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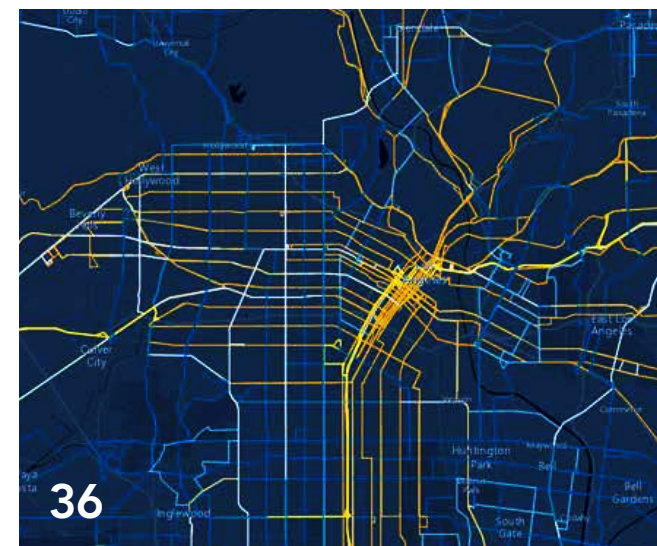
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# Managing an Increasingly Complex World

Arguably, complexity is one of the defining characteristics of our world. As Gökçe Sargut and Rita McGrath observed in an article in *Harvard Business Review*, “Learning to Live with Complexity,” something that is complicated is qualitatively different from something that is complex. While *complicated* and *complex* describe a relationship between cause and effect, they are not the same thing.

Complicated systems typically have many components. However the interactions between those components, however numerous, follow predictable patterns. If the starting conditions are sufficiently known, outcomes can be predicted with relative confidence. GIS, with its data integration capabilities and geographic framework, has long excelled at managing complicated systems such as electrical grids.

In contrast, while complex systems also have many components and potentially a large number of interactions, those components exhibit a high degree of interdependence and diversity. The relationships between components are constantly being readjusted. When dealing with complex systems, the uncertainty of the system’s state and the volume of the associated data can overwhelm decision makers.

GIS was originally developed for dealing with the dependencies inherent in land-use planning. Its use has been steadily expanded to gain a better understanding of the complexity of the natural world and mankind’s effect on it as well as the operations of organizations.

More recently, GIS has been applied to the complexity engendered by the interdependent but not necessarily integrated systems of the information technology ecosystem. The ArcGIS platform can knit these systems together and provide an aggregate value that exceeds the sum of the individual parts thanks to its analytical and communication tools.

An article featured in this issue describes how the ArcGIS platform helps manage one of the world’s largest commercial ports. Located in Southern California, the Port of Long Beach and its neighbor, the Port of Los Angeles, make up the largest port complex in the United States.

Virtual Port, an ArcGIS-centric system, integrates and provides visualization for the port’s previously existing multilayered security system. By geographically referencing the 60 databases associated with that system and adding real-time data capabilities, field data collection using mobile devices, and an operations dashboard, port personnel now have an up-to-the-minute and comprehensive view of port operations.

In addition to monitoring daily operations more effectively, the common operational picture provided by Virtual Port enhances two other vital functions: incident response and business recovery. For these applications, officials model events, such as chemical spills, and create what-if scenarios to proactively prepare for events that are possible but not predictable in this complex environment.

Monica Pratt

Monica Pratt  
ArcUser Editor

## editor’s page

# ArcUser

Spring 2016 Vol. 19 No. 2

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### ISSN 1534-5467

ArcUser is published quarterly by Esri at 380 New York Street, Redlands, CA 92373-8100 USA. ArcUser is written for users of Esri software and distributed free of charge to registered users.

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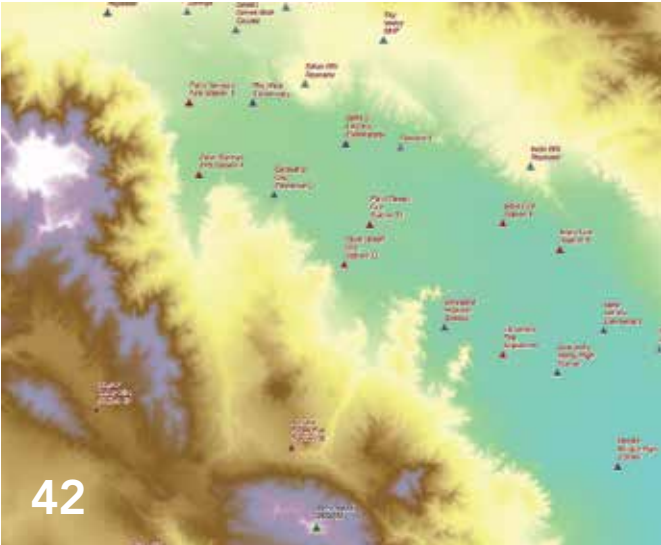
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# ArcGIS Provides New Dimensions for Looking at Data

**ArcGIS 10.4** introduces many new tools for visualizing, analyzing, and effectively communicating in both 3D and 2D. ArcGIS for Desktop, ArcGIS for Server Enterprise (both Windows and Linux) and ArcGIS for Server Workgroup (all of which come with Portal for ArcGIS), ArcGIS Engine Developer Kit, and ArcGIS Engine are included in the ArcGIS 10.4 release.

## New Ways to Look at 3D Data

This release enables sharing of 2D and 3D information in standard, scalable formats that can be used in maps and scenes on multiple clients. Global scenes, local scenes, and ArcGIS Earth are all new ways to look at 3D data that is available at 10.4.

Global scenes display 3D content in a global coordinate system, World Geodetic System 1984 (WGS-84). This coordinate system is well suited for data that encompasses a large extent and must account for the curvature of the earth.

Conversely, local scenes, available in the scene viewer, are suited to data with a limited extent, such as a college campus. Local scenes can display layers in a projected coordinate system and can be very effective for scientific and underground data display, where the relative size of features is a more important consideration than the physical location of the data on a spheroid.

ArcGIS Earth, a new app for visualizing 2D and 3D data on a globe, can be used with publicly shared elevation, imagery, and Living Atlas of the World data available from ArcGIS Online as well as with street and other nonimagery basemaps.

Behind a firewall, users can view custom basemaps and services in ArcGIS Earth, which also includes the same KML capability available with ArcGIS Runtime. ArcGIS Earth allows users to access other open standard data types, such as the Esri Indexed 3D Scene (I3S) format for scalable 3D web scenes and scene layers that allow



ArcGIS Earth, a new app for visualizing 2D and 3D data on a globe, can be used with Portal for ArcGIS or ArcGIS Online data.

serving 3D data in an accessible, common format. Currently, ArcGIS Earth runs on Windows desktop machines, but it will be available for other platforms in the future.

Now 3D point layers can be shared as scene layers in Portal 10.4 for ArcGIS, which improves visualization and performance for large point datasets including preset symbols. 3D point layers can be shared as individual web scene layers or as part of a web scene and can be consumed back into ArcGIS Pro or in the scene viewer.

At 10.4, content creators can style and publish attribute-based symbology for 3D object layers using ArcGIS Pro. This same capability will be available in other styling and authoring applications later this year.

## Vector Tiles

Vector tile maps download quickly, are easy

to style and update, and look great on high-resolution displays. Users can customize the look and feel of vector tile maps and layers by simply editing the style of a tile layer. In November 2015, initial support for vector tiles was introduced for ArcGIS Online. A set of vector basemaps, available as both layers and web maps, was made available through the Esri Vector Basemaps (beta) group and could be displayed in the map viewer.

With ArcGIS Pro 1.2 and ArcGIS 10.4 for Server, users can generate vector tiles from their own data and display them in most web browsers. Vector tile layers and vector basemaps can be served using ArcGIS Online or Portal for ArcGIS. In ArcGIS Pro 1.2, once vector tile layers are created, they can be zipped up into vector tile packages and uploaded to ArcGIS Online or Portal for ArcGIS. Vector tile packages make

it easy to update and restyle vector layers because packages contain tiles and style information. This means a vector tile package can be downloaded, modified to emphasize specific features, and shared as a new package back to the portal.

Custom web apps built with the ArcGIS API for JavaScript and ArcGIS Runtime SDKs can consume vector tile layers and vector basemaps by loading the web map or adding vector tile layers directly to the map. Developers can programmatically customize the style and the contents of the map such as turning a layer on or off.

Later this year, more desktop and mobile apps will use vector tile maps.

## Mobile Map Packages

Zip up and share basemaps and operational layers all in one package in a new format that supports high compression if the content is delivered as read-only layers. Operational layers can be queried and analyzed in the map viewer and used in specialized apps such as Navigator for ArcGIS. ArcGIS Pro 1.2 users can create and publish mobile map packages to Portal for ArcGIS and ArcGIS

Online. Later in 2016, mobile map packages will be supported in additional apps.

## Spatial Analytics

The suite of commonly used spatial analysis tools added to ArcGIS Online more than a year ago to provide powerful yet easy-to-use spatial analytics capabilities are now available in Portal for ArcGIS. Portal for ArcGIS members can access the Analysis tools via Perform Analysis from supported map layers. The tools are arranged in logical groupings—Data Enrichment, Analyze Patterns, and Use Proximity—that help users locate specific capabilities.

Users can perform analytical functions such as finding hot spots, locating streets and addresses, finding a place, or routing. Taking care of these capabilities will require setting up a web GIS implementation (i.e., Portal for ArcGIS, ArcGIS for Server, and ArcGIS Data Store).

## Imagery

Imagery classification, processing, and management are all enhanced in ArcGIS 10.4. ArcGIS now supports a wider range of sensors

including Sentinel-2, SPOT-7, WorldView-3, and a variety of Chinese sensors.

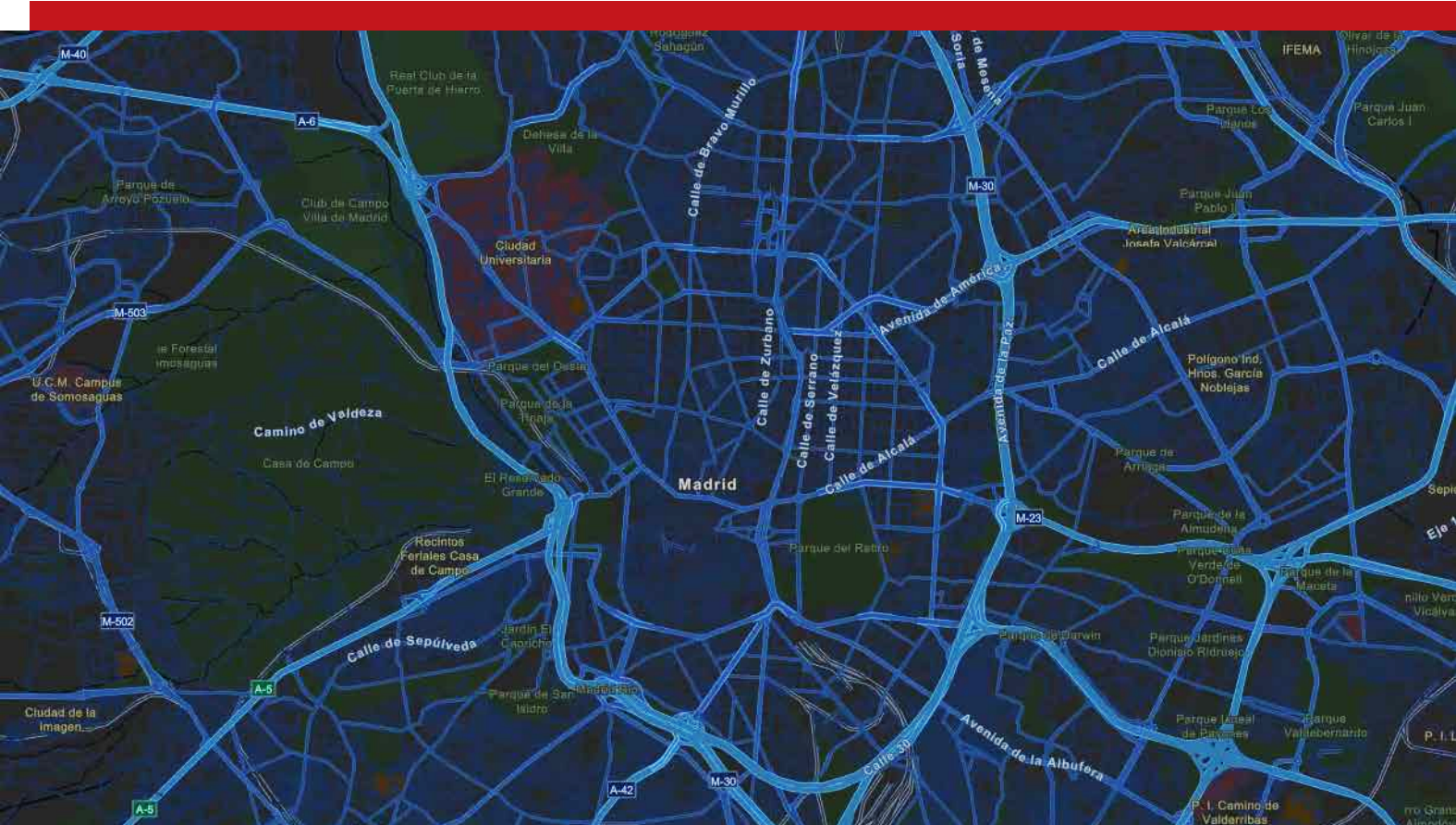
Two new formats, Meta Raster Format (MRF) and Cloud Raster Format (CRF), will be of special interest to users who work with massive volumes of imagery. MRF is optimized for storing collections of imagery and rasters in inexpensive cloud storage platforms. It enables fast image access, reduces the cost of storage, and is designed to scale using MRF on Amazon Elastic Compute Cloud (EC2).

A base implementation of CRF is included in ArcGIS 10.4. CRF allows parallel processing of rasters on multiple machines and will be a key part of new raster analytics capabilities coming later in 2016.

