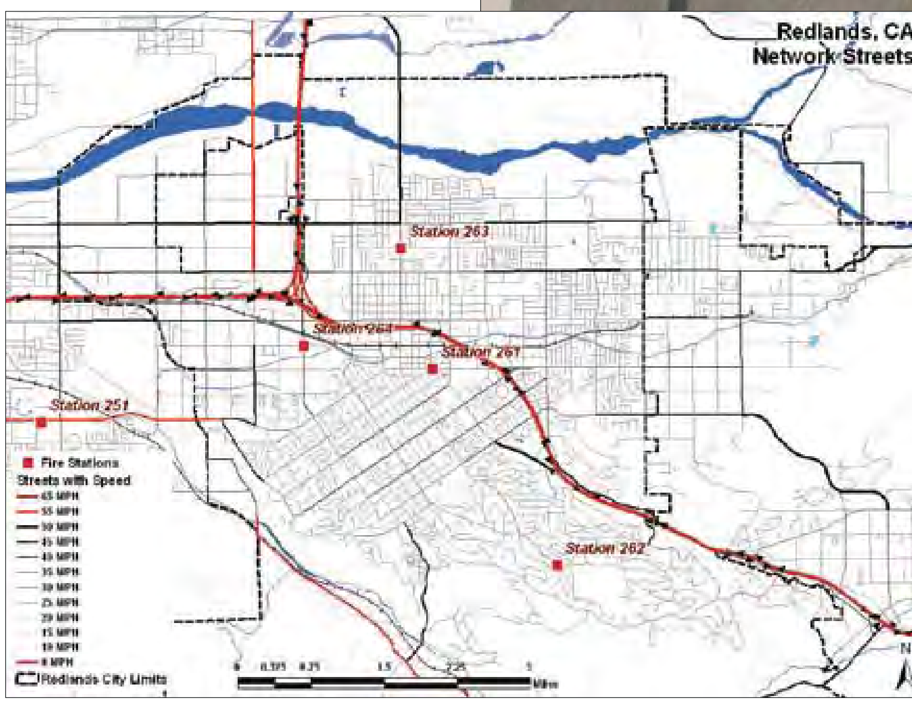
This article assumes a basic understanding of ArcGIS Desktop and the ArcGIS Network Analyst extension. To review modeling travel networks with ArcGIS Network Analyst and the concepts of distribution and concentration, please read and work the exercises published in the July–September 2007, October–December 2007, and Summer 2008 issues of *ArcUser* and available online at www.esri.com/arcuser. These articles provide background information on how emergency responders use time as a response measure.

Getting Starting

To obtain the sample dataset for this exercise, visit the *ArcUser Online* Web site at www.esri.com/arcuser and download redlands.zip. This file contains all the data necessary to perform this tutorial. Unzip this data archive near the root directory on your hard drive. In Windows Explorer, right-click on the Redlands folder; choose Properties; and on the General tab, make sure Read Only is unchecked.

Open ArcCatalog and navigate to the Redlands folder. Preview the data in Geography and Table modes. Notice that the data is in California State Plane North American Datum of 1983 (NAD 83) Zone V and units are U.S. Survey Feet. Preview the Redlands01.mxd file to see the study area for the exercise.

Locate and carefully inspect the streets shapefile. This geocoding dataset was created and maintained by the City of Redlands. To protect the original file, make a copy of streets_in and rename it streets_nw. The copied file, streets_nw, will be used for this exercise.



This exercise explores several methods for modifying street data for use in time-based network modeling.

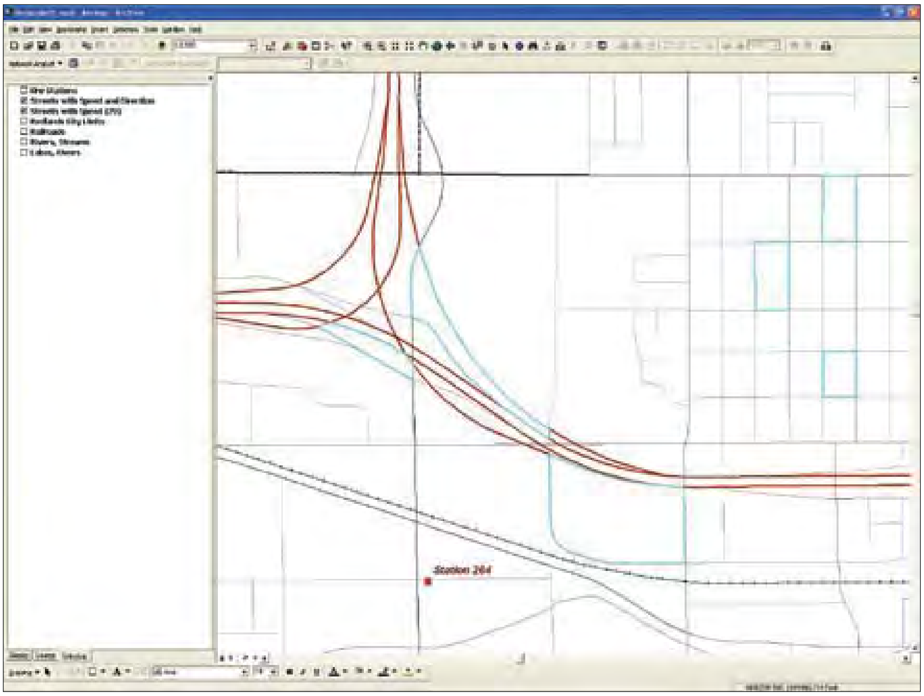
Adding Fields for Results

While in ArcCatalog, add three attributes to support the network model. Preview the streets_nw attribute table. In the Catalog tree on the left, right-click on streets_nw, choose Properties, and click the Field tab. Notice that the lowermost (rightmost) field in the source table is ADDRCITY. The three new fields will support directional time and distance networking.

1. Click the first blank line in the Field Name column and name the first new field OneWay. Specify the data type as text and the field length as four characters. Click Apply. This field will be used to code travel direction for all one-way streets.

2. Click in the next blank name field and type "Length_Mi." Specify a Double format with a Precision of 12 and a Scale of 6. Click Apply.When the length of each street segment is calculated in decimal miles later in this lesson, this field will hold those results. These values will be used to calculate travel time for all segments.

What You Will Need
- ArcGIS (ArcView, ArcEditor, or ArcInfo license levels)
- ArcGIS Network Analyst extension
- Sample data from *ArcUser Online*



This exercise will limit connectivity by merging freeway segments across city streets. These selected examples show connectivity.

3. Add a third field; name it Minutes; and set its type to Double, with a precision of 12 and a scale of 6. This field stores calculated travel times for each segment. Click Apply and OK. Close ArcCatalog.

Examining Distance and Speed, Street Class, Street Type

Start ArcMap, turn on the Network Analyst extension, and make the Network Analyst toolbar visible. Open Redlands01.mxd and verify that all data layers have loaded properly, including the two layers that display the network streets. The Streets with Speed layer will be visible and the Streets with Speed and Direction layer will be unchecked. Double-click on any layers that have a red exclamation point, choose Properties > Source, and click Set Data Source to repair the path to the data.

Switch from Layout View to Data View and open the attribute table for the Streets with Speed layer. Study all the fields for this layer.

Verify that the three new fields are available and contain either zero values or no text. Inspect all fields and look for information that

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Do It Yourself!

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will support geocoding and a time/distance network. This dataset contains speed limit [SPEED_MPH], street class [CLASS], and school zone [SCHOOLZONE] fields that can participate in the network. However, it does not contain any numeric values for distance. The TYPE field provides clues that it contains some directional streets. Select fields where [TYPE] = 'FRWY' or [TYPE] = 'RAMP' and notice that these records do not contain geocoding attributes. They can be edited without upsetting the geocoding fields.

Impedance—Distance

Notice that there is no distance field in the source dataset. The Length_Mi field added earlier needs to be populated, but before calculating street segment lengths, many of the freeway vectors need to be edited.

Impedance—Speed

Sort the [SPEED_MPH] field in ascending order and carefully review the values. Notice that nine records have 0 speed limit. Before building the network, these records must be updated or deleted. Just remember that they are now in the street dataset. The [SPEED_MPH] field will provide the primary impedance and a zero speed will not contribute to a meaningful time. Once directionality and connectivity issues are resolved, the segment length in miles and travel time in minutes can be calculated.

Crossing Relationships

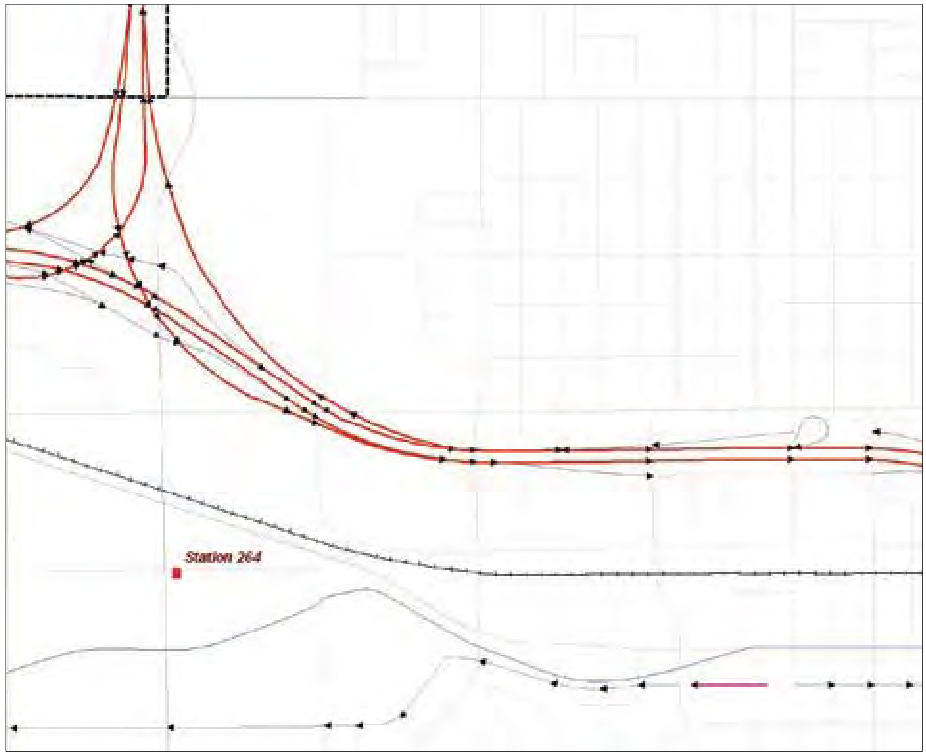
Because this is a geocoding dataset, it does not contain fields for nonintersecting crossings (which are also called z-elevations). Although two z-elevation fields could be added to this table, it would require careful editing of all the values for each crossing and intersecting street segment—a complex, time-intensive process. Instead, geometry—not attribution—will be used to define and manage crossing relationships.