## More Resilient ArcGIS for Server Implementation

At ArcGIS 10.4, ArcGIS for Server includes new tools and capabilities that maintain performance, minimize downtime, enable quick recovery, and protect against accidental or ad hoc changes. ArcGIS for Server includes a new, simplified high availability (HA) configuration that makes it much easier to achieve

Quick downloading vector tile maps look great on high-resolution displays and can be customized by users.



continuous operations and maintain performance during periods of peak load. By default, ArcGIS Server sites support multiple GIS servers working with a load balancer, either ArcGIS Web Adaptor (included with ArcGIS for Server) or a third-party load balancer. The new high-availability experience will mitigate single points of failure, minimize downtimes, and give administrators the ability to detect site failures. The Portal Admin API can be used to show machines participating in the high-availability configuration and perform health checks.

A new tool available in the Portal for ArcGIS tools directory exports a single file containing portal items and settings, including group information, hosted web layers, and federated and hosting server settings. The file also includes the Configuration store and the ArcGIS Data Store, with hosted feature layer data (a relational data store) and hosted scene layer tile caches (a tile cache data store). Users can store the exported file in a separate machine (recommended) so it can be used to restore the ArcGIS Server site or web GIS deployment, or replicate the implementation

to a standby deployment that can be brought online if the primary deployment fails.

The option to set an ArcGIS Server site to read-only mode can be used to protect production sites from inadvertent or ad hoc changes to layers and services that might impact the applications and data. Read-only mode disables the publishing of new services and blocks most administrative operations. The site can still be scaled by adding or removing machines, and the functionality of existing services continues to be available. Read-only mode is useful for managing software upgrades and enhances the server's ability to continue functioning if it fails to connect to the underlying configuration information for multimachine sites.

New and updated installations of ArcGIS for Server will default to single cluster mode, which reduces network traffic between machines at the site, reduces the network load, and improves the resiliency and monitoring of GIS server sites. Single cluster mode does not include load balancing between machines in the cluster. Users who are already using single cluster mode and sites with

multiple clusters at earlier releases will have their settings preserved when upgrading.

### New Data Store

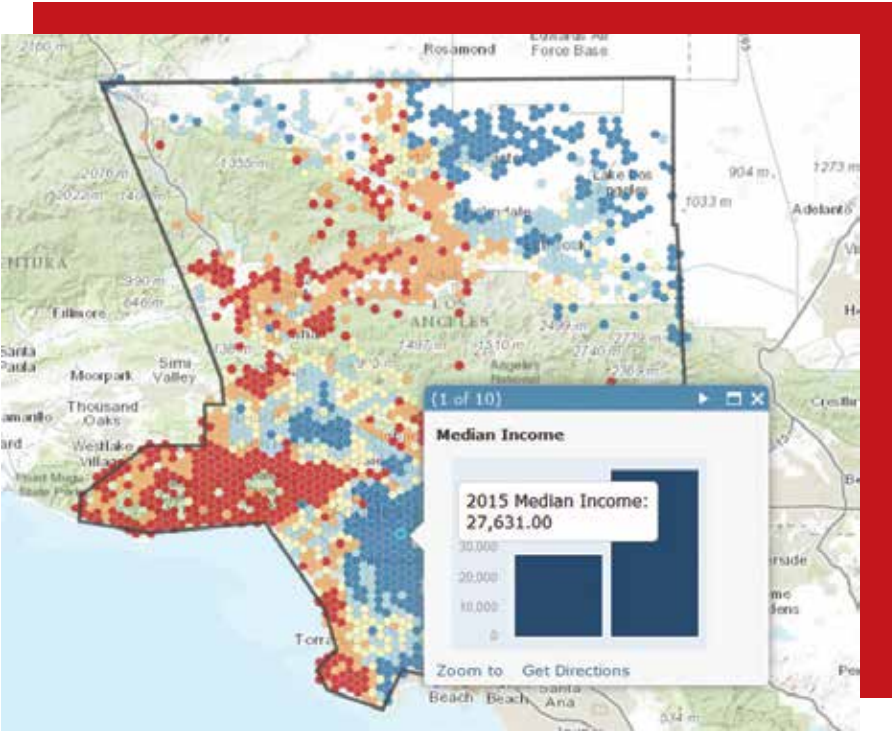
ArcGIS Data Store is an application that sets up two different types of data stores: one that stores hosted feature layer data (a relational data store) and the other that stores caches for scene layers (a tile cache data store). These data stores enable fast data access to Portal for ArcGIS applications (including map and scene viewers), ArcGIS Pro, and web clients.

ArcGIS 10.4 introduces a new data store, Spatiotemporal Big Data Store. In its initial release, this data store supports archiving of high-volume, real-time observation data using the ArcGIS GeoEvent Extension for Server. In upcoming releases, Spatiotemporal Big Data Store will play a key role in also supporting new capabilities for performing scalable and distributed batch analysis on feature and tabular data as well as raster analysis and image processing. Spatiotemporal Big Data Store significantly increases performance and reduces analytical processing time by allowing the processes to be split over a large number of machines and collating the results.

### New Apps

Several new apps are available with ArcGIS 10.4. AppStudio for ArcGIS is a groundbreaking tool that lets users convert their maps into beautiful, consumer-friendly mobile apps and publish them using their own brand to all popular app stores without requiring developer skills. Basic and Standard versions of AppStudio have no-coding app templates for Android, iOS, Windows, OS X, and Linux that can be used to create apps that can be published to Apple and Google Play app stores. With AppStudio Standard, developers can extend and customize apps and distribute them within the enterprise. AppStudio currently works only with ArcGIS Online.

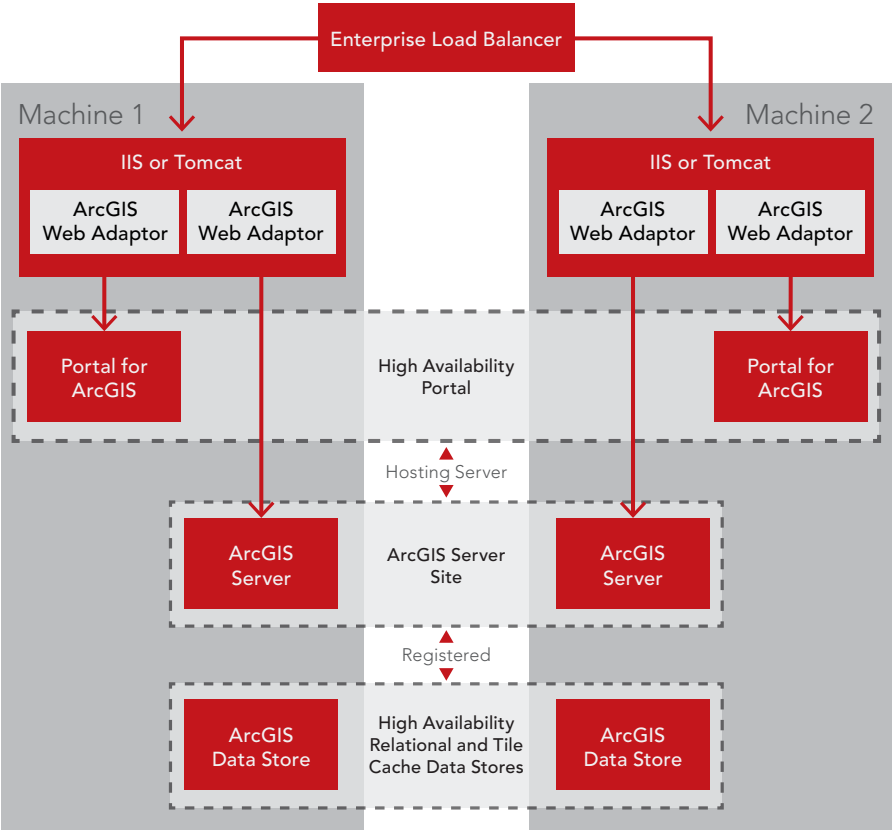
Survey123 for ArcGIS is a simple and intuitive form-centric data gathering solution that runs on iOS and Android devices and the Windows Phone. At 10.4, Portal for ArcGIS supports enterprise logins with Survey123 using OAuth (currently in beta).



Commonly used spatial analysis tools, such as GeoEnrichment, are available in Portal for ArcGIS and ArcGIS Online.



Drone2Map for ArcGIS, currently in beta, will let users create orthomosaics, 3D meshes, point clouds, and other professional imagery products in minutes, not days.



At ArcGIS 10.4, ArcGIS for Server has a high availability architecture.

The Workforce for ArcGIS mobile app for Android and iOS devices, currently in beta, helps users better coordinate teams in the field by reducing their reliance on paper and ensuring that all team members use the same authoritative data. This reduces errors, boosts productivity, and saves money. Back-office staff use the Workforce app in the web browser to assign work, monitor progress, and see where workers are in real time. Fieldworkers use the Workforce mobile app to receive assignments and status updates. Workforce for ArcGIS currently works with ArcGIS Online. Later in 2016, it will be integrated with Portal for ArcGIS.

Drone2Map for ArcGIS, currently in beta, enables users to turn drones into enterprise GIS productivity tools. Users can create orthomosaics, 3D meshes, point clouds, and other professional imagery products in minutes, not days, and can then share them in ArcGIS for further analysis and visualization.

For more details on the latest ArcGIS Online release, visit [links.esri.com/agolhelp/whatsnew](https://links.esri.com/agolhelp/whatsnew).

# GIS-Based Security System Benefits Port in Many Ways

By Jim Baumann, Esri Writer

Virtual Port is a dynamic, ArcGIS-based system that is fundamental to security operations at the Port of Long Beach.

Like many ports, Long Beach maintains a multilayered physical security system that includes closed circuit television surveillance, helicopter downlinks, radar tracking, sonar, and other sensor-based systems. About six years ago, ArcGIS was added to help visualize security operations. The benefits of making GIS central to the port's joint command and control center were quickly realized.

In 2011, the Port of Long Beach began the development of the Virtual Port application. "Virtual Port is a dynamic, ArcGIS-based system that is fundamental to our security operations," said Parsons. "It is the essential technology of our command center and has allowed us to geospatially enable our entire security operation. So we now have more than 60 geographically referenced databases that are integrated with the existing elements of our physical security system, which increases exponentially our ability to monitor and analyze our daily operations."

In addition, Virtual Port is used for two

other primary functions: incident response and business recovery. "The beauty of Virtual Port is that we are using the same ArcGIS platform with the same databases for all three of our main functions," said Parsons. "This means that our security systems operators have complete familiarity with the system and don't have to switch over to something else in the event of an emergency."

A major aspect of business recovery is to get the port operational again as quickly as possible after an incident. Virtual Port can help officials determine which areas of the port are inoperable, what remains open, and what resources are available to quickly resume port operations.

## ArcGIS Platform Supports Port Security

Virtual Port's GIS software stack makes full use of the ArcGIS platform. ArcGIS for Server is used to store data layers, services, and feeds within the port's physical server environment, while Portal for ArcGIS

The complexity and size of the Port of Long Beach make security operations especially challenging. Adding ArcGIS to existing systems substantially increased the port's ability to monitor and analyze its operations.

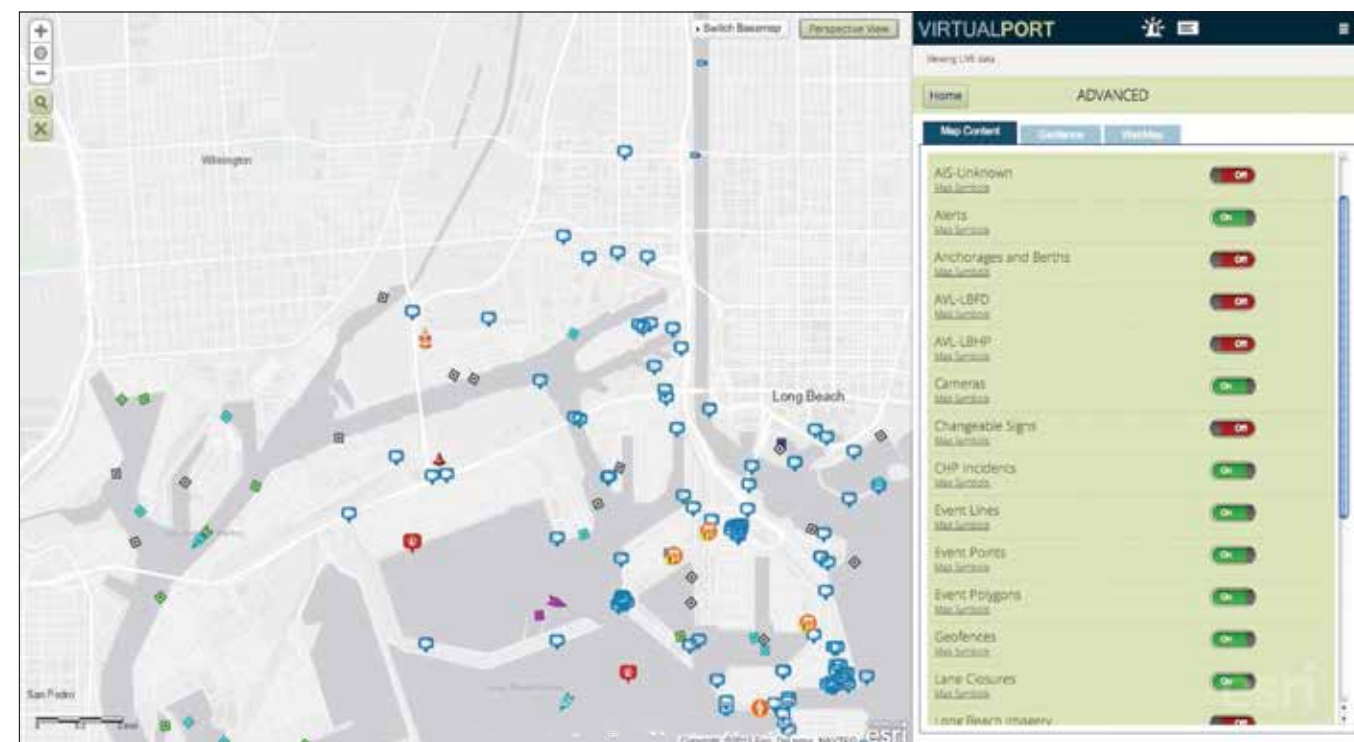
The Ports of Long Beach and Los Angeles form the San Pedro Bay Port Complex at the point where the mouth of the Los Angeles River completes its 50-mile course to the Pacific Ocean. Though operating independently, together the two facilities make up the largest port complex in the United States and are responsible for more than 40 percent of the nation's containerized cargo shipments.