Connectivity

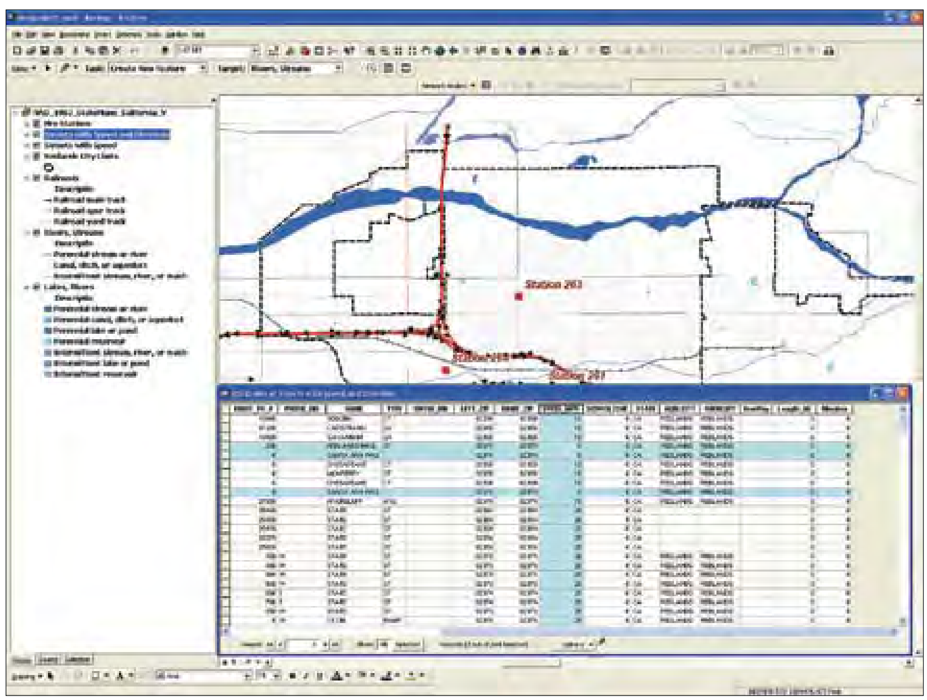
To properly create a network, all street segments must share common endpoints. Make the Streets with Speed layer selectable and zoom in or use the Magnifier Window to inspect intersections. Select street segments to verify connectivity. Notice that even freeway interchanges display connectivity where they cross city streets. Later in the exercise, freeway segments will be spanned across city streets to limit connectivity.

Directionality

Open the Layer Properties dialog box for the Streets with Speed layer, click on the Display tab, and set the transparency for the layer to 70 percent. Turn on the Streets with Speed and Direction layer. Zoom in and inspect streets near the I-10 and I-210 freeway interchange. Study the endpoint arrows and notice that not all segments are properly oriented for right-hand travel. This must be fixed. The OneWay field will be used to code all one-way segments.



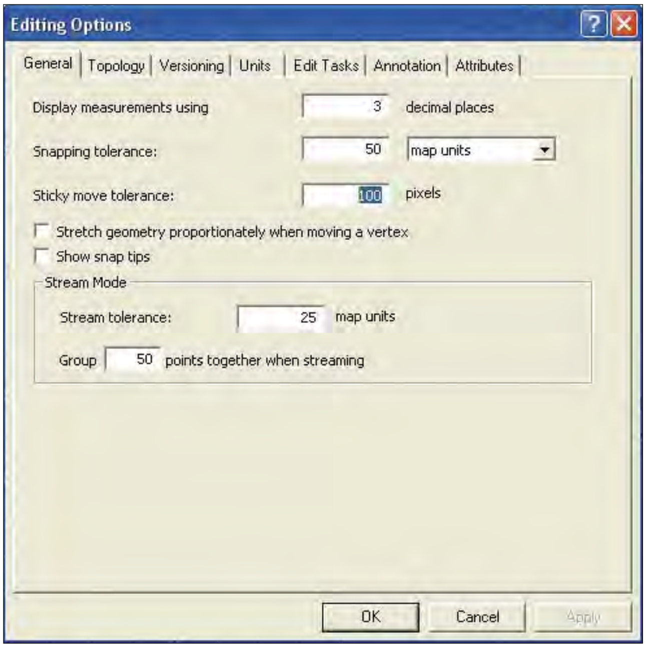
Study the endpoint arrows and notice that some segments are properly oriented for right-hand travel, while some are not.



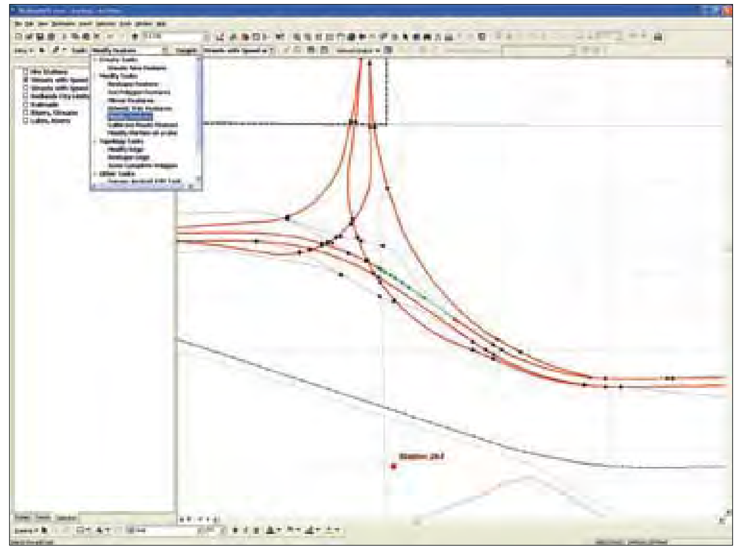
Delete Redlands Mall and the Santa Ana Wash; set all other speeds to 10 mph.

Turns and Turn Relationships

Turns and intersection slowdowns are important in a time-based network. After updating streets in the next section, the next step will be building a network using global turns. Save the Redlands01.mxd before going on to the next section.



Set the snapping tolerance to 50 feet and the sticky move tolerance to 100 pixels.



Set the editing target to Streets with Speed and Direction and specify the Modify Feature task. Select an improperly oriented street segment and notice that the red node also shows the downstream end of the selected segment.

Editing the Streets with Speed and Direction Layer

Open the Editor toolbar by choosing View > Toolbars > Editor, and choose Start Editing from the drop-down to start an editing session. Use the Selection tab in the table of contents to make only the Streets with Speed and Direction layer selectable.

Speed Limits

Open the attribute table for the Streets with Speed and Direction layer and inspect the new fields (Length_Mi, OneWay, Minutes). Locate all records where SPEED_MPH = 0. Zoom to and inspect each record. Decide whether to increase the speed limit or delete the record. If the choice is increasing the speed limit, use 10, 15, or 20 mph.(Hint: Delete Redlands Mall and Santa Ana Wash; set all other speeds to 10 mph.) Save the map document.

Directionality

Now to properly orient all freeway and ramp street segments. There are several segments of one-way streets in downtown Redlands that will be validated.

1. Before beginning an editing session, set a sticky move tolerance that will prevent accidentally moving a segment while modifying its orientation. In the Editing toolbar, select the Editing drop-down and open Options. Set the snapping tolerance to 50 feet and the sticky move tolerance to 100 pixels.

2. Close the attribute table for Streets with Speed and Direction and zoom in to the freeway interchange area. Study the segments displaying directional arrows. In the Editor toolbar, set the editing target as the Streets with Speed layer (which is a nonselectable layer) and specify the task as Modify Feature. Select an improperly oriented street segment. Notice that the red node also shows the downstream end of the selected segment.

3. To flip a segment, verify that the nodes are displayed and select the Edit tool (this tool has a black arrowhead icon and is usually located to the right of the Editing toolbar drop-down).

4. Carefully position the mouse cursor near the line's midpoint. (Hint: Look for the small *x*.)

5. Right-click and select Flip from the context menu. The red leading node swaps ends with the arrow, which indicates the line has reversed direction. Deselect this line.

6. Inspect all freeway and ramp segments and flip all improperly oriented segments. Caution: Be careful not to move any segments. If you think that you might have moved a segment, go to the Editor drop-down and choose Undo Move to return the segment to its original location.

7. Save edits about every 10 flips. (Hint: Use the shortcut keys to navigate the map more rapidly: C to pan, Z to zoom in, and X to zoom out.)

8. Check the Task window on the Editor toolbar to be certain that it displays Modify Feature. It will probably take 20 to 30 minutes to flip all segments.

The city streets in Redlands that show directionality are properly oriented. Inspect street segments carefully to ensure this. If you accidentally flip a correct segment, simply flip it back. Check all on-ramps and off-ramps and watch out for a rest area on eastbound I-10. A OneWay code will be assigned to several ramps. Save the edits and the map document.

Crossing Relationships

In the next process, certain freeway and ramp segments will be merged to build correct crossing relationships. Do not perform this step before all appropriate directional segments are properly oriented.

Reopen an edit session and zoom to the I-10/I-210 interchange. Verify that only the Streets with Speed and Direction layer is selectable. Inspect all directional vectors. Use the Select Features tool to individually select several directional vectors.

Because all directional vectors share endpoints with other segments, a network built with these segments would maintain correct one-way travel, but might include segments that would make sharp turns from a limited-access travel lane onto crossing freeways and even city streets. This is not good.

Crossing geometries will help fix this issue. Simply stated, where a limited-access travel lane intersects another class of noncontinuous line segments, the limited-access segments will be merged to create a single crossing element. If two limited-access segments merge into one, which happens with on- and off-ramps, these segments will not be merged.

In the interchange area, study these crossing relationships carefully. Using the

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Select Features tool, highlight two or more continuous segments that make up a ramp in this area. Do not select any line segments that cross the ramp segments being selected. Zoom in to make certain all segments for that section of ramp are selected. Select elements by beginning at one end of a section of continuous segments and select them in the direction of travel.

In the Editing toolbar, click the Editor drop-down and select Merge. Explore the Merge list and verify that all segments have the same source name. If the Merge dialog box contains more than one feature name, cancel the task and reselect the segments. Click OK to merge the segments and inspect the results.

There should be only one arrowhead, pointing onto I-10 in an easterly direction. Continue the process of merging line segments for all ramps that cross in this interchange, including freeway roadways and ramps.

If incorrect segments are accidentally merged, immediately use the Undo button on the standard toolbar to correct this problem. Zoom in and pan as necessary and save the map document frequently.

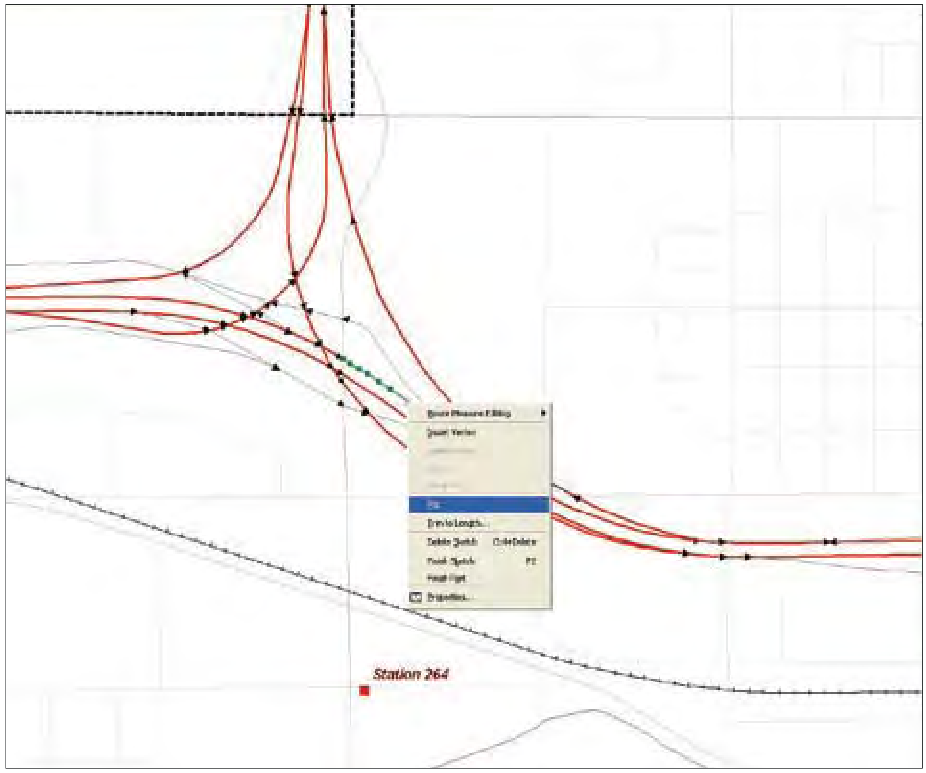
When all crossing freeway and ramp segments in the I-10/I-210 interchange have been merged to form single crossing elements, follow the rest of I-10 and I-210 and merge all these segments also to create single crossing elements. Watch the directional arrow and the red endpoint symbol while merging segments. If an endpoint lands in the middle of a merged segment, undo the merge, check directionality, and change the segment selected in the Merge dialog box. If segments in an interchange contain speed limit changes, merge only segments with the same speed limit.

Remember not to merge any segments across valid limited-access intersections. Undo the selection immediately to correct any accidental merges. Advanced users can use the Split tool to disconnect segments when needed.

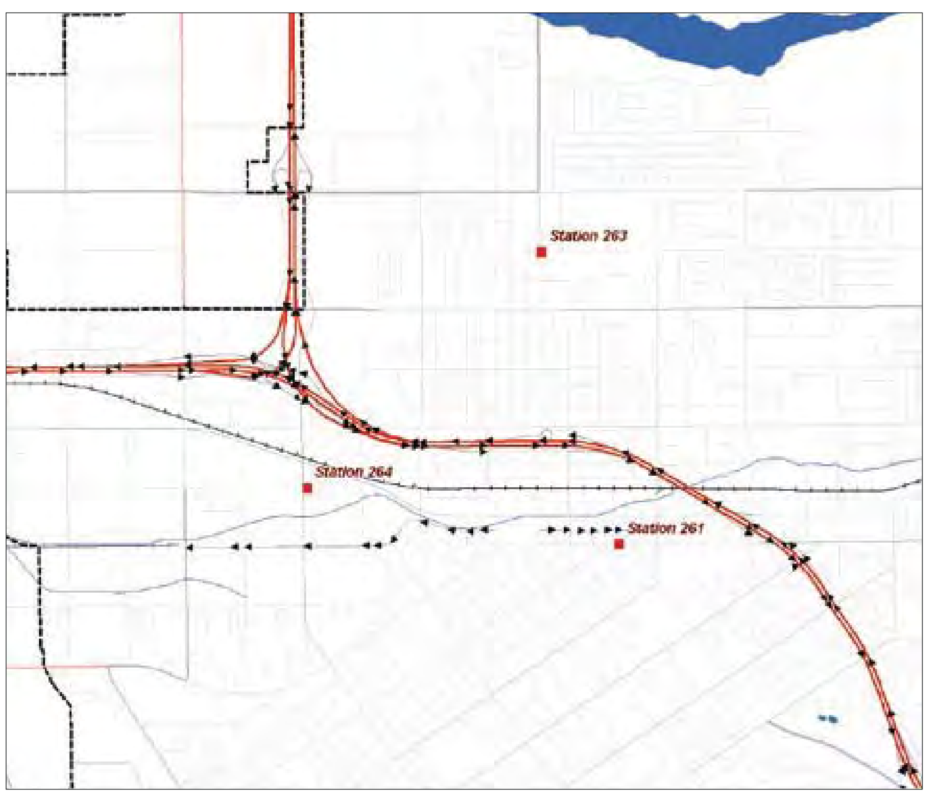
After completing all merging operations, inspect all freeway lands and ramps. Several ramps are problematic. It is difficult to tell if the feature being merged is part of an interchange or part of a crossing relationship. (Imagine how helpful high-resolution imagery would be.) When finished, stop editing, save edits, and save the map document. Now, length for all Redlands streets can be calculated and OneWay attributes can be assigned.

Editing Attributes

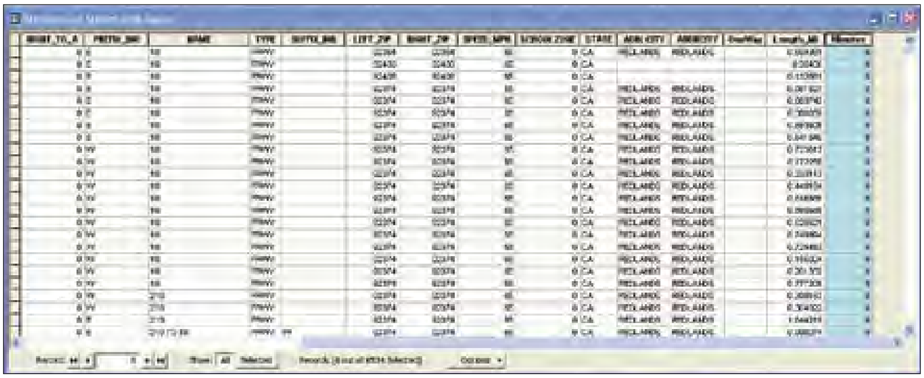
Now segment lengths and travel times can be calculated and directionality codes assigned to the OneWay field.



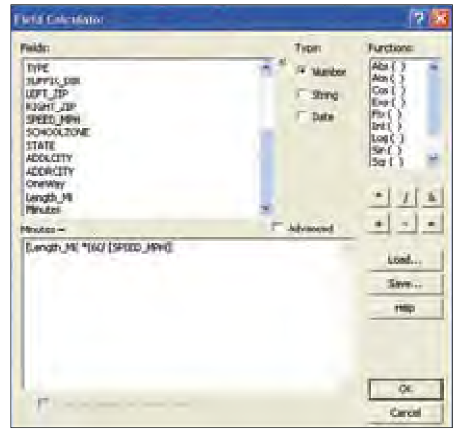
Carefully position the mouse cursor tip near the line's midpoint. (Hint: Look for the small x.*) Right-click and select Flip from the context menu. Watch as the red leading node swaps ends, indicating that the line has reversed direction.*

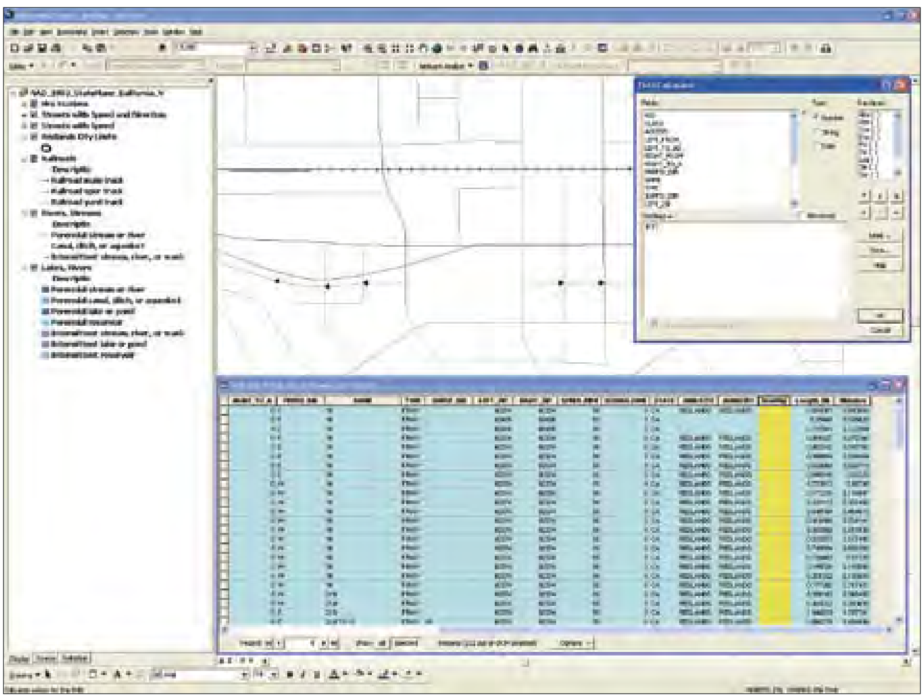


A properly oriented network



With length in miles, calculate travel time in minutes. Select the minutes field, type [Length_Mi] * (60/ [SPEED_MPH]) in the formula box, and click OK.





Create a query that shows only streets where Type = 'FRWY' or Type = 'RAMP' and use the Field Calculator to populate the OneWay field with the FT (From-To) code for each selected record.

1. Make Streets with Speed and Direction nonvisible, set transparency at 0 for Streets with Speed, and make Streets with Speed the only selectable layer. This layer displays all records in streets_nw.

2. Open its attribute table, locate the Length_ Mi field, and click on its field header.

3. Select Calculate Geometry and specify Property: Length. Use the coordinate system for the data frame and specify units as Miles U.S. Click OK to calculate all segments.

4. With length in miles, travel time in minutes can now be calculated. Open the Field Calculator. Select the MINUTES field and type

   [Length_Mi] * (60/ [SPEED_MPH])

   in the formula box. Click OK and check the calculations.

5. Now, assign a OneWay code to all limited-access streets. Close the Streets with Speed attribute table and open the Streets with Speed and Direction attribute table. This layer also references the streets_nw shapefile, filtered to show only limited-access streets and a subset of Redlands streets.

6. Create a query that shows only streets where Type = 'FRWY' or Type = 'RAMP'. Use the Field Calculator to populate the OneWay field for each selected record with the value FT (a code for From-To). Because directionality has been carefully managed for this data, these codes can be applied for all the limited access dataset.

7. Assign an FT code to five specific Redlands city streets by creating a query where "TYPE" = 'ST' AND "NAME" = 'STATE' AND "PREFIX_DIR" = 'E' AND "LEFT_ FROM_" <500. Use Field Calculator again to place an FT code in the OneWay field for these five records.

Redlands streets are now ready to be used for building a time-based network. Zoom to the data extent, save the map document, and admire the project.

The tasks in this exercise might seem a bit rigorous, but these steps were necessary to create a quality network source without compromising the data. Save this enhanced dataset for future activities.

Summary

In previous exercises, the ArcGIS Network Analyst extension was used to model time and distance response from fixed facilities. Experiment with this network street dataset by creating a network dataset from it and using it to work the Routes and Service Areas exercises in previous *ArcUser* articles in this series, noted at the beginning of this article.

Acknowledgments

Thanks go to Tom Patterson, ESRI public safety specialist, for requesting this exercise and obtaining the Redlands data. Special thanks also go to the Redlands GIS staff members for providing this excellent dataset and allowing me to prepare and use it for this exercise.

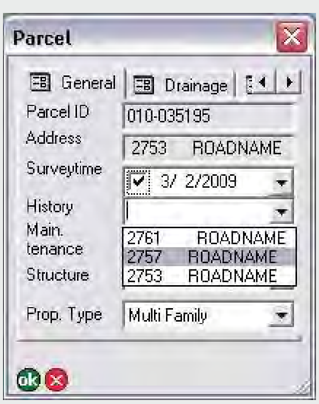
Little Effort, Big Savings

Add a fill-form-from-history tool to ArcPad in two steps

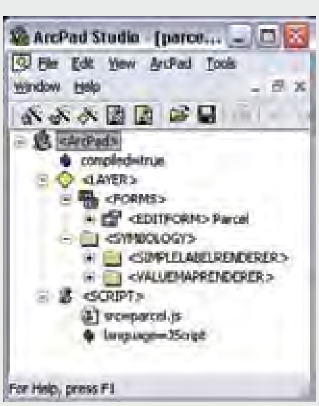
By Mel Yuanhang Meng, DLZ Ohio

How the Tool Was Developed

For a sanitary sewer improvement project, DLZ Ohio needed to inspect the condition of houses in the study area to evaluate the potential for storm water entering the sanitary sewer system. Initially, condition codes for whole blocks were assigned as project team members drove through neighborhoods in the study area. This process didn't take long but missed lots of details, and ratings were not consistent from one neighborhood to another. Was it possible to collect data for each property without blowing the budget?