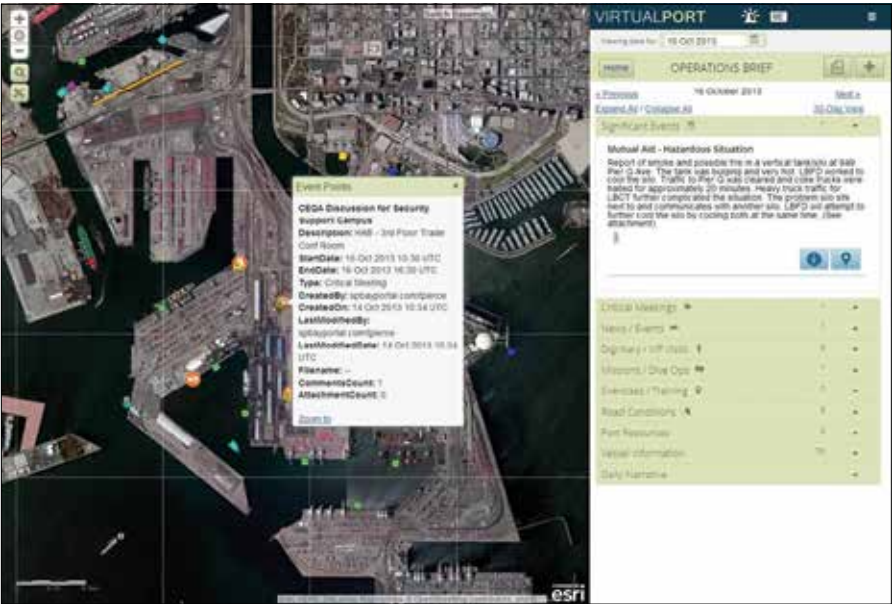
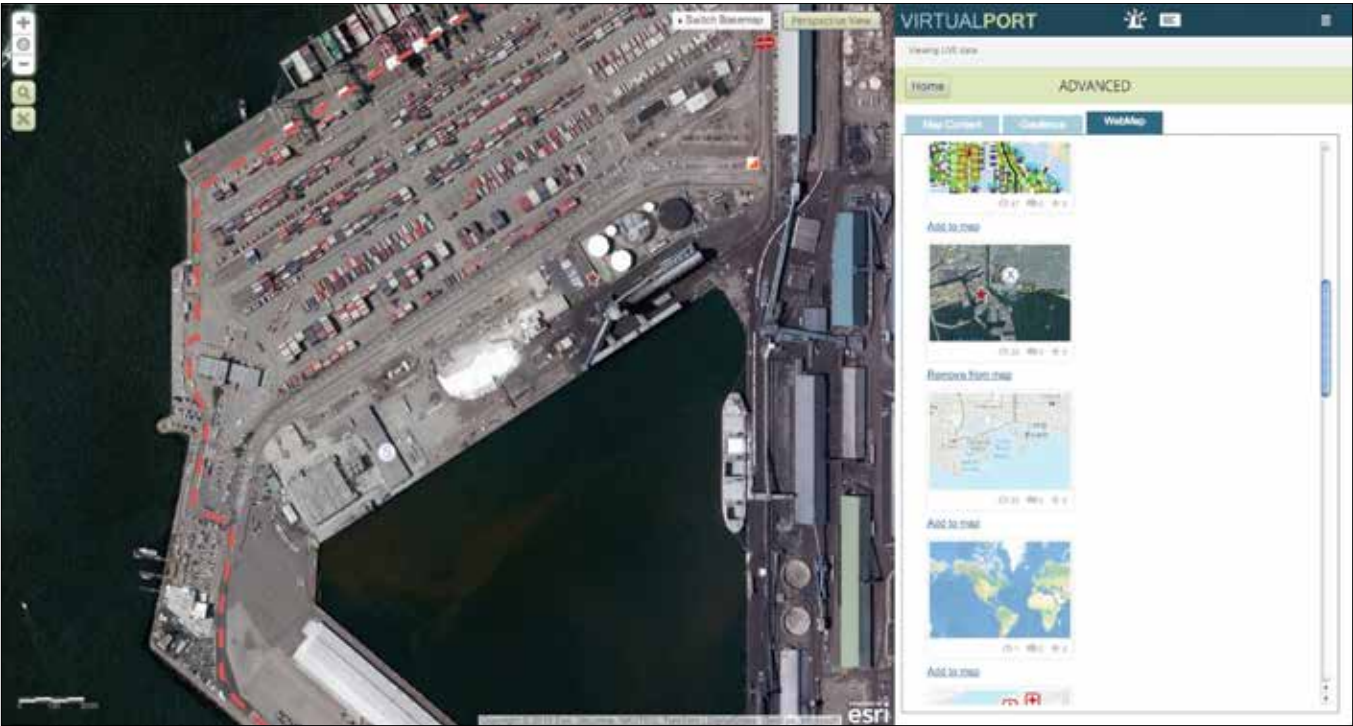
With an eye to the future, the Port of Long Beach is currently involved in a massive, 10-year capital investment program that will cost more than \$4.5 billion. According to Randy Parsons, director of security for the Port of Long Beach, "This will enhance our position of being big ship ready. We will be able to provide docking services to ships that can carry cargo up to 21,300 TEU [*twenty-foot equivalent unit (TEU) is the unit that*

*measures a ship's cargo capacity*]. With increasing competition and the growing size of the container ships that are transporting cargo, our expansion program is designed to sustain us as a leader in the industry for the foreseeable future."

## Implementing the Virtual Port

Occupying more than 3,200 acres (or 13 square kilometers) of land with 25 miles of the waterfront, the Port of Long Beach poses a major challenge for security operations, particularly since it is an open port that provides docking services to pleasure and small business craft as well as commercial cargo ships. In addition, more than 15,000 trucks and 100 trains move in and out of the port every day. The dynamic nature of the port, with its constant movement and 24-hour operations, requires close surveillance.





Virtual Port is used for two other primary functions: incident response and business recovery.

creates, manages, and shares web maps through Virtual Port. This application, built with ArcGIS API for JavaScript, allows users to access Virtual Port from many different environments and devices. Because it is a web app, users do not have to install any native applications or plug-ins to access

Virtual Port. Each user is given credentials and a physical or soft token for a two-step authentication. The ArcGIS GeoEvent Extension for Server is used to display dynamic services and feeds, such as asset or automatic identification system vessel tracking. Rule-based

More than 60 geographically referenced databases are integrated with the existing physical security system.

alerts are built into the GeoEvent Extension and provide instant notifications to port personnel when certain conditions occur such as a vessel coming within the designated radius of a restricted area. Collector for ArcGIS and Operations Dashboard for ArcGIS support in-field data collection and situational awareness for Virtual Port.

### Interagency Collaboration and an Increasing ROI

Partner agencies can connect to Virtual Port and access its common operational picture to collaborate and share information, ensuring the resiliency of the facility. Port officials can also run what-if scenarios that model chemical plumes and other hazards to help agencies prepare for and better understand the impact of potentially dangerous situations.



A variety of federal, state, and local public service agencies use some aspect of Virtual Port for their operations.

Virtual Port functions as a bidirectional, open-source clearinghouse for the agencies that partner with the security division of the Port of Long Beach. Partner agencies have access to the port's data but are also encouraged to add their own data to the system. The twelve law enforcement agencies that station personnel at the port are allowed access to Virtual Port.

A variety of federal, state, and local public service agencies use some aspect of Virtual Port for their operations. The port also partners with agencies in the surrounding area including the City of Long Beach Emergency Communications and Operations Center, local police and fire departments, and some of the local health agencies. To manage the many users, multiple security levels have been implemented.

Not all ports are the size of the Port of

Long Beach or command the resources to implement a GIS-based security system as comprehensive as Virtual Port. However, Parsons indicated that the system is scalable for operations of different sizes. It can be applied to ports with different cargo operations, such as shipments of break bulk cargo or liquid natural gas.

Parsons realized the Port of Long Beach has gained an additional benefit from Virtual Port.

"While Virtual Port provides us with a clear operational picture of our extensive day-to-day security activities, we have found that it is also helping lower our business operating costs by streamlining those processes," concluded Parsons. "This is a huge benefit to centralizing our security operations around ArcGIS because it provides us with an increasing return on investment."

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# Bidders Can See Opportunities in Spectrum Auction with ArcGIS

On March 29, 2016, the Federal Communications Commission (FCC) is expected to begin its first-ever Broadcast Incentive Auction designed to reallocate licenses on the 600 MHz spectrum to provide more bandwidth for wireless devices.

Spectrum allocation has traditionally been based on geographic areas, but for this auction the FCC created 416 new geographic divisions for the auction called Partial Economic Areas (PEAs), which will not correspond to the boundaries of any

geographic designation previously used.

For wireless companies planning to participate in the auction, understanding these new areas and which spectrum will potentially be available is crucial to developing a winning strategy.

Wireless carriers and others participating in the auction need geospatial tools to optimally plan network expansion; prepare initial bids; and continually modify their bidding strategy to factor in the status of licenses, which constantly changes

throughout the auction, and the relation of potential holdings to existing holdings, target markets, and competitors.

In contrast to previous auctions, information on the availability of spectrum by geography will not be obtainable much in advance. So wireless carriers will also need to be adept in processing real-time opportunities as they emerge during the auction. Esri has addressed these needs with Solutions for Smart Spectrum Analysis.

The auction is a high-stakes event not

only because it will determine which wireless carriers will hold licenses for specific locations and provide wireless connectivity for the ever-increasing number of smartphones and other mobile devices in the United States but also because billions of dollars will change hands in the process.

The FCC manages the public spectrum in the United States, including the District of Columbia and US territories, by granting licenses to use portions of the spectrum based on use (television, radio, and wireless) and location to avoid problems caused by signal interference. The exponential growth in the number of smartphones and other mobile devices that are

used for accessing email and consuming digital content has created a tremendous demand for additional wireless spectrum.

In addition to making more spectrum available, the FCC would like to ease spectrum congestion by establishing a wireless spectrum that is generally uniform across markets. Realizing this goal will require that broadcast television providers relinquish spectrum that can then be reassigned to meet wireless broadband needs.

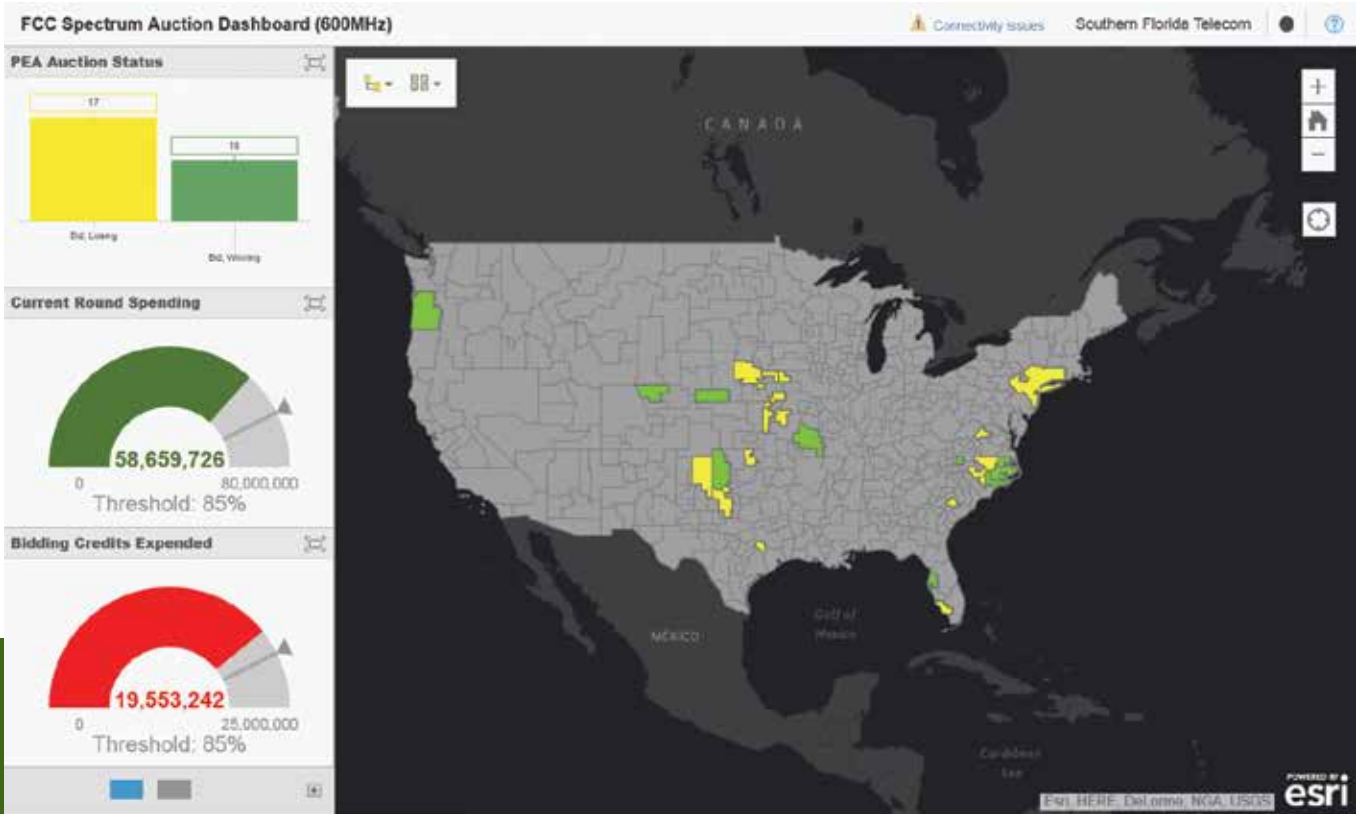
To accomplish this transfer, the FCC is holding a spectrum auction. Although the FCC has been conducting auctions to license spectrum rights for more than 20 years, the Broadcast Incentive Auction

is a new tool designed to help with the reallocation of spectrum. It is far more complex than previous auctions because it includes two interlinked auctions: a reverse auction and a forward auction.

The entire process begins with the reverse auction, which consists of discrete, successive rounds of bidding to acquire spectrum licenses from television broadcasters. Bids to acquire spectrum start high and move successively lower until the FCC acquires the desired amount of spectrum within a market area. After each round of bidding, the remaining television band in each market area is repackaged by the FCC to determine how much space is left and



Esri Solutions for Smart Spectrum Analysis can identify both market opportunities and competitor threats after each bidding round.



Dynamic maps and visualizations via dashboard or web- or mobile-based apps support fast and accurate decision making during the auction and help ensure bids align with an organization’s auction goals.

ensure that it has a channel for each of the remaining stations.

Repackaging is a distinctive feature of this auction and one that introduces a much greater level of complexity to the bidding process. It not only frees up spectrum for wireless use and reorganizes television station usage so that it takes up a smaller portion of the band, but it also resets the priorities of bidders in a market area after each round.

The forward auction allows wireless carriers to buy spectrum that has been freed up by the reverse auction. But again, it is not a simple process. There are several added twists. Not only does the available spectrum in any location change after each bidding round—shaped by repackaging—but the format of the auction enforces specific bidding behavior.

Unlike a traditional real-time auction in which bidders can wait until the last minute to place bids, FCC rules for this auction require bidders to actively participate throughout the auction process. Each bidder makes a payment before the auction

starts, which determines its eligibility in the auction. That bidder is required to bid on a specified portion of its maximum eligibility to continue to participate in the auction.

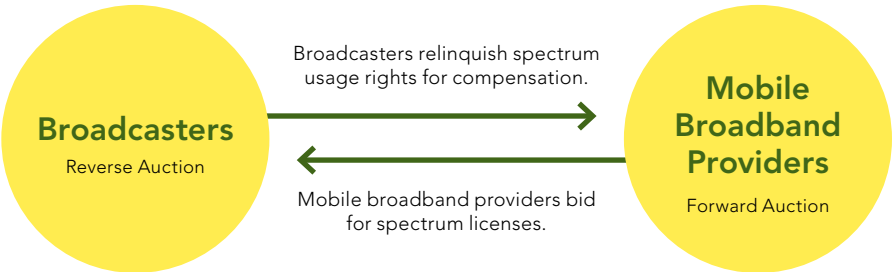
The results of a bidding round are released approximately 15 minutes after that round closes. Only then do bidders learn about bids that have been placed by other bidders. This information influences how bidders value licenses, particularly in relation to any bidding strategies. These factors are likely to require a thorough reassessment of the current bidding strategy and quick modification of that strategy for

future rounds.

The number of bidding rounds is not predetermined. This iterative process continues, with bidders dropping out as the bidding level for licenses they wish to acquire exceeds the amount they are willing to pay. Bidding continues until all bidding activity ceases in a round and that becomes the final round. The FCC estimates that the Incentive Auction could take two to three months.

Auction participants need to quickly visualize the location of available licenses and competitor holdings to uncover opportunities and threats and respond to

The Incentive Auction is far more complex than previous FCC auctions because it includes two interlinked auctions: a reverse auction and a forward auction.



them. Wireless carriers will be trying to expand and consolidate market areas to increase revenue and improve the customer’s experience. Using the ArcGIS tools and data available in Esri’s Solutions for Smart Spectrum Analysis, particularly GeoEnrichment, bidders can analyze market penetration and evaluate potential market areas. GeoEnrichment provides demographic and economic information at a local level.

At the same time, ArcGIS can identify threats from competitors. The three bundles available with Solutions for Smart Spectrum Analysis that scale offerings to need and include access to Mosaic CoverageRight, the most comprehensive wireless coverage and licensing database in the United States.

These tools are vital for preauction planning and even more critical for reformulating bidding strategies quickly during the course of the auction, as licenses are taken off the table in successive rounds and the remaining licenses repackaged, changing the competitive landscape. Rather than

stare at pages of tabular data, ArcGIS maps these changes and makes them immediately comprehensible. ArcGIS can quickly map round-by-round results that are supplied by the FCC in comma-separated values (CSV) format to show the current status of the auction or results from past rounds.

The ArcGIS platform gives auction participants access to real-time auction information that is easily shared with decision makers but is secure. Dynamic maps and visualizations via dashboard or web- or mobile-based apps support fast and accurate decision making during the auction and help ensure bids align with an organization’s auction goals.

One of the great strengths of GIS has always been its ability to make patterns in data apparent. With powerful tools and authoritative market data that can be easily combined with auction results and instantly shared, Esri’s Solutions for Smart Spectrum Analysis can provide a competitive advantage during the auction and a comprehensive view of the capacity and opportunities available to move market strategies forward.



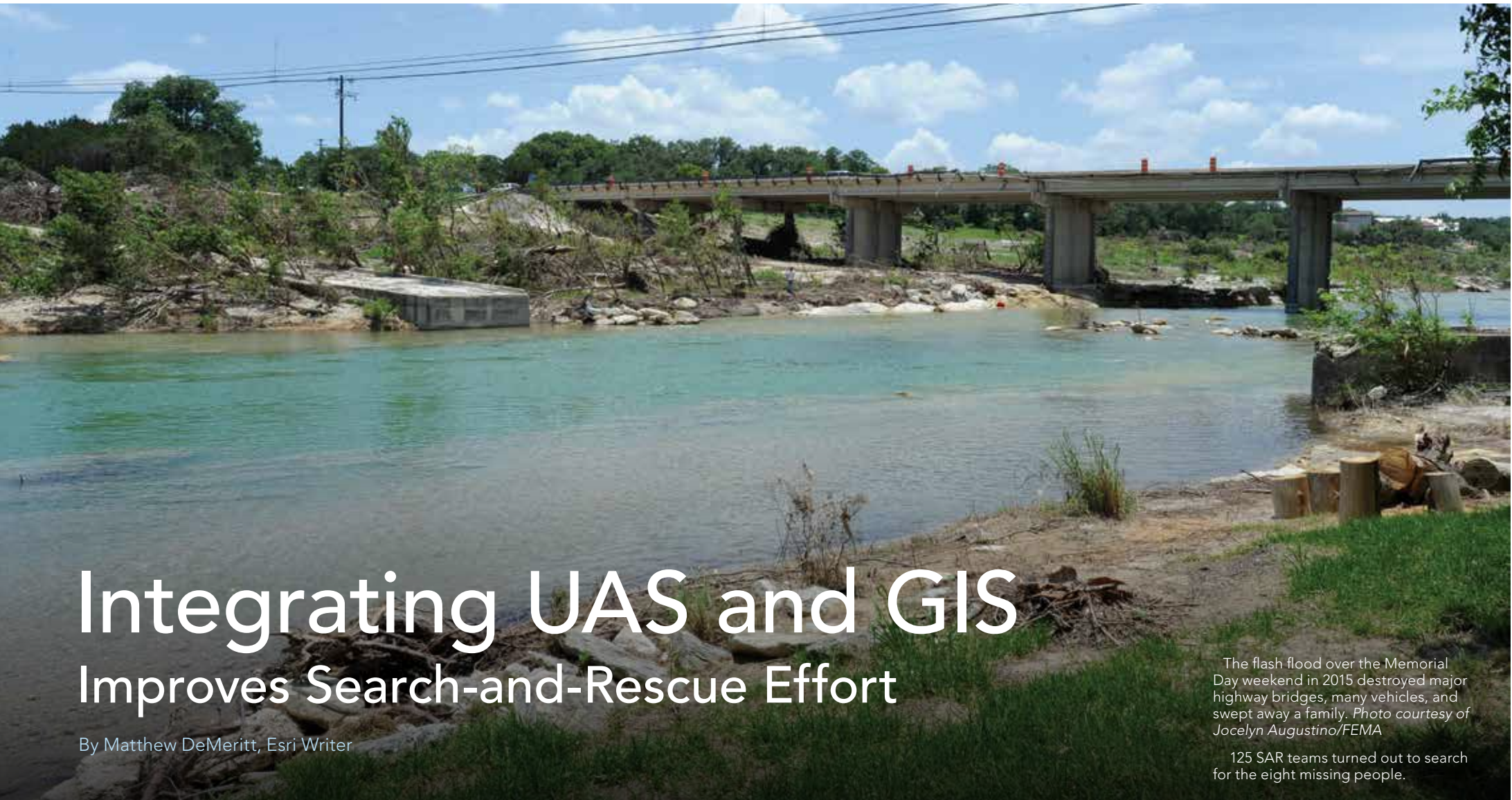
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# Integrating UAS and GIS Improves Search-and-Rescue Effort

By Matthew DeMeritt, Esri Writer

The flash flood over the Memorial Day weekend in 2015 destroyed major highway bridges, many vehicles, and swept away a family. Photo courtesy of Jocelyn Augustino/FEMA

125 SAR teams turned out to search for the eight missing people.

On Memorial Day weekend in 2015, a 40-foot wall of water rushed down the Blanco River and hit the city of Wimberley, Texas. The flash flood, caused by a freak rainstorm, destroyed major highway bridges and many vehicles and swept away a nearby vacation home and the eight members of a family inside it.

The ensuing search-and-rescue effort to find the family involved more than 1,500 volunteers and covered almost 100 miles of the river over several weeks. Fortunately for the responders organizing these efforts, Devon Humphrey lives nearby in Dripping Springs. The founder of Esri partner Waypoint Mapping, Humphrey has decades of experience in the use of GIS and emerging technologies, including unmanned aerial systems (UAS), for disaster response.

## Mobilizing Assistance

Almost immediately after he heard that the victims' friends, family members, and local community members had formed a volunteer force, Humphrey contacted Esri and began setting up geospatial tools that could be used in the search effort. Initially, Esri and Waypoint offered resources through the Esri Disaster Response Program, which offers free geospatial help during emergencies.

That help consisted of a property owner-

ship map, real-time weather layers, and a data collection app that would feed a GIS dashboard for coordinating the search. This would enable those stationed at the volunteer command post (VCP) to coordinate rescue teams and view the resources assigned to the response. The data collection app was based on the Collector for ArcGIS app. The dashboard app was based on Operations Dashboard for ArcGIS. All data was hosted in Esri's cloud-based platform ArcGIS Online.

## Coordinating Volunteers

When volunteers and first responders convened on the morning after the flood, Humphrey was taken aback. The number of search-and-rescue (SAR) teams, each containing 8 to 12 members, had grown from an

initial 25 to a staggering 125. Managing this many teams could be overwhelming.

Fortunately, nearly every volunteer owned a smartphone. Humphrey's wife, Bonnie, who is not a GIS user, was able to quickly set up additional ArcGIS Online user accounts. Members of the additional 100 teams signed into ArcGIS Online and downloaded the Collector for ArcGIS app. Bonnie provided them with instruction on how to use the data collection app to post search data. Average training time for each volunteer team was about two minutes. All the volunteers understood how the app worked with the live dashboard and could see other search team members' points of interest and the areas already searched appear in real time.

## Getting the Big Picture

The fire department suspected that a section of the river near Wimberley might contain a concentration of victims, debris, and cars that could be leaking fuel and other toxic fluids into the river. A few days into the response, they asked Waypoint Mapping's sister company, Flightline Geographics, to use its UAS capabilities to capture new high-definition imagery of that area.

Since severe storms were ongoing and the river channel was still hazardous to navigate, a UAS was the safest way to capture





# Empowering Citizens

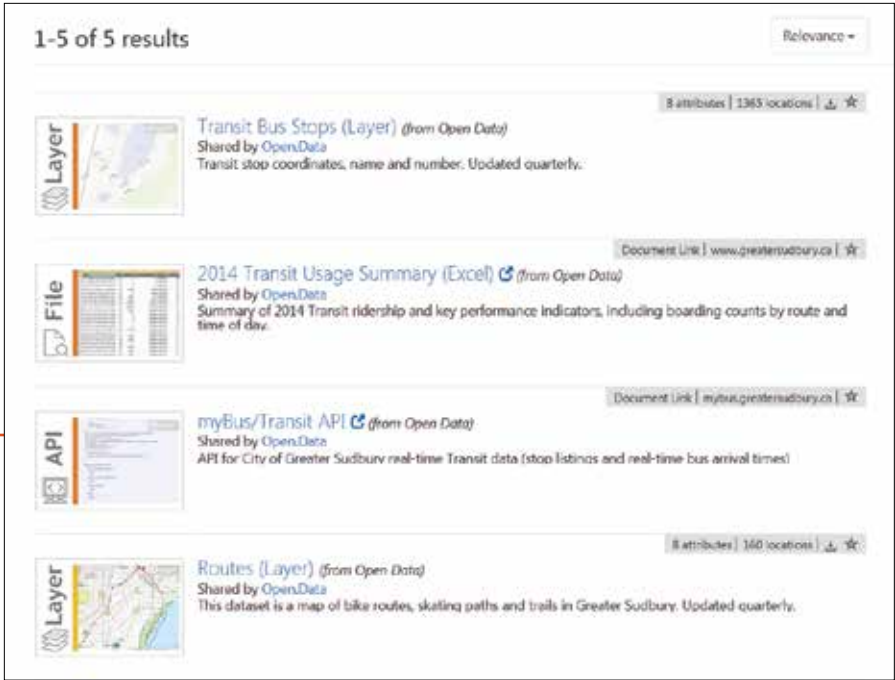
By Emily Gibson, Esri Product Engineer

The University at Buffalo Regional Institute (UBRI) in western New York and the City of Greater Sudbury in Ontario, Canada, are using ArcGIS Online to improve communication with citizens and provide them with data and tools to make better decisions for their neighborhoods.