The fill-form-from-history tool



The parcel APL file

ArcPad came to the rescue. Switching from a paper to an electronic format immediately freed the team from entering the address and other information that was already available for each house. However, compared with driving through neighborhoods, this was a much slower process. The project budget simply wouldn't cover this expense.

However, houses on the same block are very similar and many entries were repeated for every house. This discovery led the team to develop a fill-form-from-history tool that easily cut the time needed for inspecting a block by 50 to 80 percent. Selecting a previously inspected address listed in the History drop-down list populated the values from that address into the current form. For a form with 30 fields, the time savings provided by this tool were significant.

Add the Tool to Your Form in Two Steps

The fill-form-from-history tool was developed using ArcPad Studio 7 and tested on ArcPad 7. Any ArcPad form developed using an APL file and a JavaScript file can be easily modified to use this tool in just two steps.

1. Add a history combobox control in the form.
2. Reference the JavaScript file that defines a global variable that stores the history and functions that update the history control, read, and save form entries to the history.

The form associated with a shapefile is defined by an APL file (layer definition file or *.apl) and a JavaScript file (*.js) that defines the global variables and the functions. An APL file is automatically created when a shapefile is exported using the ArcPad Data Manager extension for ArcGIS Desktop. The APL file is later customized using ArcPad Studio.

An APL file is an XML file that defines the symbology data entry forms and references any additional script files. The APL file shares the same base name as the shapefile with an .apl file extension. Table 1 explains the control flow and event names for the fill-form-from-history tool. As a shapefile is loaded into ArcPad, the global variables and functions defined in the JavaScript file are automatically loaded. The function is called when the corresponding event is triggered.

Event (Event name)	Action (Function name)
Add shapefile into ArcPad (NA)	**Loading global variables** (NA)
Form is on load (onload)	**Populate the history control with previous entries** (draw_history)
Form is closed and saved (onok)	**Saving the entry into the global history variable** (save_history)
History control on select change (onselchange)	**Populate the form with values for the selected entry** (fill_form)

Table 1: Control flow of fill-form-from-history tool

What You Will Need
- ArcPad 7 or higher
- ArcPad Application Builder 7 or higher
- Sample data downloaded from *ArcUser Online*
- An unzipping utility such as WinZip

A simple customization to an ArcPad form greatly increased the efficiency of house inspections and allowed the author's consulting firm to collect more accurate data more rapidly and remain under budget for a project. This tool can easily be added to existing ArcPad forms following the instructions in this article.

Do It Yourself

The following instructions guide the reader through the process of installing the fill-form-from-history tool in an ArcPad form. Download frmhis.zip from *ArcUser Online* (www.esri.com/arcuser) and unzip it. This archive contains the sample data and application that illustrate the process of adding the fill-form-from-history tool.

Step 1:

Add a history Combobox control in the form.

1. Open the APL file for your form in ArcPad Studio.
2. Double-click the <EDITFORM> tag to display the form.
3. Click on the Controls palette and drag a Combobox control over to the form. Name the combo box History.
4. Add a label control and label the combo box History.
5. Double-click on the combo box and click the Events tab to bring up the Control Properties dialog box.
6. Scroll to the onselchange event and add the following event script: fill_form (ThisEvent.Object.ListIndex);.
7. Click OK and choose Form > Form Properties from the form's dialog box. Click the Events tab, select the onload event, and reference the draw history script draw_history();.
8. Select the onok event to reference the script save_history () script.

Step 2:

Reference the JavaScript file.

Its powerful features make JavaScript an ideal scripting language for this application. If VBScript is used instead, the code will be much longer and more complicated.

1. Copy the parcel.js file (which was included in the sample dataset) to the same folder that contains the shapefile and APL file for your project.
2. In the APL file, double-click on the <SCRIPT> tag and set the scr to parcel.js and language to JScript.
3. Open parcel.js using ArcPad Studio and inspect the code.

Continued on page 58

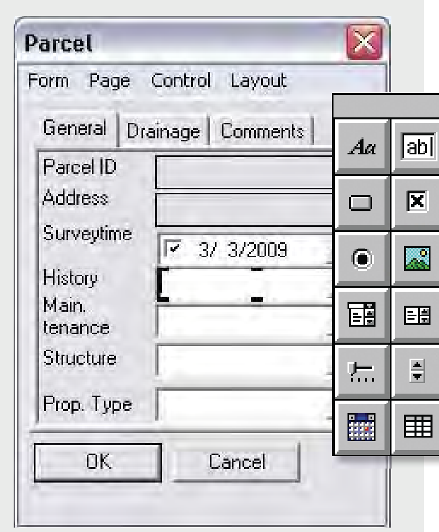
```
//*Configuration Section -- Start*

//prefix for control name. Prefix controls that you want to save in history with the character
defined below.
//eg. a control with a name _structure will be saved while structure won't.
_flag = "_";
//history control definition. The name of the page it is on and the name of the control
//Below defines a control on PAGE1 with a name of history
_hctl = {
    page: "PAGE1",
    ctl: "history"
};
//The field used to identify a previous entry.
//Below uses the address as the identifier. It is the value of a control txtAddress on PAGE1
_hctlsrc = {
    page: "PAGE1",
    ctl: "txtAddress"
};

//*Configuration Section -- End*

_history = []; //global array storing the history of last 5 entered records.
_record = "desc"; //global variable, the key to retrieve the address from a record.
```

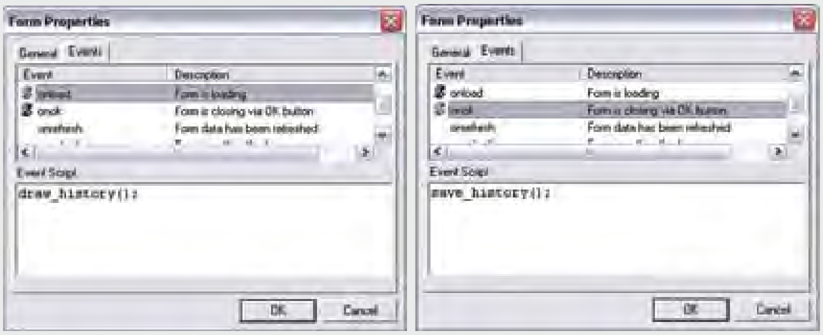
Listing 1: Global variables



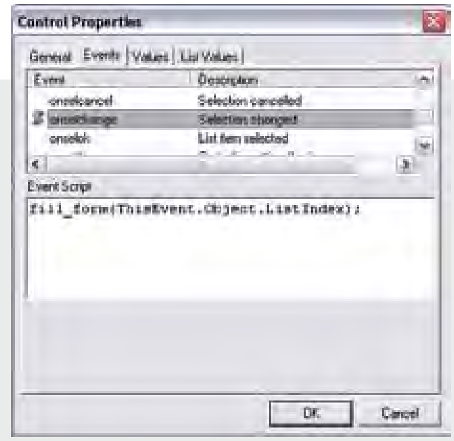
Adding the history Combobox control

Little Effort, Big Savings

Continued from page 57



Setting the Form events



Setting the History control events

The configuration and global variables are shown in Listing 1. In this application, the _flag variable is used to filter the controls that need to be populated by the tool. Make sure the names of the controls that will be populated by the tool start with the underscore character "_".

Any ArcPad form developed using an APL file and a JavaScript file can be easily modified to use this tool in just two steps.

The save_history() function is called when the OK button of a form is clicked as shown in Listing 2. As the program loops through the controls page by page, it scans the name of the control. If the name starts with a character defined by the _flag variable, its value is saved in the associated values array (which is indexed by the control's name). Then the values array is pushed into the _history global variable. The program also checks the number of entries in the _history variable and removes older entries, if necessary.

As shown in Listing 3, the fill_form() function is fired when the selected item in the history control has changed. The index of the selected item will be passed to this function. Since the most recent entry is listed as the top item in the history control, the order of the items in the _history variable needs to be reversed to match the index from the history control.

As shown in Listing 4, the draw_history() function is fired as the form is loading. It populates the history control with previous entries.

```
//save the values of the current entry into the history variable
//triggered by the Form onok event
function save_history(){
   var ctls, i, j, pgs, pg, m;
   var values = {}; //An associate array to store all the values
   pgs = ThisEvent.Object.Pages; //Reference to all the pages
   for (j = 1; j < pgs.Count + 1; j++) {
      //loop all the pages
      pg = pgs.Item(j);//current page
      ctls = pg.Controls;//all the controls on the current page
      for (i = 1; i < ctls.Count + 1; i++) {
         //loop all the controls
         m = ctls.Item(i).name.toLowerCase();//In case the name control is not case sensitive.
         if (ctls.Item(i).name.substr(0, 1) == _flag) {
            //filter the controls, if it starts with "_", then remember it
            switch (ctls.Item(i).Type) {
               //depending on the control's type, find the value need to be remembered.
               //the data looks like, values[control name] =  "contro value"
               case "COMBOBOX":
                  values[m] = ctls.Item(i).ListIndex;
                  break;
               case "CHECKBOX":
                  values[m] = ctls.Item(i).Value;
                  break;
               case "EDIT":
                  values[m] = ctls.Item(i).Value;
                  break;
               case "RADIOBUTTON":
                  values[m] = ctls.Item(i).Value
                  break;
            }
         }
      }
   }
   //Now all the data are saved into the values variable
   //add the address to the values, so it can be populated for the history combobox
   values[_record] = pgs(_hctlsrc.page).Controls(_hctlsrc.ctl).Value;
     //Before saving values to the global history variable, check the length of the _history
variable.
   //Only keep most recent 5 entries
   if (_history.length > 4) {
      _history.shift();
.......//get rid of the oldest one
   }
   _history.push(values);
....//add the current one on the top
}
```

Listing 2: Global variables

```
//Populate the current form with values from the selected entry in the history combobox
// triggered by the history combox onselchange event
//--ind, index of the history
function fill_form(ind){
    var ctls, i, j, pgs, pg, r, f, m;
    //reference to the pages and loop each page
    pgs = ThisEvent.Object.Parent.Parent.Pages;
    for (i = 1; i < pgs.Count + 1; i++) {
        pg = pgs.Item(i);//current page
        //To change the values of a control, the page the control is on must be activated.
        //if it is not the first page, activate the page
        if (i > 1) {
            pg.Activate();
        }
        //as the most recent entry is listed as the first item in the in the combox
        //To match the an item in the _history array using the index from the combox, the order
need to be reversed.
        _history.reverse();
        r = _history[ind];//get the record from the _history
        _history.reverse();//reverse it back to normal order
        //reference to all the controls on the current page and loop through them
        //to populate values from history
        ctls = pg.Controls;
        for (j = 1; j < ctls.Count + 1; j++) {
            //get the name of the control and filter out those not saved.
            m = ctls.Item(j).name.toLowerCase();
            if (m.substr(0, 1) == _flag) {
                //if the control has ListIndex attribute, it must be a combobox
                if (ctls.Item(j).ListIndex) {
                    ctls.Item(j).SetFocus();
                    ctls.Item(j).ListIndex = r[m];
                }
                else {
                    //if it is not a combobox, it should have a Value field.
                    ctls.Item(j).Value = r[m]
                }
            }
        }
    }
    //Go back to the first page
    pgs.Item(1).Activate();
    }
```