Both organizations are empowering citizens to explore authoritative data about their neighborhoods, create maps and applications based on that data, analyze the results contained in these information products, share their insights with local officials, and ultimately make better decisions about their neighborhoods. While UBRI has been accomplishing this using a public gallery app it created and hosts on ArcGIS Online, the City of Greater Sudbury has been achieving this by leveraging its ArcGIS Open Data site and the city’s ArcGIS Online site.



The University at Buffalo Regional Institute used an ArcGIS Online Public Gallery app to create Mapping Metrics for Buffalo Niagara.



The City of Greater Sudbury Open Data Portal site makes a variety of data on transportation and other topics available.

## Central Location for All Regional Data

UBRI is a public policy, urban planning, and design center for the University at Buffalo School of Architecture and Planning. A year ago, UBRI realized that while it had lots of data on the Buffalo Niagara region that residents would find valuable, it was not sure what to do with it.

The team had been collecting and analyzing geographic data as part of a three-year regional planning and community engagement project called One Region Forward. The project was supported by the Partnership for Sustainable Communities program created by the US Department of Housing and Urban Development (HUD). Although much of this was public data, few residents knew of its existence, where to get it, or how to use it to improve their lives. In addition, this data was not available at a regional scale.

The One Region Forward team created mapping metrics for Buffalo Niagara using the Public Gallery app that comes with ArcGIS Online. The One Region Forward app makes all the data and maps about Buffalo Niagara that the team created over three years accessible from one easy-to-use interface.

The gallery also features intuitive tools and applications. Using regional data available from the gallery, residents can make maps related to topics such as land use, economic activity, and food systems and share these web maps with local officials. They can also find out the local zoning regulations, hazardous waste locations, and how individual parcels in the region perform on key place-based measures of sustainability. The gallery’s Community Snapshots summarizes data relating to housing, demographics, and the workforce for any neighborhood in Buffalo Niagara.

The One Region Forward project team integrated the gallery into Citizen Planning School, its civic engagement program. The One Region Forward team held workshops with program participants to show them how to access the gallery tools, use these tools to create maps on sustainability topics, and share maps to gain support for projects to increase the region’s sustainability.

Once the One Region Forward team had gathered and analyzed all the regional data as part of the project, it took only about two months to organize the data, set up the server, and configure the site and mapping applications. Training Citizen Planning School participants was not resource-intensive because the tools are intuitive.

Using ArcGIS Online saved time and money. Multiple analysts with ArcGIS experience could simultaneously work on configuring mapping services and web applications without spending

time learning an API or new software. By using ArcGIS Online, the One Region Forward team didn't need to code anything, so it avoided the expense of hiring a web developer and could use this money for other components of the project, such as the Citizen Planning School workshops. Although the One Region Forward team would have liked to tailor the look and feel of applications a bit more, the benefits of using ArcGIS Online outweighed this limitation.

More important, the One Region Forward public gallery has enabled active community members, who keenly understand their neighborhoods' challenges and opportunities, to use meaningful maps and data to gain support for citizen-led sustainability. Brian Conley, GIS research analyst for UBRI said, "While there are other public data tools that Buffalo Niagara residents can use to do this, having one accessible interface that combines all the data related to the numerous issues that affect the Buffalo Niagara region—with experts on hand to offer instruction and guidance on how to best communicate results—provides citizens with a much richer and more useful experience."

### Leveraging ArcGIS Open Data

In 2015, the City of Greater Sudbury Information Technology (IT) Division found itself in a similar situation. It wanted to share its authoritative data with citizens so they could create impactful maps and applications. Although the IT Division had successfully administered its ArcGIS Online site for several years, the site was used primarily for employees and offered the public only a few datasets. The city's location platform had not been fully realized as a tool for sharing information and engaging with the public.

That April, Greater Sudbury city council unanimously approved the creation of an open data site as part of its Open Government initiative. The Sudbury Open Data Portal was launched just three months later. It contains datasets related to the environment, community, government, transportation, and other categories. Each category contains map layers, RSS feeds, APIs, and other items that were all easy to make available to the open data site through ArcGIS Online.

After just six months in operation, the open data site receives hundreds of visits each month. The data it makes available has resulted in the creation of several free apps by local developers. Open datasets hosted on ArcGIS Online for Organizations are also being used by the city to create the Childcare Locations in Greater Sudbury map, the Your Municipal Council app, and other maps and apps.

The open data site was easy to set up. Renée Higgins, the city's open data lead, said the city spent three months educating staff, reviewing dataset suggestions, following the city's publishing process, and preparing data for public use. Creating and customizing the open data site itself took only three days. The open data site has resulted in considerable cost savings



The MapIT Greater Sudbury site allows residents to access and explore the city's GIS applications and data.



a handful of city employees and a few applications.

Paul Giroux, GIS analyst/administrator for the city said, "We understand that the connection between the open data site and our location platform provides us with an opportunity to raise civic proficiency about modern mapping (web GIS), and through engagement, we can begin fostering a set of public geo-innovators."

Now, Sudbury residents as well as city employees can create and share layers, web maps, data, interactive stories, and applications on MapIT Greater Sudbury. Some information products are then shared to the open data site.

Like One Region Forward, Greater Sudbury's IT Division is teaching citizens how to use both Sudbury Open Data Portal and MapIT Greater Sudbury. Giroux explained, "Having quality open data and products on the platform is one thing, but what good are these if people don't know how to use them?" One way the IT department has been building civic proficiency is by creating recipes that explain how to get started with MapIT. Giroux also plans to use these recipes as the basis for lessons at local elementary schools and universities and as part of employee and public MapIT User Group meetings.

As a result of these sites, residents and employees can easily and efficiently view, analyze, and share quality public data on a variety of devices. They can also better collect, store, find, and manage their own spatial data. This has resulted in significant time and cost savings for the city and continues to introduce greater efficiency as more users become empowered with Esri's location platform.

### Increasing Geoawareness

More generally, the public sites have fostered an increase in geoawareness among constituents, employees, and students. They have learned how to use the ArcGIS platform and harness this knowledge to improve their neighborhoods.

Unlike GIS professionals in many organizations, those working on the One Region Forward project and at the City of Greater Sudbury did not stop after they created great data and applications. They put data and apps into the hands of residents and showed them how to use the data to improve local communities. In doing so, these organizations increased citizen participation, government transparency, and data-driven decision making in their neighborhoods.

Both organizations used ArcGIS Online to accomplish this, but in slightly different ways—UBRI by leveraging the Public Gallery app and the City of Greater Sudbury by enabling the open data capability available through ArcGIS Online.

For more information about Mapping Metrics for Buffalo Niagara, contact Bart Roberts, Associate Director of Research and Faculty Engagement, at bjr8@buffalo.edu or Brian Conley, GIS research analyst, at bwconley@buffalo.edu.

To learn more about MapIT Greater Sudbury, contact Paul Giroux, GIS analyst/administrator, at gis@greatersudbury.ca. For questions about the city's open data site, contact Renée Higgins, open data lead for the City of Greater Sudbury, at Renee.Higgins@greatersudbury.ca.

To learn more about how to make your data, maps, and applications more accessible to your community and foster civic engagement, visit ArcGIS Online (www.arcgis.com) and ArcGIS Open Data (opendata.arcgis.com).

and efficiency gains for the city.

Higgins explained, "We evaluated other popular open data solutions and determined that costs could range from \$10,000–\$20,000 annually for hosted open data sites." Because the City of Greater Sudbury has an Esri Enterprise License Agreement, it could establish its ArcGIS Online and open data sites at no additional cost.

With the success of the open data site and its seamless connection to MapIT Greater Sudbury, Greater Sudbury's main ArcGIS Online site, residents began making greater use of the city's site. Previously it had served

Recipes, an innovative idea implemented by the City of Greater Sudbury's Information Technology Division, helps users get started with MapIT Greater Sudbury.

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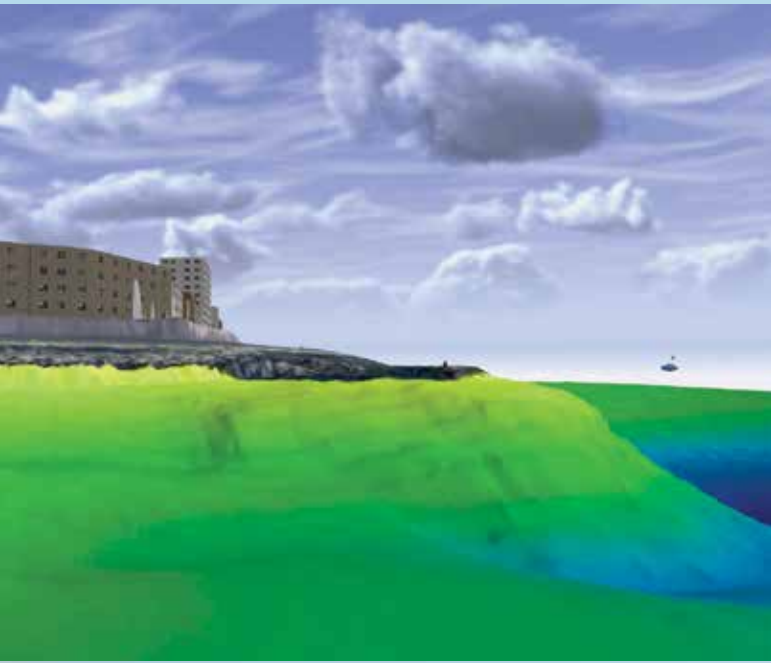
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# Adding a Dimension to Monitoring Activities

By Harmen van Doorn, Esri Nederland, B.V.

Innovation in 3D technology has been advancing rapidly. Disaster response experts, city planners, law enforcement officials, architects, tourism professionals, and many others in an increasing number of organizations are beginning to use 3D data for analysis.

3D modeling helps the water board get to the heart of a problem and determine the best course of action, which saves time and helps the board reach its safety and quality goals.



One of those organizations is the Scheldestromen Water Board. A public agency, this regional governmental body is charged with managing water quality and making it available in adequate quantities to the 380,000 customers it serves. The water board protects Zeeland, a province in the south of the Netherlands, from flooding by managing 525 kilometers of sea defenses. The water board also ensures that the outlying areas are accessible by managing and maintaining more than 3,900 kilometers of roads.

GIS contributes significantly to water board operations. It is especially valuable for internal and intra-agency communications. ArcGIS is the standard GIS platform for all water boards in the Netherlands. According to Ignaas Bisdorn, a GIS analyst for Scheldestromen Water Board, the board handles many business processes with ArcGIS apps, templates, and dashboards. By using what the ArcGIS Online platform provides and configuring apps, the board has eliminated the need for customization. "The cost reduction realized by using standard tools is enormous, but in this way we will also be able to incorporate new features as they are added to the ArcGIS platform," said Bisdorn. 3D imagery, an aspect of the standard capabilities in ArcGIS, can provide further insight and allow decisions to be made more quickly.

## 3D View of the Seabed

The Meermin III, a survey boat, regularly travels along the coast in Zeeland for the Scheldestromen Water Board. As part of the board's annual monitoring of the flood defenses along the coast, this boat measures the location and height of the defenses from the foreshore. The foreshore, that portion of the seashore that is between the high-water and low-water marks, is often about 200 meters out from the edge of the coast. In the past, measurements of the foreshore were made using tangential measuring points, but now this area is measured by making a 3D scan of the entire surface of the seabed.



To quickly assess the condition of sea defenses, the water board creates visualizations of the data in 3D using Esri CityEngine and the ArcScene module of the ArcGIS 3D Analyst extension.

Data on the condition of these defenses has been collected for decades so that historical visualizations and analyses can be made. Based on that data, it is possible to determine whether the section of the dyke under the water's surface is holding strong, or whether it has been subject to erosion and should be strengthened.

## Seeing the Problem Clearly

A scan of the seabed can be analyzed particularly well by using hydrographic software, but to quickly understand a given situation, the Scheldestromen Water Board creates a visualization of the data using Esri CityEngine and the ArcScene module of the ArcGIS 3D Analyst extension.

"Previously, it was difficult to get an overview of the situation. This wasn't very surprising, because figures didn't provide much information and 2D maps are not always suitable. Visualization in 3D provides the viewpoint missing from 2D representations and are more easily understood by people who are not as familiar with maps," explained Jelmer van der Veen, a GIS analyst and applications manager for the Scheldestromen Water Board.

When working for previous employers, Van der Veen had often used 3D technology, so he drew upon this experience in his job

with the water board. "I saw 3D visualization as a good option for bringing the foreshore closer, which is normally not visible. For people who are not so used to working with *[the]* data, this gives a good picture of what is going on."

## Reaching Safety and Quality Goals

The water board initially worked with 3D analysis in mid-2014. Raster data was combined with digital elevation model data in Actueel Hoogtebestand Nederland (AHN) format and visualized using ArcScene and CityEngine. The seafront promenade at Vlissingen was the first visualization project. "This was interesting, because the foreshore already dipped very quickly at this point. There was a shear. In the viewer, you can see how the situation was and how it is now," said Van der Veen.

3D modeling helps the board get to the heart of a problem and determine the best course of action. This saves time and also helps the board reach its safety and quality goals. Just as other organizations plan to do more work with 3D in the future, so will the Scheldestromen Water Board.

For further information, contact **Harmen van Doorn**, communications specialist for Esri Nederland B.V. at [contact@esri.nl](mailto:contact@esri.nl).



This article was provided by Esri Nederland.

# Downsizing the ROI Report

By Wade Kloos, GIS Director, Utah Department of Natural Resources

In my previous article in the fall 2015 issue of *ArcUser*, “The ROI Mind-Set for GIS Managers,” I emphasized that the purpose of a GIS return on investment (ROI) effort is to discover and communicate the value that GIS (and you) deliver to your organization.

I mentioned that there may be many GIS professionals who have reasons for not spending time on ROI studies. One of those reasons could be that they don’t know where to start or how to do ROI. This article addresses that very issue: how to get your organization started documenting ROI.

### Who Is Your Audience

Let’s first consider: who are you documenting ROI for? The audience for your ROI results are the people that made the choice to invest in your GIS program whether it was to start or continue it. Let’s also include the people who review your performance.

The people who set the goals for your organization should also be included, as they may have more than a passing interest in knowing what you have done for them lately. You will recall from our previous discussion that these organizational leaders can be fickle. They need constant reminders of your impact.

There is one person in your organization who cannot be left off this audience list. Although often underestimating their contributions and influence, this person plays a key organizational role. This person is you.

Throughout your career, you will engage in hundreds of projects that will help others accomplish important tasks. Each time you document your GIS results in an ROI report, you get to keep a piece of that project for

yourself. You help define your value. You document the difference you make. With this knowledge, you will always be able to answer the question, what have you done for us lately?

### Key References

Before delving into the nuts and bolts of defining GIS value, let’s look at two pivotal books on the subject. I want to give credit where credit is due. These are essential references for understanding GIS, its management, and its ROI. I often find myself pondering some core GIS principle only to discover these authors have already “gone down that road” and then drawn a map for the rest of us.

The first is *Thinking about GIS* by Roger Tomlinson. While Tomlinson’s book does not focus specifically on ROI, he explains many core components of GIS success that naturally spill into ROI as easily as rivers flow to the ocean.

The other book, *The Business Benefits of GIS, An ROI Approach*, by David Maguire, Victoria Kouyoumjian, and Ross Smith, will give you an understanding of the methodology for conducting a comprehensive ROI study within a dynamic organization. These authors are thought leaders in the GIS field.

### Starting Your Journey

The ROI journey that I am asking you to consider does differ from these books in a significant way. After reading these books, a GIS professional could likely conclude that that ROI documentation requires a costly, mission-critical project or new GIS program, a team of people to research and document,

and the dedication of a good portion of a year to produce a complete report. It’s no wonder few GIS professionals raise their hands when asked if they measure their GIS results. Perhaps, if we change our assumptions about GIS ROI and our approach to it, we could convince more GIS professionals to document their work and its impact on their organization.

### ROI at DNR

In looking at the multitude of GIS projects conducted within the Utah Department of Natural Resources (DNR), it was evident that we did very few high-cost GIS projects. The vast majority of GIS effort involved projects that just consumed staff time or only required a modest investment. Surely these projects produce benefits, so why not examine these projects and their impact on our department?

To undertake ROI tracking for smaller GIS projects, it made sense to consider an abbreviated ROI process. DNR was intrigued by this concept for several reasons. First, like every other organization, we have GIS managers who are busy. With a short, focused ROI process, documenting results would be more likely to happen rather than using an ROI process that required many months of effort. Second, if fairly simple information was collected, a single staff member could complete an ROI study. This would lead to the creation of more documented GIS value. Third, creating something new for GIS staff to do represented change, and change is not always easy to implement. A small change is easier to implement than a big change, and we were fine with taking baby steps into ROI.

GIS Project ROI and Benefits Report

Project Name:

Department or Division:

Project Manager/Sponsor:

Project Completion Date:

Executive Summary: (Concisely state the problem and its impact on the organization then describe the solution and its impact on the organization)

Describe current workflow or limitation: (Be as detailed as needed)

Describe proposed enhancement: (Be as detailed as needed)

Current Workflow Costs: (Enter values for hours, wage - see note below, and occurrence. Dollar values are calculated, no need to enter these values)

Hours to complete current workflow	6.0	Current workflow cost	\$150.00
Hourly wage rate*	25.00	Current annual cost	\$11,250.00
Annual occurrence of workflow	75		

Enhanced Workflow Costs

Hours to complete workflow after enhancement	2.0	Enhanced workflow cost	\$50.00
Hourly wage rate*	25.00	Enhanced annual cost	\$3,750.00
Annual occurrence of workflow	75		

Enhancement Production Costs and Savings

Hours to complete enhancement	20.0	Enhancement cost	\$500.00
Hourly wage rate*	25.00	Annual Savings	\$7,500.00
Annual maintenance costs of enhancement, if any	\$0.00	3 year savings	\$22,500.00

Projected ROI

ROI=Savings-cost of improvement/cost of improvement	1 Year ROI	1400%
	2 year ROI	2900%
	3 year ROI	4400%

Tangible Benefits to the Organization: (i.e., quality or quantity improvements, effects to throughput, cost avoidance, better decisions, etc.)

Benefit 1:

Benefit 2:

Benefit 3:

Tangible Benefits to Others Outside the Organization: (i.e., other divisions, state agencies, stakeholders, public, etc.)

Benefit 1:

Benefit 2:

Benefit 3:

Meaningful Measures of Success: (Describe how can/will the project be measured - what is needed to implement regular measurement?)

Measurement Observations: (interval varies depending on project, typical may be 3-6 months, 1 yr., 2 yrs. and 3 yrs. after completion date. The purpose of these observations is to record measurements, validate ROI projections, and adjust workflows as necessary for continued improvement)

Date:

Date:

Date:

Submitted by:

Date:

Project Sponsor/Manager Confirmation by:

Date:

\*Generalized wage rates are used for simplicity and consistency: Intern \$15/hr., General Clerical \$20/hr., GIS Analyst \$25/hr., GIS Manager \$30/hr., Division Professional \$35/hr.

DNR created a one-page GIS ROI report that is simple to use but collects information relevant to the organization.

The fact that an ROI study could be completed in a short time by a single person or small team created a greater sense that documentation efforts were personally beneficial to our GIS staff. With knowledge gained from completing an ROI report for a small project, we felt we would be better prepared to handle ROI reporting for larger, more complex GIS projects in the future.

Our goal at DNR was to create a one-page GIS ROI report. The report’s information needed to be fairly simple to collect and include information relevant to our organization. As a government agency, we are often asked for efficiency measures, so we knew we needed to hone in on business workflows and how GIS projects affect them. We asked our finance and HR teams to help us create/validate a simple way to document workflows and other measures critical to our department mission.

When considering ROI content, we believed it was important to ask for qualitative benefits in addition to the quantitative data that provided the numerical score of ROI. In addition, DNR is interested in benefits that extend beyond our own organization because they exemplify efforts to break down information silos and foster more interagency workflows and information sharing. We were able to squeeze all the information into a report template on a single Microsoft Excel page. We consider this GIS ROI Report template to be a work in progress.

The GIS ROI Report is fairly self-explanatory. However, there are some points worth mentioning. We encourage our staff to write compelling executive summaries to ensure that the business impacts are well understood by those that may not take the time to fully examine a project’s finer details. The workflow costs/savings are calculated

fields, so the math is automatically worked out. DNR believes it is important to document the specific measurements of GIS project success to get staff thinking about what it takes to track project performance and then take the actions needed to validate assumptions and results over time. We ask that all GIS ROI Reports be confirmed by a project sponsor or staff manager so that the assumptions and information collected can be vetted by management. Our hourly wage information for various staff levels is suggested so that the collection of salary information is not an uncomfortable/inappropriate situation for GIS staff and helps ensure consistency across the department.

The DNR GIS ROI and Benefits Report template is available for you to download from the online version of this article at the *ArcUser* website ([esri.com/arcuser](http://esri.com/arcuser)). You can use it to give abbreviated ROI reporting a try. If you find ways to improve the report, please pass these suggestions back to us.

In my next article, I will share some specific examples of DNR’s GIS ROI and Benefits Report and summarize what we have learned from using this abbreviated ROI Report over the past two years.

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# Getting Started with UAS

By Devon Humphrey, Waypoint Mapping

Unmanned aerial systems (UAS) are demonstrating their value for capturing high-resolution aerial imagery and 3D terrain content for GIS and other uses. However, the wide variety of hardware, software, and regulations related to UAS can be baffling. If you want to start exploring the use of UAS for GIS, this brief explanation will get you off the ground.

## Pick a Platform

As defined by the Federal Aviation Administration (FAA), UAS consists of the unmanned aircraft (UA) or drone and all the associated support equipment, control station, data links, telemetry, communications, and navigation equipment necessary to operate the UA.

In UAS, the unmanned aircraft is often referred to as the platform. Platforms consist of both fixed-wing and rotary-wing (rotorcraft) aircraft. Each platform has its own strengths and weaknesses. Many users start off with inexpensive consumer-grade rotorcraft. These aircraft allow them to more easily become familiar with the workflows and techniques involved with basic data capture.

Most rotorcraft can manage only 15 to 20 minutes of flight time on a full charge, but batteries can be swapped out and the survey resumed. Rotorcraft are easier to operate, thus requiring a minimum of training. The short duration of their flights makes them suitable for project areas that range from 1 to 100 acres. Many rotorcraft operators upgrade to fixed-wing platforms for larger surveys.

In general, fixed-wing aircraft commonly have flight times of 45 to 90 minutes, or roughly twice the duration of rotorcraft. In addition to covering hundreds of more acres in a single flight, a fixed-wing aircraft can often carry larger cameras and equipment and handle challenging weather conditions. However, they are considerably more complicated, expensive, and require more training to master.

This aspect of platform choice cannot be underestimated. A GIS manager at a pipeline company recently shared the story of an overconfident radio control (RC) pilot who had convinced his boss to purchase a UAS on the basis of his many years of RC airplane aerobatic experience. The first day—while company representatives watched—he flew the company's new \$80,000 drone into the ground and smashed it to smithereens.

## Deciding on the Payload

The payload that a UAS carries is determined by the project requirements and limits of the platform. Digital RGB cameras are the leading sensor type, ranging from inexpensive GoPro cameras to high-end digital SLR cameras with quality lenses.

GoPro cameras are popular because of their price but have some drawbacks. Their fish-eye lenses add curvature to imagery. This isn't ideal for aerial photography because lines need to match up when creating a mosaic. Designed for sports photography, their focus settings are fixed at medium range to catch action in that range, rather than at infinity—the setting needed for long-range capture. As a result, imagery is often slightly out of focus at altitudes between 200 and 400 feet, where the UAS would usually be flown. However, GoPros are lightweight and inexpensive.

There are also specialized sensors for agriculture, wetlands analysis, and environmental monitoring. These are multi- or hyperspectral sensors that allow analysis

of vegetation or wetlands through the use of remote-sensing software. Many of these sensors are now small enough to be carried on either platform.

Another sensor type is full-motion video (FMV), a special geoencoded video taken with cameras that output files in Motion Imagery Standards Board (MISB) standard video format. Videos in this format can be overlaid and viewed in GIS in either real time or recorded mode using the ArcGIS Full Motion Video Add-In. In the past, these sensors were marketed to military and law enforcement and were too expensive for most GIS users. Now lower-priced FMV sensors are becoming available.

## Other Considerations

Several commercial off-the-shelf photogrammetry programs can process UAS imagery and flight logs into orthomosaics [*collections of contiguous aerial photos that have been geometrically corrected to remove image distortion*] and 3D point clouds. Evaluate them with sample imagery before choosing one.

Capture technique and GPS ground control have a huge impact on the quality of resultant output. Get some training or learn from experienced users to avoid wasting time using a flawed methodology.

Requirements for processing can be demanding on hardware depending on the number of images being processed per batch. Most software and hardware currently available will easily handle 100 to 200 images. Projects involving thousands of images will



require increasing hardware processing, graphics, and memory capabilities.

UAS content can be delivered via traditional means, such as USB hard drive, but GIS users are increasingly using cloud delivery services such as Dropbox. Many customers are now receiving data through ArcGIS Online, which also gives non-GIS users access to the data through web maps that display on any client.

## Evolving Regulatory Environment

Regulation of UAS is in flux and can vary significantly by location. UAS operators need to comply with FAA (federal), state, and possibly local regulations. The FAA handles everything to do with air safety.

Until permanent regulations are in place, the FAA has instituted an interim process for professional UAS operator authorization called the 333 Exemption. To obtain this exemption, organizations must submit system and operational information and specify how they intend to safely operate a UAS. In doing so, operators are requesting exemption from several FAA rules including

the ban on commercial operation without a commercial pilot's license. *All organizations using UAS in a professional capacity, even if not offering as a service and even if for in-house use only, are required to obtain a 333 Exemption prior to operating.* Hefty fines—as much as \$1.9 million—have been levied against companies operating without FAA commercial authorization.

The exemption provides a blanket authorization as long as several key provisions are met. The main condition is that a licensed pilot, with at least a Sport Pilot Certificate, operates the UAS, but a commercial license is not required. This requirement ensures that the operator is aware of existing FAA air space and related flight safety regulations.

Other layers of regulation include state and local government restrictions that usually have more to do with privacy than safety. These vary by state, and some municipalities have passed local ordinances against UAS operations.

There are no-fly zones around airports, national parks, government facilities, and critical infrastructure. Prior to flight, any

temporary flight restrictions (TFRs) or Notes to Airmen (NOTAMS) that the FAA may have issued should be confirmed.

In January 2016, the FAA released the B4UFLY smartphone app for iOS that tells users about any restrictions on the air space in which they wish to operate. A version for Android smartphones is in beta.

Although there is a lot to learn before taking to the skies, UAS can be a cost-effective way of capturing quality GIS content. For more information, visit [www.waypointmapping.com](http://www.waypointmapping.com) or [www.flightlinegeographics.com](http://www.flightlinegeographics.com).

## About the Author

**Devon Humphrey** is a longtime GIS user, instructor, and system architect of Esri technology. He has worked in state and local government at the Esri San Antonio regional office and as an Esri partner with a special focus on emergency management. Since 2007, Humphrey has worked on federal government and university research projects for wildfire modeling, FMV, and other applications of UAS. He was the geographic information officer (GIO) and architect of the GIS common operating picture for the 2010 Deepwater Horizon oil spill in the Gulf of Mexico response effort. As an instructor at the Texas A&M National Spill Control School for the past 21 years, he has promoted the use of GIS and emerging technologies, including UAS, for disaster response to all hazards. He can be reached at [devon@flightlinegeographics.com](mailto:devon@flightlinegeographics.com).

# The Living Atlas Can Provide Better Access to Data for Hydrologic Modeling

Datasets available from the Living Atlas of the World are a valuable source for hydrologic modeling. Its seamless, national datasets are available online and can be extracted locally and used for spatial analysis without extensive preprocessing. This article describes the advantages of this workflow and a GIS tool to facilitate it that is currently under development by Cynthia V. Castro at the University of Texas.