Listing 3: The fill_form function

```
//Populate the history control with previous entries
//Triggered by Form onload event
function draw_history(){
    var ctl = ThisEvent.Object.Pages(_hctl.page).Controls(_hctl.ctl);
    //the history control
    var l = _history.length;
    ctl.Clear();//clear all existing items in it
    for (var i = 0; i < l; i++) {
        //populate the list, so that the last record are the first in the list
        r = _history[l - i - 1];
        ctl.AddItem(r[_record], i);//add the item in the list
    }
}
```

Listing 4: Draw_history function

Conclusion

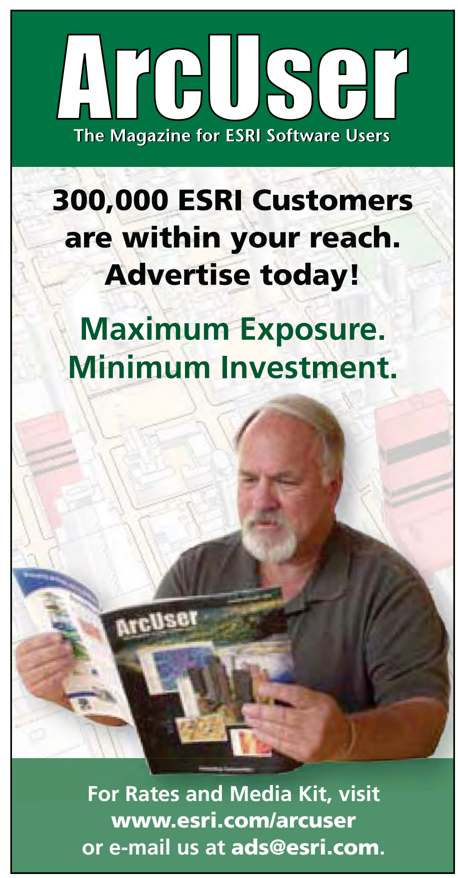
A fill-form-from-history tool was developed for ArcPad using JavaScript. The tool can be easily adapted for existing ArcPad applications in only two steps. The advanced features of JavaScript achieve more functionality with less and simpler code, making it an excellent choice for ArcPad customization.

About the Author

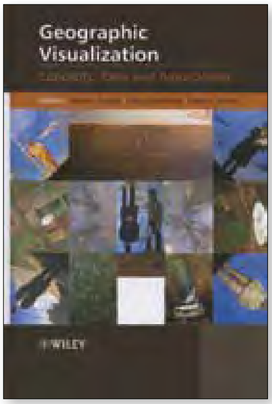
Mel Yuanhang Meng is the CAD/GIS manager for DLZ Ohio, an architectural and engineering consulting firm. He works in the field of water/wastewater infrastructure design, maintenance, and modeling. His professional interests include asset management, field data collection, and Web-based GIS application development. He holds two master's degrees, one in geography and the other in environmental engineering, from the University of Cincinnati.

More Information

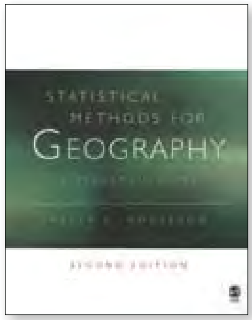
Working with ArcPad 7, a free Web course, and *Customizing ArcPad,* another Web course, are offered by ESRI. Visit www.esri.com/training to enroll.



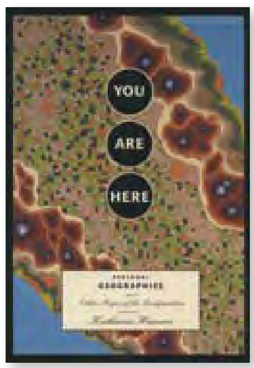
gis Bookshelf



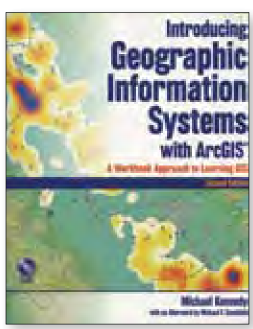
Geographic Visualization: Concepts, Tools and Applications
Edited by Martin Dodge, Mary McDerby, and Martin Turner
This collection of papers documents the progress that has been made in the field of geographic visualization (or geovisualization) and indicates possible developments in the future. Although many GIS practitioners may be more familiar with the geovisualization of data relating to the physical sciences, this book contains many applications for these techniques in the social sciences. It addresses topics such as three-dimensional display, mobile data, and representing uncertainty. The sweep of this book is broad: case studies cited are drawn from Europe, North America, and Australia, and contributors include scholars and researchers from cartography, GIScience, architecture, art, urban planning, and computer graphics. Numerous illustrations and explanations of visualization concepts make the text accessible. Graduate students, researchers, and geographic information professionals are the target audience for *Geographic Visualization: Concepts, Tools and Applications.* Wiley, 2008, 348 pp., ISBN-13: 978-0470515112



Statistical Methods for Geography—A Student's Guide, Second Edition
By Peter A. Rogerson
This textbook supplies a systematic introduction to the use of statistical methods in geography. The second edition was completely revised and supplies expanded introductory chapters and information on probability and descriptive statistics. This edition gives students more hands-on experience applying these concepts, with downloadable datasets and additional exercises. SPSS for Windows and Microsoft Excel are used to illustrate the application of these methods. Additional lecture material and study skills materials, along with sample datasets, are available from the companion Web site. Peter A. Rogerson is a professor of geography at the University at Buffalo, State University of New York. Sage Publications Ltd., second edition, 2006, 320 pp., ISBN-13: 978-1412907965



You Are Here: Personal Geographies and Other Maps of the Imagination
By Katherine Harmon
In the introduction to *You Are Here: Personal Geographies and Other Maps of the Imagination,* Katherine Harmon writes: "I sense that humans have an urge to map and that this mapping instinct, like our opposable thumbs, is part of what makes us human." The rest of this artfully designed and lavishly illustrated book makes this argument with maps that reveal not only the physical world but also the realms of myth and fiction. Some maps have unexpected perspectives: one from the 1920s portrays a dog's trip through the ideal country estate. The more than 100 inventive maps presented in this volume—created by cartographers, artists, and explorers—push the definition of a map. Princeton Architectural Press, 2003, 192 pp., ISBN-13: 978-1568984308



Introducing Geographic Information Systems with ArcGIS—A Workbook Approach to Learning GIS, Second Edition
By Michael Kennedy
As in the first edition, *Introducing Geographic Information Systems with ArcGIS—A Workbook Approach to Learning GIS,* Second Edition, combines the theoretical and practical in one volume. Designed as a one-semester textbook for university, college, or advanced high school students, it provides a solid foundation that will allow students to grasp the central concepts of GIS needed to understand spatial analysis while providing the ability to use major tools in ArcGIS. This foundation will allow students to progress on to more advanced study of GIS or GIScience. This edition has been updated for ArcGIS 9.3 and adds information on file geodatabases and 3D GIS with terrains. The accompanying CD contains the data for the book's 60 regular exercises and 9 review exercises. Wiley, second edition, 2009, 624 pp., ISBN-13: 978-0470398173

A Classic Reissued and Expanded

Sixth edition of Map Use *continues its educational mission*

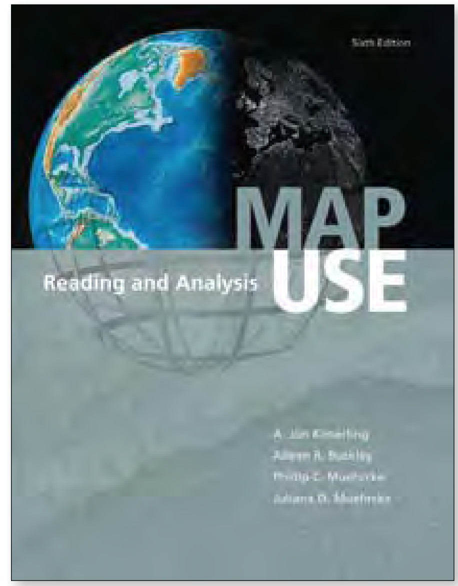
Unlike most texts dealing with maps, *Map Use: Reading and Analysis* is written for the map user rather than the mapmaker. The mission of this book is even more important now than when the first edition was published in 1978 because GIS has made map reading and analysis skills more—not less—important than previously.

Once maps were the closely guarded repositories of geographic data. Now maps generated using GIS are ubiquitous—they pop up all over the Internet and can be accessed from cell phones. By streamlining the process of compiling and processing data and designing and producing maps, GIS has expanded not only the number of maps produced but also the topics mapped. In addition to people who need to accurately read and analyze maps as part of their job, many people depend on maps when engaging in recreational activities such as sailing, hiking, or mountaineering.

Although maps are nearly universally familiar and seem deceptively simple, special skills are needed to interpret the graphic language used by maps. As the databases associated with GIS have taken over the storage of geographic information, the role of maps as tools for conceptualizing and solving problems has increased. Maps are now more likely to be used for communicating highly processed data that is produced by GIS analysis. These densely symbolic documents often mask the complexity of the information they portray.

Because a map is a representation, creating a map is a process of deciding what to include and what to leave out, what information to emphasize and what information to subdue to communicate the message of the map effectively to the map reader. As a result, a map can also tell a great deal about the cartographer who created it.

"The underlying theme that separates *Map Use* from other books on mapping is its emphasis on the fact that maps do not merely show what is in our environment but are windows into how people think, adjust to their surroundings, make decisions, and communicate geographic information with each other," said A. Jon Kimerling, one of the book's coauthors. "In this sense, users get more out of a map than the graphic product created by the cartographer, especially when they have mastered the map reading and analysis skills so carefully presented in the book."



Map Use was first published by Phillip C. Muehrcke, professor emeritus of geography at the University of Wisconsin, and Juliana O. Muehrcke, the founding editor of *Nonprofit World,* to help as many people as possible better understand and use maps. Through six editions, it has continued to do this in a manner that is entertaining as well as informative. The topics covered have expanded to include information on GIS and other geospatial technologies.

This edition marks many changes for *Map Use.* ESRI purchased the rights from longtime publisher JP Publications, owned by the original authors. With this edition, Aileen Buckley, a cartographic researcher at ESRI, joined the Muehrckes and Kimmerling, interim chairman of the Department of Geosciences at Oregon State University in Corvallis (and a veteran of two previous editions of the book), as one of the book's four authors. Readers of previous editions will note this one is lavishly illustrated with 500 four-color maps and diagrams.

This book continues to be a tremendous resource for the interested layperson and has won a place in homes, offices, and libraries. However, this edition has been designed for use as a textbook in a three-credit, 15-week course for upper high school to lower college level students.

Map Use: Reading and Analysis, Sixth Edition, can be purchased at www.esri.com/esripress or by calling 1-800-447-9778. Outside the United States, visit www.esri.com/esripressorders for complete ordering options or contact your local ESRI distributor. ESRI Press, 2009, 528 pp., ISBN: 978-1589481909

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Improving the Study of Soil and Landscapes

GIS visualization clarifies relationships between soils, topography, and land use

By Barbara Shields, ESRI Writer

Understanding how soils occur and how they vary across landscapes is a critical skill for today's agronomists. At Purdue University (Indiana), it is an integral component of the curricula.

Darrell G. Schulze, professor of soil science, and Phillip R. Owens, assistant professor of soil geomorphology and pedology, coteach the class *Soil Classification Genesis and Survey.* They incorporate the latest version of ArcGIS to study the relationships between soils, topography, land use, and geology.

Using GIS in the classroom and in the field helps students better understand soils and the landscapes in which they occur and recognize geological features that indicate different soil types.