Hydrologic models are designed to provide a quantitative understanding of what happens to rain after it reaches the earth's surface by simulating rainfall-runoff processes over a watershed. Decision makers require this information to mitigate flood hazards.

The Hydrologic Modeling System (HEC-HMS), developed by the US Army Corps of Engineers Hydrologic Center, is a widely used program for the assessment of watershed hydrology, and typical applications include urban drainage design, floodplain mapping, reservoir safety, land-use studies, and flood forecasting. GIS processing tools may be used to analyze watershed characteristics, but the speed of model development is often limited by extensive data input requirements.

A fully functioning HEC-HMS model requires at least three main components to run: a meteorological model, control specifications, and a basin description. The meteorological model describes the precipitation conditions for the basin, which are usually specified from historical rainfall measurements or precipitation statistics for a given location and storm magnitude. The control specifications are simply time parameters that determine the starting and stopping point of the model simulation. The basin component is a summary of the hydrologic elements within the model and includes connectivity information, hydrologic processes, and all parameters required to run the analysis.

GIS data may be used to describe the physical properties of the watershed and populate an initial basin file. Once the preliminary model has been created, the user should refine and calibrate hydrologic parameters according to local observations.

Datasets commonly used to determine the physical properties of a watershed include digital elevation, land use, impervious cover, and soil classifications. Much of this data is spread across various websites, each with unique methods for downloading and extracting information. Once obtained, the data must often be manually processed to remove seams and ensure a common coordinate system. Depending on the quality and availability of the spatial information, this data management process may require significant

effort by an experienced GIS user.

Whenever authoritative data is updated by government agencies, older hydrologic models become obsolete. These problems have become a major hurdle in the effort to maintain current hydrologic models across the nation. The issue is no longer with data scarcity but instead with the timely acquisition and management of data.

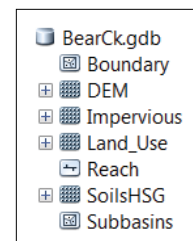
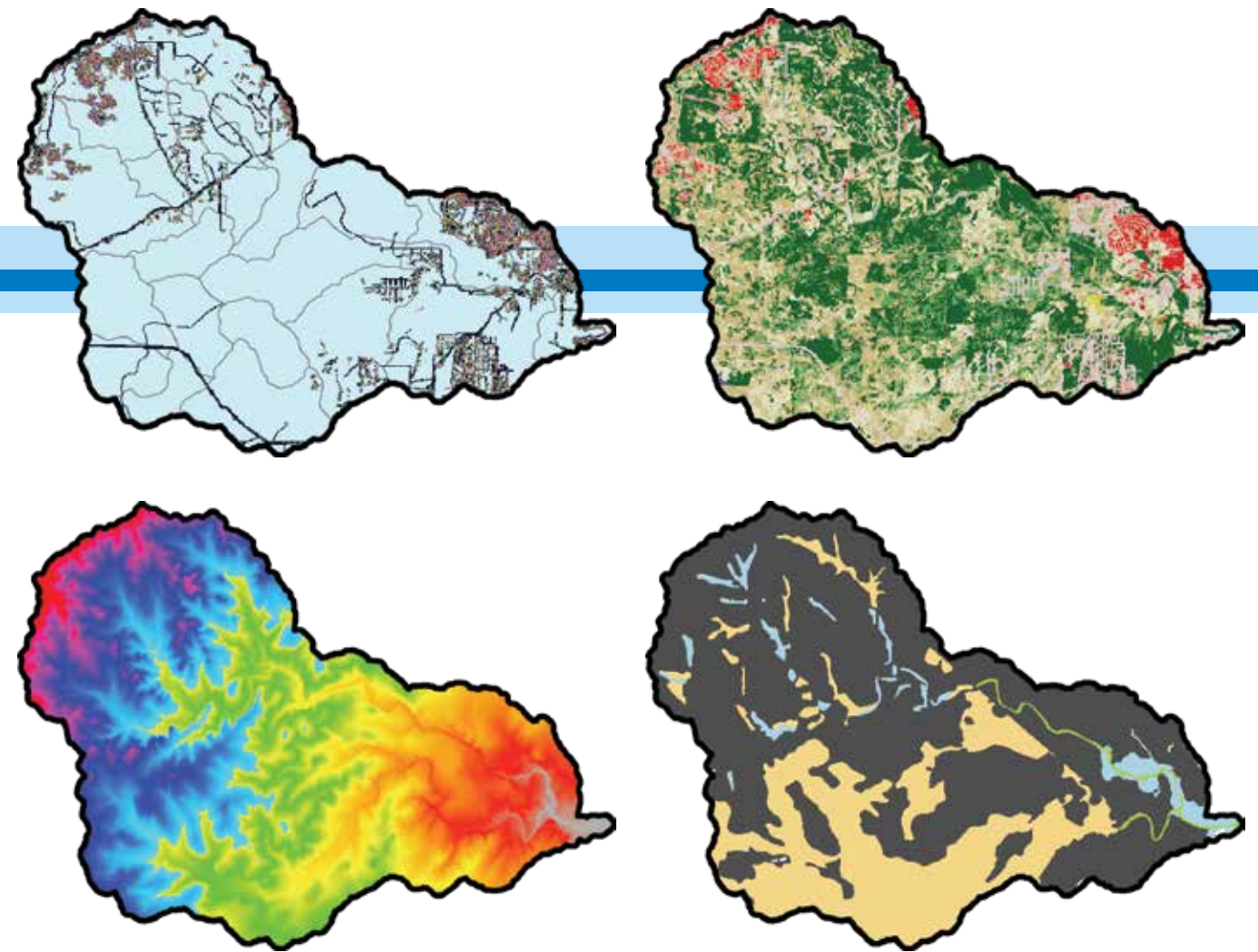
Esri's Living Atlas of the World was created to aid data management tasks by providing an operational linkage between geographic information and end users. The Living Atlas contains seamless, national datasets that may be used in common GIS processing tasks. The cloud-based data may be extracted to a local computer and immediately used in spatial operations without the need for extensive preprocessing.

Some of the Esri Living Atlas layers that are relevant to hydrologic models include:

- Elevation (3 meter, 10 meter, 30 meter, and lidar, as available)
- Land use
- Percent impervious
- Soil Survey Geographic Database (SSURGO) Hydrologic Soils Group
- NHDPlus and NHDPlusV2.1 Hydrology

The United States Geological Survey (USGS) National Elevation Dataset (NED) is a seamless raster representation of the earth's terrain derived from 10-meter and 30-meter digital elevation models (DEMs) for the continental United States. Esri's Living Atlas provides a collection of the highest-resolution elevation datasets that are publicly available. The National Land Cover Database (NLCD) comprises a national land-cover classification scheme based on satellite imagery maintained by the USGS.

In the Living Atlas, land-use types and percent impervious values may be obtained from the NLCD 2006 and 2011 datasets. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) maintains the SSURGO national database of soils information, which is mapped for most of



Geodata relevant to hydrologic models can be downloaded from the Living Atlas of the World. This data pertains to the Bear Creek watershed located in Hays County, Texas.

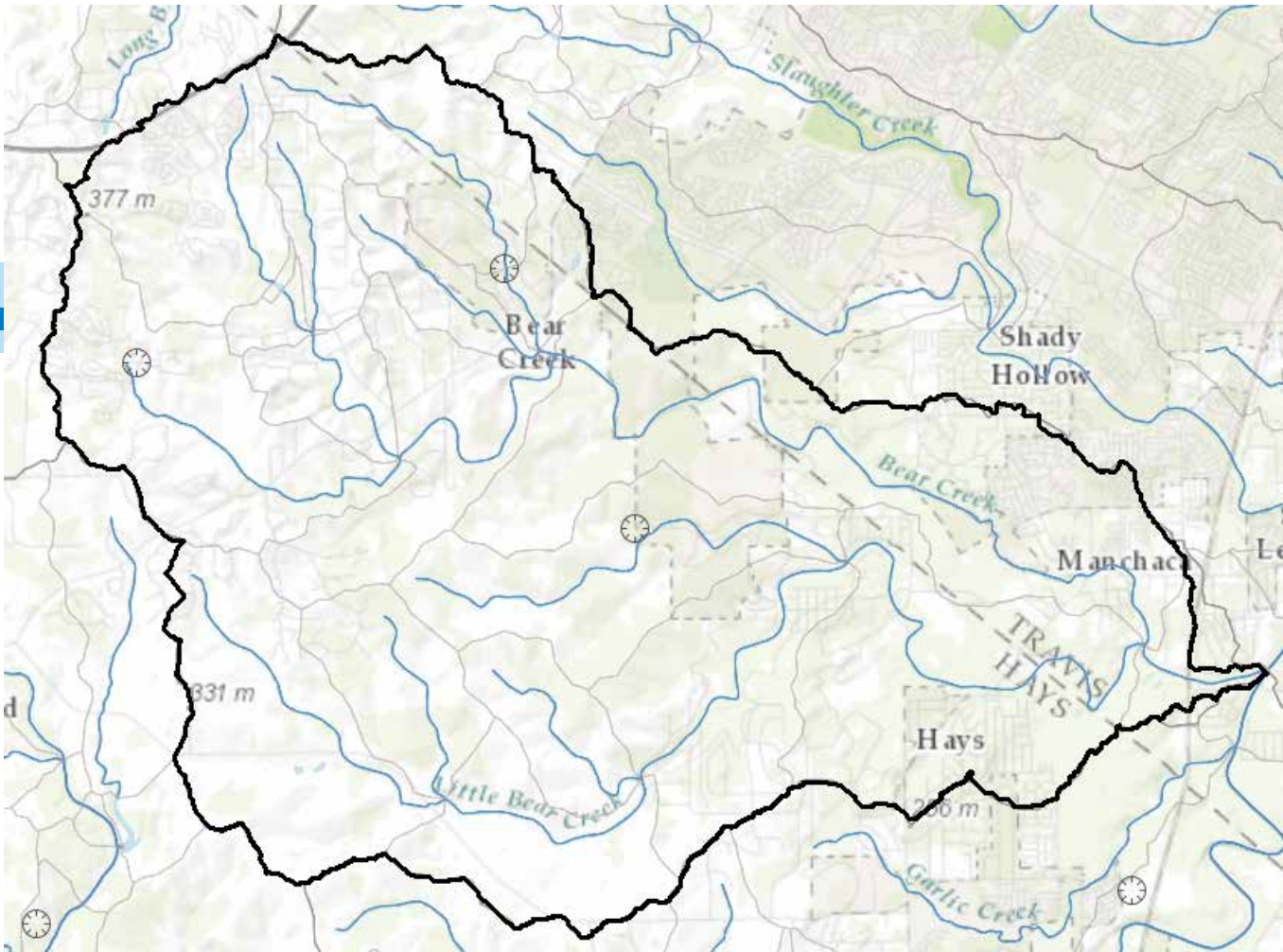
the United States. SSURGO provides information pertaining to unique soil properties. The hydrologic soil groups (HSG) are commonly used for determining parameters in HEC-HMS. Traditionally, it was necessary for a user to derive the HSG from SSURGO data and reference tables. To aid data requirements for hydrologic modeling, Esri's Living Atlas provides a seamless raster dataset of SSURGO soils with HSG already populated.

In addition to standard land characteristics, the Living Atlas contains national hydrography information. The USGS National Hydrography Dataset (NHD) is a GIS-based stream network containing surface water data for the continental United States. The NHD dataset was released by the USGS and the Environmental Protection Agency (EPA) and was designed as a companion dataset to the national Watershed Boundary Dataset (WBD). WBD is identified by Hydrologic Unit Codes (HUC), representing a hierarchical organization of watershed definitions (region, subregion,

basin, subbasin, watershed, and subwatershed).

The surface water datasets within the NHD, such as reaches, dams, and stream gauges, are related to the HUC classification scheme through GIS attributes. The NHDPlusV2.1 dataset was derived from the NHD and includes a compilation of hydrologic geospatial information from a decade-long process of merging terrain-based data with vector-based EPA streams. The NHDPlusV2.1 dataset contains approximately 2.67 million stream segments that are each connected to a unique catchment boundary. Its subbasin boundaries are geographically consistent with the national WBD watershed boundaries. Moreover, the NHDPlusV2.1 stream network is based on EPA topographic maps, USGS NLCD, and NED. By combining national land information with an established hydrologic framework (i.e., HUC), the NHDPlusV2.1 provides a nationally consistent stream network at a high resolution.

HMS-PrePro is a GIS tool under development by Cynthia Castro at the University of Texas that uses Python programming to extract geospatial information from the Living Atlas of the World,



Bear Creek NHDPlusV2.1 data

a collection of ArcGIS Online layers that is curated by Esri. The extracted data is saved in a local geodatabase that is used to estimate hydrologic parameters and initialize an HEC-HMS basin model.

HMS-PrePro uses the watershed bounding polygon as a common denominator to connect these distinct datasets into a comprehensive hydrologic geodatabase. The data is extracted from the Living Atlas server and then preprocessed in GIS to expedite the development of models, thus bridging the gap between hydrologic data and spatial analysis. Using the Living Atlas data service, a spatial database for a watershed of interest may be created expeditiously. HMS-PrePro may also be used to combine web-based datasets with local data into a common coordinate system for increased flexibility.

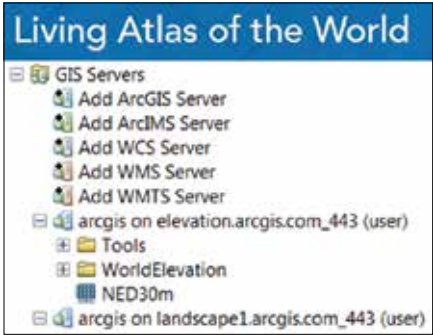
The hydrologic geodatabase is used to derive basin topology and estimate a number of hydrologic parameters. The HMS-PrePro toolbox contains two script tools: Get Data and Run HMS-PrePro. The Get Data tool connects to Esri's Living Atlas and extracts hydrologic data layers to a local geodatabase for a user-specified area of interest (i.e., a watershed). The NHDPlusV2.1 dataset is the default option for extracting a stream network from the watershed. Additional options include delineating the watershed with Arc

Hydro or providing user-defined data layers, such as project-specific subbasins. [Arc Hydro is a geospatial and temporal data model for water resources that works with ArcGIS.]