At the beginning of the class, most students know little about geography and GIS, but by the time they complete the course, they are able to access geographic data and view it with GIS tools. The teachers use GIS to share data with the students who, in turn, use it to observe different points in the landscape.

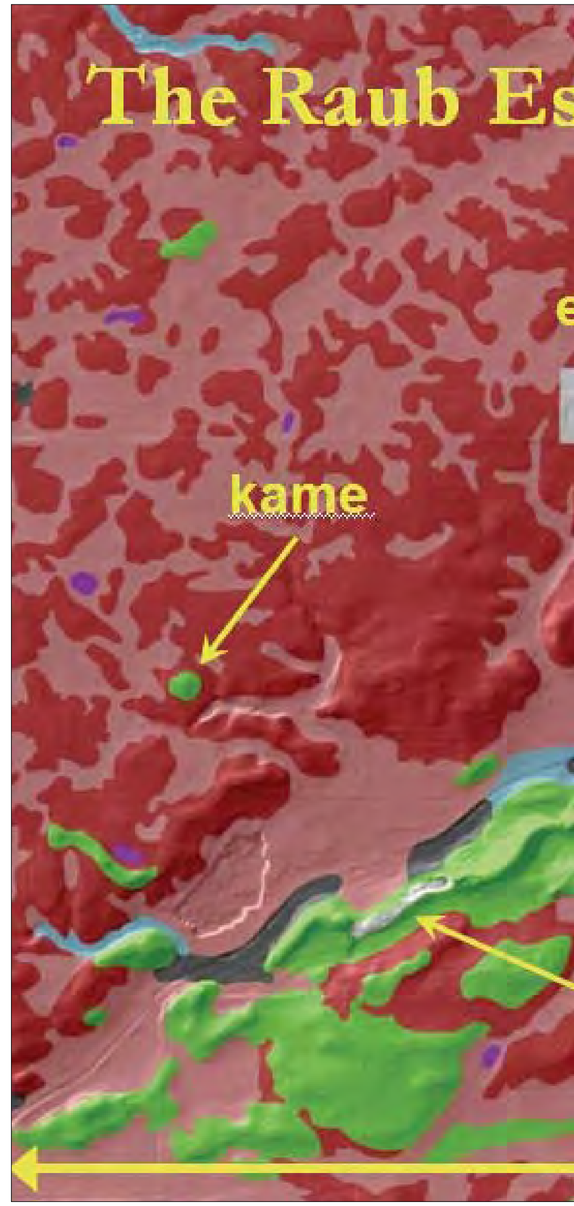
Schulze accesses the U.S. Department of Agriculture (USDA) soil survey data as well as data from the Indiana Spatial Data Portal and the Indiana Geological Survey. "This data is robust," notes Schulze. "In 2007, the USDA completed digitization of soil data for Indiana, so I can access soil data for any county in the state." Schulze downloads this data along with high-quality aerial photography and high-resolution digital elevation model (DEM) data. Using GIS, he aggregates the data into files that fit class objectives.

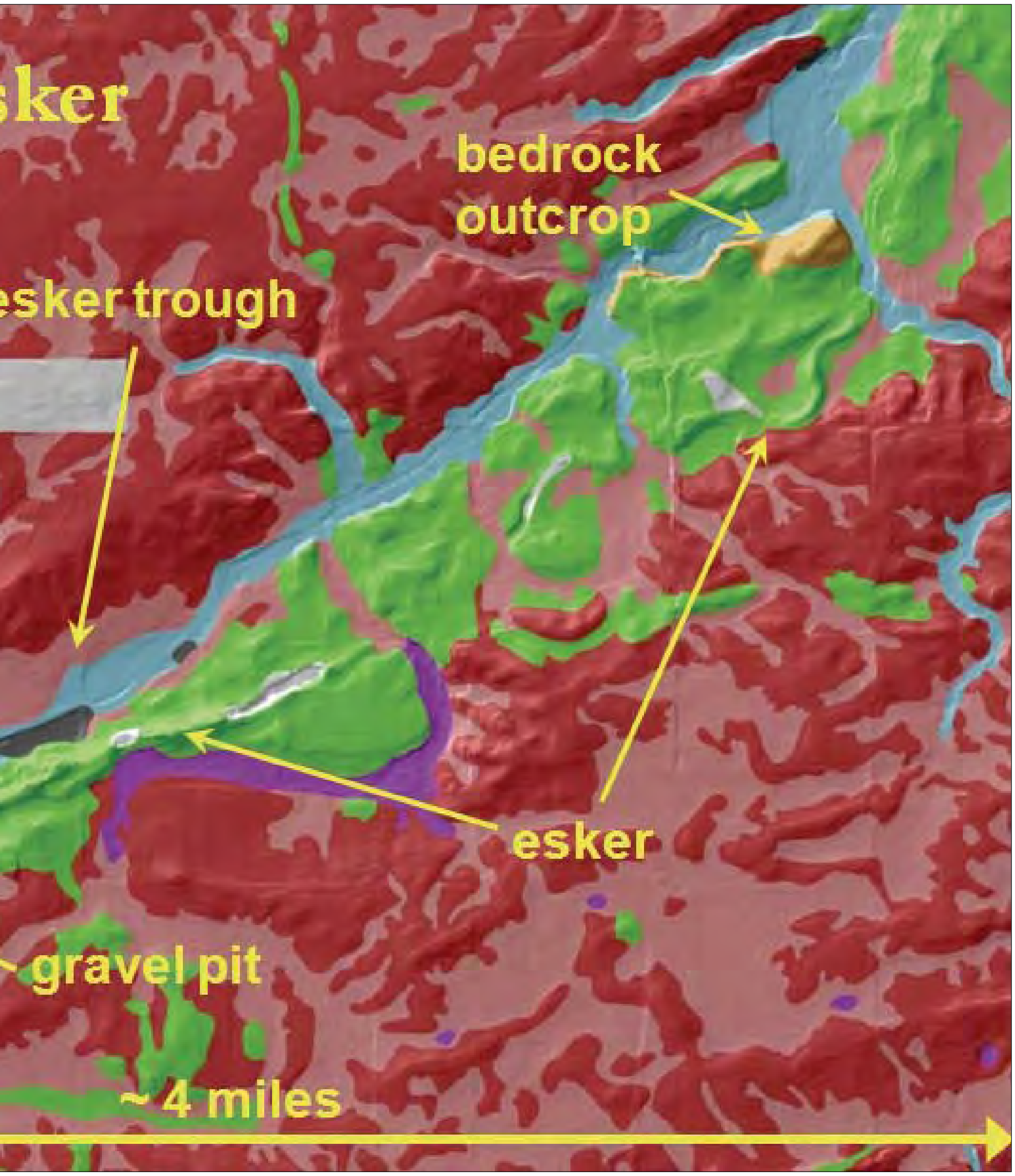
> "GIS is helping us to teach concepts in our class that would otherwise take students years of field experience to acquire."
>
> —Darrell G. Schulze, professor of soil science at Purdue University

For example, he created a dominant soil parent material model that groups polygons so that students can see relationships that are not readily apparent from traditional representations of soil survey data. With GIS, students are able to visualize the geomorphology of their study area. Owens stated "Students easily relate to the features they can see while they are standing in a field; however, larger landscape features that occur over kilometers are much more difficult to immediately understand. Teaching soil geomorphology using Tablet PCs and GIS provides the students with tools to see relationships over large distances and has revolutionized our ability to teach spatial relationships."

Students can see, for instance, that Purdue is located in a part of the world that was glaciated 20,000 years ago and understand close correlations between the soil parent material and the surficial geology. The DEMs highlight relevant topographic variations. By comparing this with soil data, students make

Purdue students take GIS on the road to better understand the real world of soil assessment via digital data.





The clear imagery of a GIS-created map highlights key data elements such as the characteristics of landforms like this esker.

GIS loaded on a ruggedized tablet allows users to view specific data in the field to determine soil characteristics and perform analysis.

conjectures about how geological phenomena have affected soils.

They can see, for example, that soils formed on dense glacial till that was smeared down and compacted by the ice as the glacier moved along its path are wet because the water cannot move readily through the dense till. Sandy and gravelly soils that formed on the outwash that was deposited by the rapidly running water from the melt are better drained, and they do not have a high water table in the winter like the soils on glacial till. GIS shows how the difference in the internal soil drainage class of those soils is influenced by the different parent soil materials.

In the classroom, students become familiar with basic viewing features such as zoom in, pan, and toggling layers on and off as they begin to review datasets and relationships. They also see how to access data with ArcExplorer and import it into their map projects.

During weekly three-hour lab periods, the class goes on short, local field trips near campus to examine soil pits and study soil types. Students take along assigned ruggedized Tablet PCs loaded with ArcGIS and integrated with GPS receivers.

Later in the semester, students participate in two all-day field trips. They travel by bus from Lafayette, Indiana, north to Lake Michigan on the first trip and as far south as Bloomington, Indiana, on the second. Class time is continued while traveling on the bus, and students are literally oriented as they follow their routes via the GPS and ArcGIS interface on their Tablet PCs.Students can explore the lesson and make observations on their PCs.

"While we are traveling to our destination, I use GIS displaying the outcome on a monitor mounted in the bus. We can show them how to read the landscape," Schulze explains. "They learn that a slope or a particular shape of a hill was formed by a particular geomorphic process and can then deduce the material that is underneath."

For instance, they learn to recognize an esker, which is a long, skinny hill that has sand and gravel under it where there was once water flowing under the ice. Using their Tablet PCs, they can compare the virtual esker with the landscape before them. GPS indicates, in real time, where they are on the map, verifying their interpretation of what they are seeing.

Purdue is located in Tippecanoe County, which is the easternmost boundary of the prairies of the Great Plains. In the western half of the county, a lot of the soils have been formed under prairie vegetation, giving them dark-colored surfaces. In the eastern half of the county, soils formed under forest vegetation have a lighter color. Prairie soils tend to be slightly better for growing crops because they are higher in organic matter, and overall, topsoil has better physical properties. Forested soils are more prone to crusting. This type of soil identification can help agronomists predict yield.

The available data, map products, and models improve with each new class. Schulze is currently working on an application in which students can click on a polygon to query the attribute table as well as click on a link that leads them to a schematic diagram of a soil profile that illustrates what the soil looks like below the surface.

"Two approaches can be taken in using GIS for education," explains Schulze. "One is teaching about GIS and how it works and the other is using GIS to teach agricultural concepts." In the latter, teachers design maps for students and put them into a format that works well for the specific class. The data is preassembled and put into a format that works easily for the student and helps the teacher focus precisely on the topic. Students' hands-on use of GIS-loaded Tablet PCs reinforces concepts from the lecture. Schulze concludes, "GIS is helping us to teach concepts in our class that would otherwise take students years of field experience to acquire."

New ESRI Authorized Instructors

The Authorized Training Program (ATP) is pleased to acknowledge the newest class of ESRI Authorized Instructors. These candidates have passed all ATP requirements and have been granted authorization to teach the specified ESRI courses within the United States. These instructors join a network of more than 400 ESRI Authorized Instructors. For a complete listing of ESRI Authorized Instructors in your area, please visit www.esri.com/atp; contact the ATP by e-mail at atp@esri.com; or call 909-793-2853, ext. 1-2111.

Abbreviations for each course authorization are listed in the table. The course authorizations shown with each instructor listed indicate only the most recent authorization(s) received by that instructor. Visit the ATP Web site for complete information on all authorizations held by an instructor.

Course Abbreviations

AAV	Advanced ArcView 3.x
AG1	Introduction to ArcGIS I (for ArcGIS 9)
AG2	Introduction to ArcGIS II (for ArcGIS 9)
AGD1	ArcGIS Desktop I
AGD2	ArcGIS Desktop II
AGD3	ArcGIS Desktop III
AGSA	Working with ArcGIS Spatial Analyst
AIMS	Introduction to ArcIMS
AV3	Introduction to ArcView (3.x)
BGDB	Building Geodatabases
IAGS	Introduction to ArcGIS Server
LGAD	Learning GIS Using ArcGIS Desktop
MGDB	Introduction to the Multiuser Geodatabase
PAO	Introduction to Programming ArcObjects with VBA
PAOJ	Introduction to Programming ArcObjects Using the Java Platform
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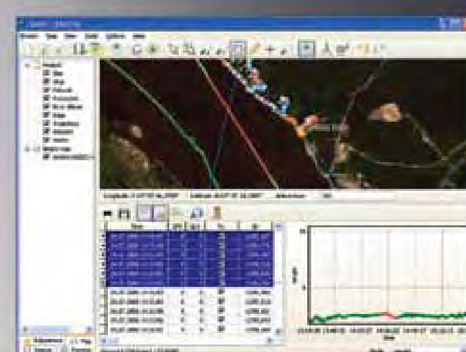

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When Every Second Counts

Yosemite uses GIS for coordinating search and rescue operations

By Jesse Theodore, ESRI Writer

GIS has helped the Yosemite Search and Rescue (YOSAR) team improve its methods of operation and has been used successfully in searches for missing persons in Yosemite National Park.

Every year, three million visitors come to Yosemite National Park to enjoy the outdoors. One of the nation's greatest travel destinations, Yosemite provides camping, fishing, hiking, and other activities for guests to enjoy. While most visitors have the time of their lives, a few face the frightening prospect of becoming disoriented or getting injured while hiking the park's many trails.

Each year, Yosemite National Park responds to hundreds of calls reporting missing persons. Most often, a lost hiker or vacationer is found during the first 24 hours. However, when someone is missing for more than 24 hours, multiple search teams are dispatched. Search and rescue operations require a significant, coordinated effort on the ground and in the air. For these incidents, the National Park Service calls on YOSAR, a team of specialists.

Photo by David Pope

A helicopter rescue technician rappels from Yosemite's contract helicopter H-551.

YOSAR is a group of park rangers, technical climbers, helicopter pilots, and incident management staff who are directed by Keith Lober, the emergency services coordinator for Yosemite National Park.

These skilled search and rescue operators are known around the world for their ability to make backcountry extractions of injured hikers; perform climbing rescues off of "big walls," such as El Capitan; search for missing hikers; and respond to multi-casualty incidents. They work primarily in the park, but are requested by mutual aid management teams throughout the country.

Once activated, YOSAR assembles and deploys ground, technical, canine, and air units and manages the entire incident response process. Managing complex emergency situations requires rapid response capability that ensures a comprehensive, coordinated search is carried out in the fastest possible time frame.

Expanding GIS at Yosemite

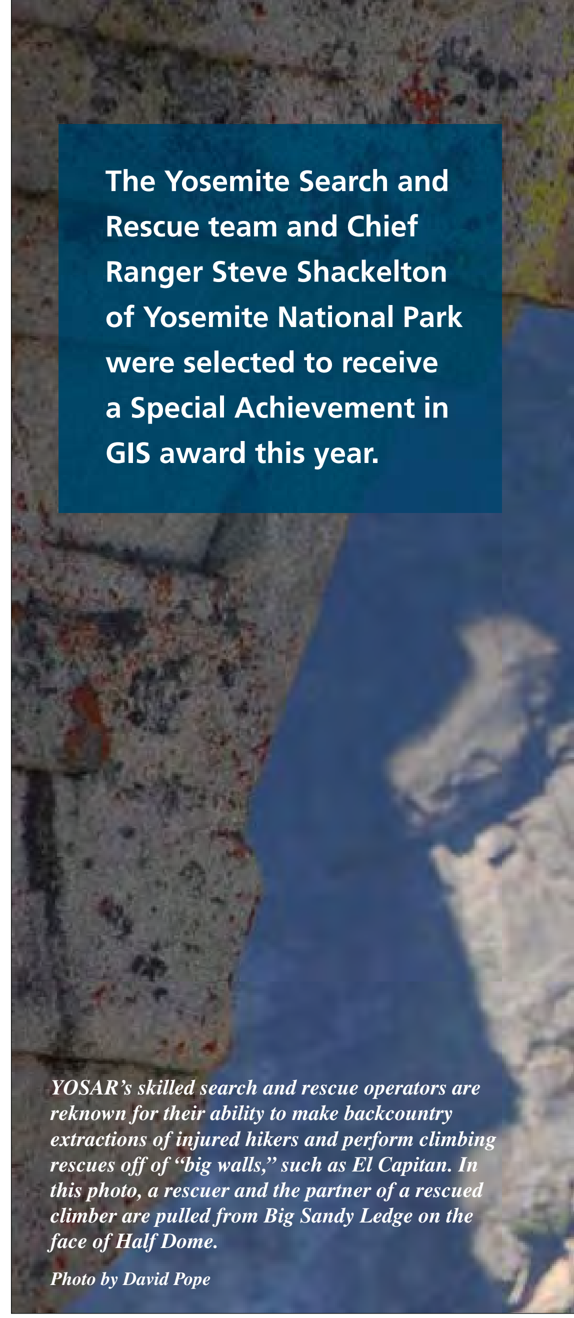
Paul Doherty, a park ranger and GIS specialist for the National Park Service, was hired in May 2008 to establish GIS support specifically for search and rescue operations.

"Once I settled in and started working, the GIS needs in the Protection Division were evident and the opportunity to get involved was very exciting," said Doherty.

The National Park Service has successfully used GIS in its Resource Management and Science Division, as well as in its response to wildland fires. Protection Division chief Steve Shackelton envisions applying the same technology and services to all branches of emergency response (i.e., search and rescue, law enforcement, disaster management, and structural fire) in the park.

Managing a Complex Operation

Missing person incidents are common in Yosemite. When a hiker is missing or overdue, it requires an initial response known as a "hasty search." These searches are carried out in the first 24 hours in the immediate vicinity where the lost person was last seen. Trail blocks are established to interview possible witnesses and gather information on hiking conditions.



The Yosemite Search and Rescue team and Chief Ranger Steve Shackelton of Yosemite National Park were selected to receive a Special Achievement in GIS award this year.

YOSAR's skilled search and rescue operators are reknown for their ability to make backcountry extractions of injured hikers and perform climbing rescues off of "big walls," such as El Capitan. In this photo, a rescuer and the partner of a rescued climber are pulled from Big Sandy Ledge on the face of Half Dome.

Photo by David Pope

If the person is not found quickly, a large search area of 1–40 square miles is drawn on a map. This area is segmented to create smaller search assignments, and a comprehensive search and rescue case is created.

Finding a missing person in the wilderness is a complex process. Maps are at the core of this process. Incident managers and field teams want to know the coordinates where the person was last seen to determine where they should begin the search. They also want to know about the surrounding landscape so they can safely and efficiently locate, stabilize, and extract victims as quickly as possible.

These search and rescue operations, managed under the Incident Command System, can increase in complexity very quickly. YOSAR members are adept at implementing modern search theory as well as using lessons learned from previous searches.

Photo by David Pope

Rescuers carry an injured climber to an awaiting helicopter.

Photo by Tom Patterson

Paul Doherty, a park ranger and GIS specialist for the National Park Service, was hired in May 2008 to establish GIS support specifically for search and rescue operations.

In 2008, YOSAR wanted to use GIS to quickly and easily print accurate assignment maps that teams would use in the field. To provide more information about the landscape before teams go into the field, these maps use vector layers and raster imagery. In the past, the mapping component of a search required using hard-copy, outdated 7.5-minute quadrangle (quad) maps, transparent Mylars, erasable markers, and—on occasion—limited mapping software.

"It was difficult to keep things organized," said Doherty. "Hard-copy maps and forms are difficult to update and properly archive." Search teams would sketch their assignments on their maps using erasable markers, a process that had the potential to increase error. Because YOSAR staff members were open to innovation, Doherty could implement novel GIS techniques that have changed how YOSAR operates.

Maps, Data, and Accountability

Doherty built a solid GIS platform for preparation, response, and the postevent analysis of rescue operations, employing ArcGIS Desktop (specifically ArcInfo and the ArcGIS 3D Analyst and ArcGIS Network Analyst extensions). The first priority was coordinating existing GIS resources at the park to build databases and processes that could be activated at a moment's notice.

With GIS in place at YOSAR, Doherty and staff can now

- Supply accurate field maps with search segments outlined.
- Provide aerial imagery and elevation data.
- Show hazards and terrain patterns.
- Record GPS tracks from field teams.
- Load search assignments onto GPS units.
- Build an assignment database to track team deployments.
- Show probability of detection (POD) *[the probability of the missing person being detected, assuming that person was present in the segment searched]*.
- Depict probability of person in area (POA) *[chances that the missing person is in the area being searched]*.
- Plot the locations of known helicopter landing zones.
- Plot the locations of clues as they are discovered.
- Determine observer/communication tower line of sight.
- Generate briefing maps.

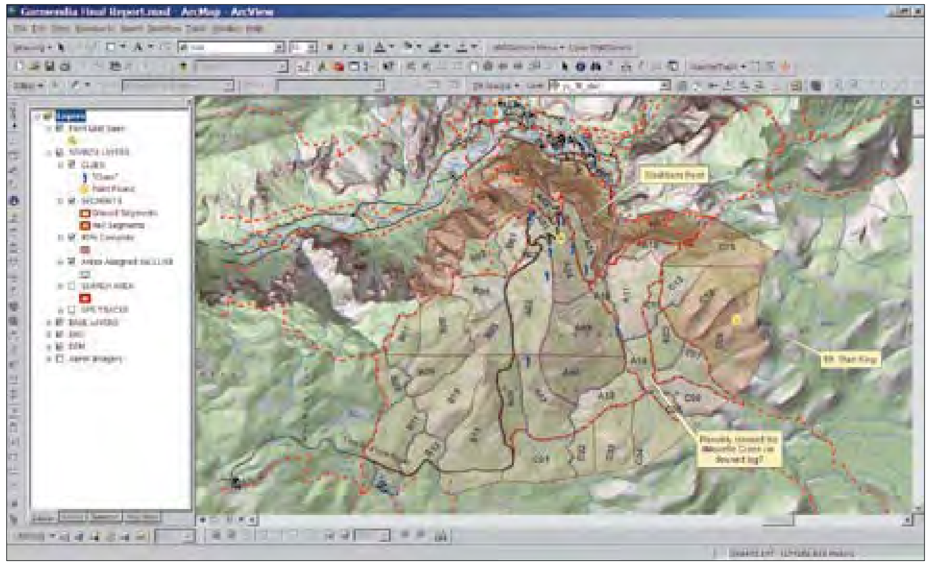
Continued on page 68

When Every Second Counts

Continued from page 67

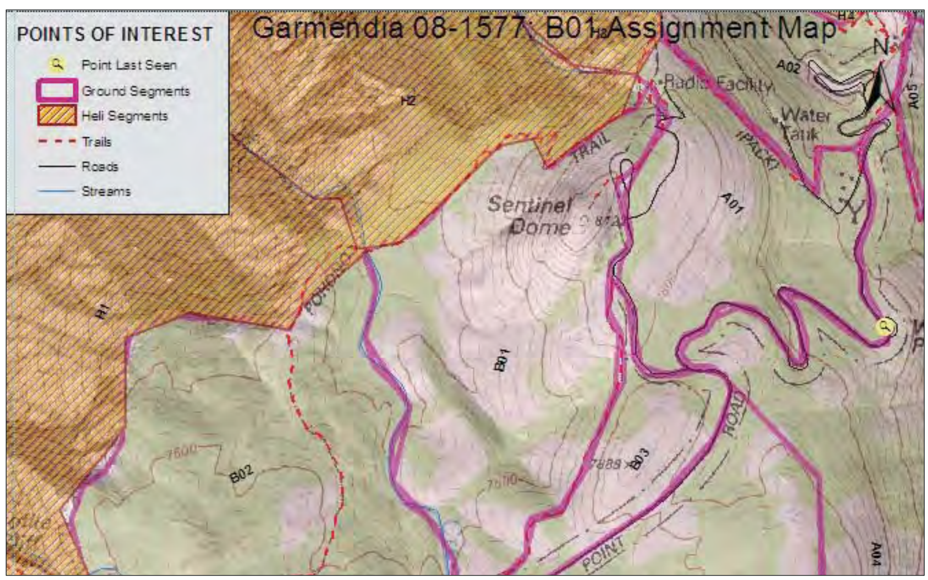
Photo by David Pope

Paul Doherty and Ranger Matt Stark digitize search segment polygons on the first day of the Garmendia search.



Map by Paul Doherty

ArcMap project screen shot of the Garmendia search segments, a "clue" database, status of search segments, and Yosemite National Park base data used to create search assignments



Map by Paul Doherty

ArcMap project screen shot taken during the Garmendia search. These segments were assigned to either ground, dog, or helicopter teams based off of slope characteristics. The orange shading highlights the cliff bands of Sentinel Dome where ground teams should avoid the treacherous cliffs.

A myriad of data is built and maintained by the National Park Service and the YOSAR GIS team. This includes vector data for roads, streams, trails, park buildings, vegetation, and helispot locations. Raster data includes digital elevation models (DEMs), which supply a three-dimensional surface with topographic features; digital raster graphics (DRGs), which are high-quality scanned images of U.S. Geological Survey quad maps that provide contour lines and detailed terrain information; and 2005 National Agriculture Imagery Program (NAIP) aerial imagery.

During a search incident, Doherty works with YOSAR search incident data to generate additional data such as search area polygons; search segments/assignments; clues (i.e., point last seen, footprints, litter, and trail interviews); viewshed analyses; and GPS tracks from helicopters, ground crews, and dog teams.

GIS Gets the Job Done

With each new search operation carried out by YOSAR since the adoption of GIS in 2008, GIS has become more of a key component.

The successful search for Esmin Garmendia illustrates the many uses of GIS by YOSAR. Garmendia, a 23-year-old man who had visited the park with friends, left the parking area and ventured into the woods alone. He was last seen by his friends at about 3:00 p.m. on June 8, 2008. Garmendia's friends returned from their hike, but when he did not appear after some time, he was reported as a missing person. Soon a full YOSAR operation was under way.

At a planning meeting, searchers examined where Garmendia was last seen and where he might have gone. DEM, trail, stream, and vegetation data, as well as local knowledge, was used to generate an appropriate search area. The search area was segmented into manageable and clearly identifiable subsections to ensure a new search area would be covered by ground teams, dog teams, and helicopters each day.

GIS was used to determine where to place teams in the field. Using the same layers that were used to predict Garmendia's travel, teams were strategically placed to best cover their assigned terrain and ensure that the maximum search area was sufficiently covered.

For example, YOSAR used slope data from a DEM of the park to assign technical teams to areas having a slope of more than 45 degrees and dog-assisted ground teams to safer, flatter terrain. In the past, YOSAR staff read the contours on standard quadrangle maps and estimated slope of the terrain. However, with this objective tool for determining slope, decision makers could spend time on other operational, planning, and logistical functions.

Next, a briefing was held to communicate search and rescue operation plans to all teams and individuals involved. Incident action plan (IAP) maps were generated to show possible search areas and list objectives. These 8.5" x 11" maps contain metadata such as map scale, title, author, and the date the data was generated. These maps included the point location where Garmendia was last seen; search buffer zones (created using GIS analysis); and topography generated by overlaying DRGs, DEMs, and imagery layers.

Search teams were then deployed. GPS and other data was captured in the field and sent back to the incident command post. Updated maps were generated to reflect where resources were sent, how the search was progressing, and what evidence (if any) was collected and where it was found. Previous manual tracking methods using paper maps lacked any type of objective data capture and required scanning to archive the information in a digital format.

Incident briefing maps were used during daily meetings. These paper maps were 24” x 36” and included data from debriefing forms as well as any significant clues from the clue log. The maps showed hazards for new searches in the field, such as cliffs and steep drainages and dense vegetation, and any updates from the previous day’s operations. Numerically labeled polygons showed areas that had yet to be searched. These polygons were overlaid with data on trails, rivers, and other physical features.

The incident command staff were briefed with maps that showed all areas that were actually searched the previous day and where the new search teams would operate over the next 24 hours. Field teams were provided with new IAPs and 8.5” x 11” assignment maps the next day. These maps included additional information such as declination, a Universal Transverse Mercator (UTM) grid in the correct local datum (North American Datum of 1983), significant landmarks, hazards, and search segment boundaries.

GIS helped during all phases of the Garmendia search operation, which encompassed nearly 23 square miles. It helped coordinate more than 190 ground, helicopter, and dog teams. Fortunately for this hiker, Yosemite had a helicopter available for aerial observation throughout the entire operation. After three days of search and rescue operations, a helicopter located Garmendia from the air. He was found safe and healthy, despite his arduous ordeal.

GIS provided an information platform to map operations, update information, and improve decision making. GIS methods enhanced YOSAR operations through

- Supplanting old paper maps and hand-written notes with digital data capture, management, analysis, and dissemination
- Supplying a standard for measuring or quantifying search variables versus simply supplying map images or approximating map polygons
- Helping document exactly where resources were directed and where to change actions as needed in a real-time search

“GIS supplies powerful tools, but it will not direct a search,” said Doherty. “It does not replace the institutional knowledge of veteran search managers and never will. It does, however, allow us to take advantage of analyses that are far more useful than simple hard-copy maps. It helps us perform a search more efficiently, with enhanced team safety, and with a greater probability of returning victims to their loved ones.”

Doherty is looking forward to continually expanding the use of GIS in search and rescue during his career with YOSAR and collaborating with incident management teams around the globe who are interested in utilizing GIS.

In less than a year, YOSAR’s geospatial platform has been used successfully in half a dozen searches. From the peak visitor season in summer to the cold and icy conditions in winter, this platform provides an information-based method for outlining initial search strategies, helps refine the exploration as time progresses, and keeps information continuously flowing from the field to the incident command post and back again. Everyone operates using the same accurate data, which helps find the missing person as quickly as possible. In search and rescue operations, this can mean the difference between life and death.

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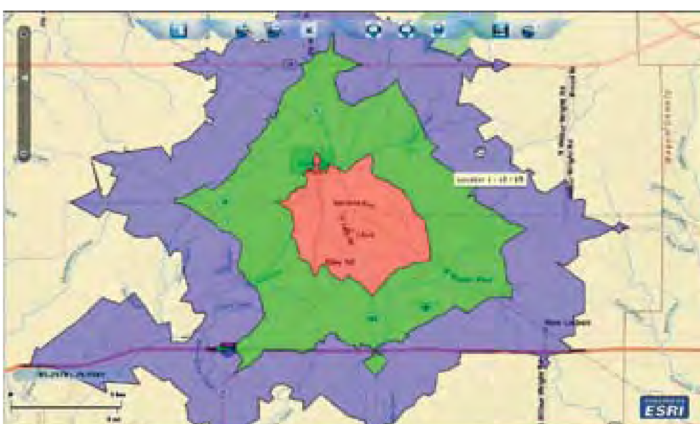

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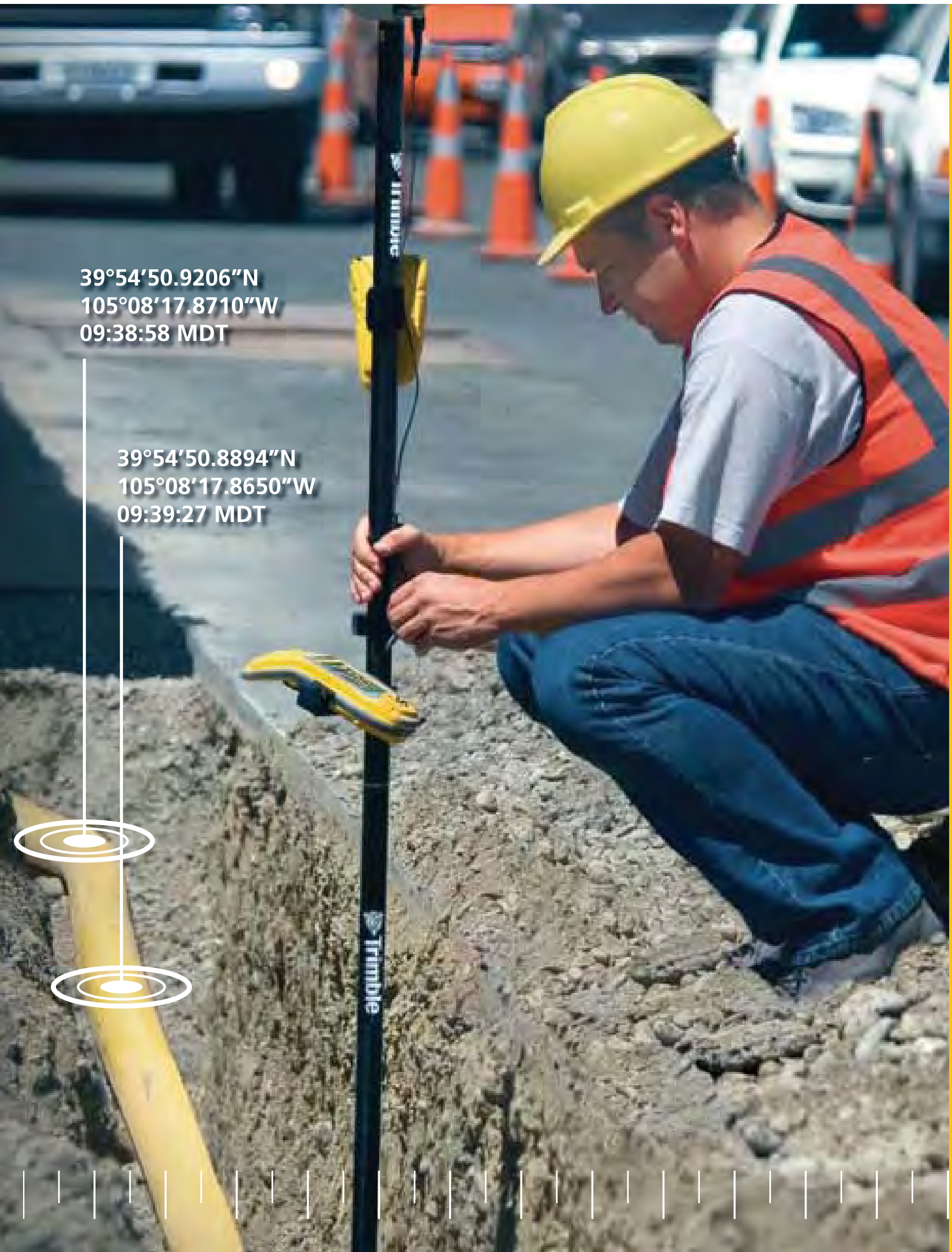

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