The Run HMS-PrePro script tool performs spatial operations on the database created by the Get Data tool. For widespread applicability, standard hydrologic methods may be chosen to represent basin abstractions, runoff transformation, and reach routing. Watershed parameters from HMS-PrePro should be treated as initial estimates and further optimized with engineering judgment, published resources, and local observations. A description of each hydrologic element is written to an ASCII file, which comprises the HEC-HMS basin model.

While other GIS tools may be used for model initialization, HMS-PrePro

Living Atlas of the World servers



was designed with unique data processing capabilities and a streamlined toolbox approach.

[HEC-PrePro v 2.0 and Hydrologic Engineering Center's Geo-spatial Hydrological Modeling (HEC-GeoHMS) were earlier GIS tools. HEC-PrePro v2.0, developed at the University of Texas, was a system of ArcView GIS scripts developed to extract hydrologic, topographic, and topological information from spatial data. HEC-Geo, the successor to HEC-PrePro v2.0, was created to more expeditiously construct hydrologic models. The Wisconsin Department

of Natural Resources (WDNR) and Esri contributed to early versions. HEC and Esri continued working on this tool and created a version that runs with ArcGIS 10.1.]

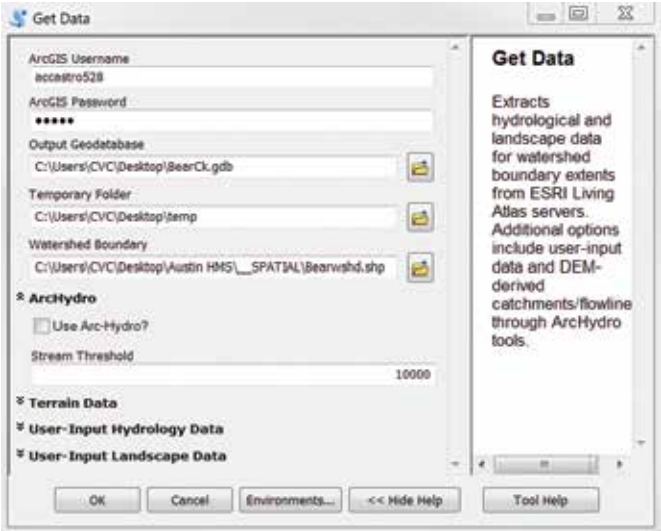
Instead of requiring the user to obtain, process, and manage data for each watershed, HMS-PrePro connects to Esri's Living Atlas and extracts authoritative data in a ready-to-use format. Using the ArcPy library in Python, the tool then constructs topologically correct hydrologic networks compatible with the HEC-HMS software. All hydrologic options are represented in just two toolbox interfaces, and common processing steps are combined for rapid execution.

In HEC-GeoHMS, for example, a lengthy process is required to estimate the curve number value from land-use and soils data. The user must navigate several dozen input requests, and manual pre-processing of the data is necessary.

In HMS-PrePro, spatial analysis is used to rapidly estimate the curve number value from the hydrologic geodatabase without any intermediate user steps required. HMS-PrePro and HEC-GeoHMS produce similar parameter results from the same set of input data.

Instead of representing physical processes through labor-intensive data subsistence, it is possible to characterize watershed hydrology through an information-based GIS cloud environment. Connecting the Living Atlas with HEC-HMS allows modelers to continue working with familiar tools but with much greater speed and consistency. The improved GIS technology provides much-needed operational links between raw hydrologic data and average end users. With data from the Living Atlas, GIS preprocessors may significantly enhance efforts associated with flood modeling for decision-making purposes.

For more information on HMS-PrePro, contact Cynthia V. Castero at [cynthiav11@gmail.com](mailto:cynthiav11@gmail.com).



Get Data script tool

Run HMS-PrePro script tool

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# Harnessing the Power of Geotechnology

GeoHub, launched by the City of Los Angeles and Esri on January 29, 2016, gives Angelenos inside and outside city government not only visibility into how the city works but also tools to help make the city work better.

This portal at [geohub.lacity.org](http://geohub.lacity.org) provides anyone access to the city's geodata. In doing so, GeoHub realizes LA Mayor Eric Garcetti's desire to make government data a platform for innovation. It does this by going beyond supplying open data and providing open services and APIs for leveraging that data.

Esri president Jack Dangermond was on hand for the launch, which was held at the La Kretz Innovation Campus, the city's cleantech industry hub. He noted that the vision that he and Garcetti shared was one

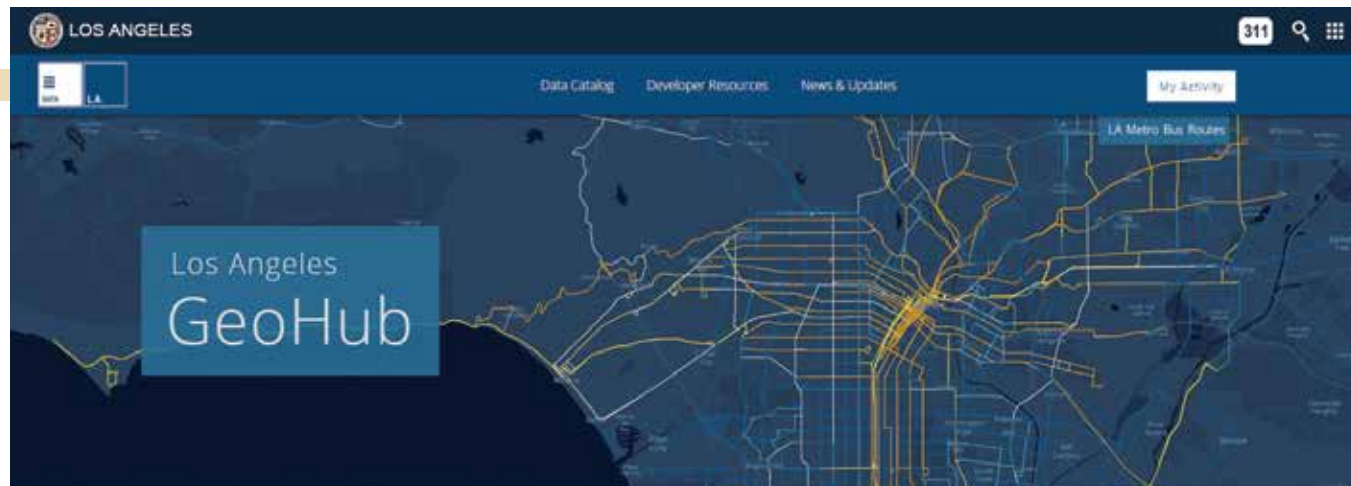
in which open data grew into open services that in turn would facilitate not only better work inside the city but enable startups, nongovernmental organizations (NGOs), and citizens to incorporate geographic insights into their thinking and decision making. The creation of services enables web GIS mapping, and that is what has made this revolution in understanding possible.

"Maps can actually be much more transparent than just data or even charts and graphs. You see it all and BANG, you get

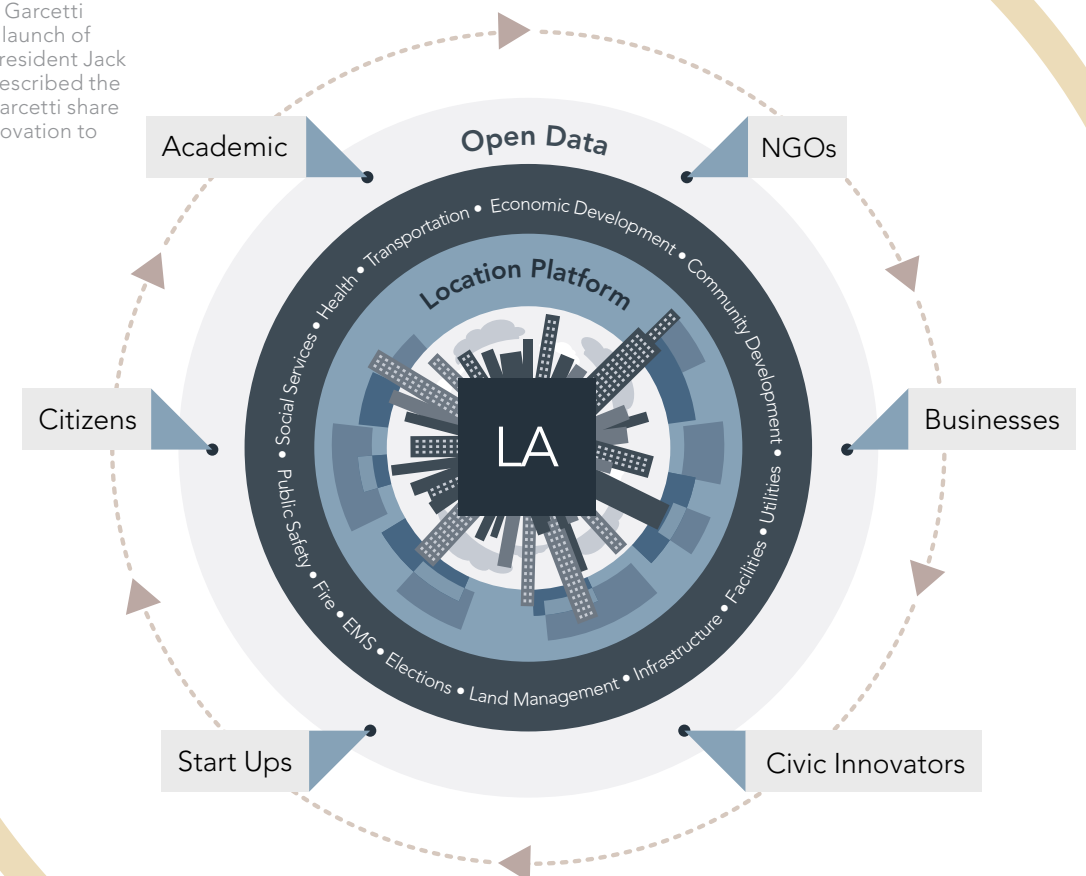
the idea," said Dangermond. Mashing up data from various sources in the city lets you see where the problems are and understand them by seeing geospatial data presented in maps. The city is making more than 500 layers of map-based data readily available. GeoHub flattens out a shared infrastructure of content.

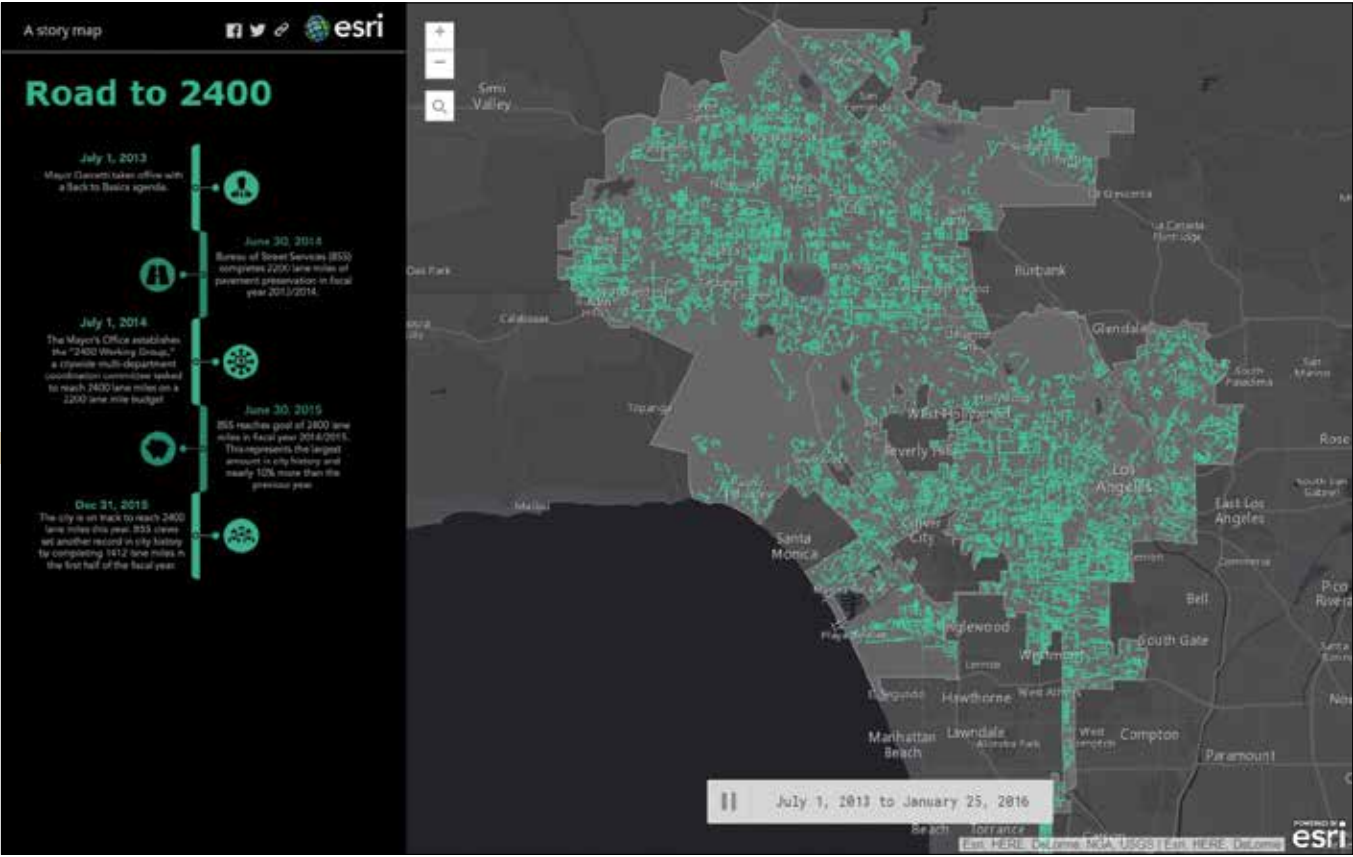
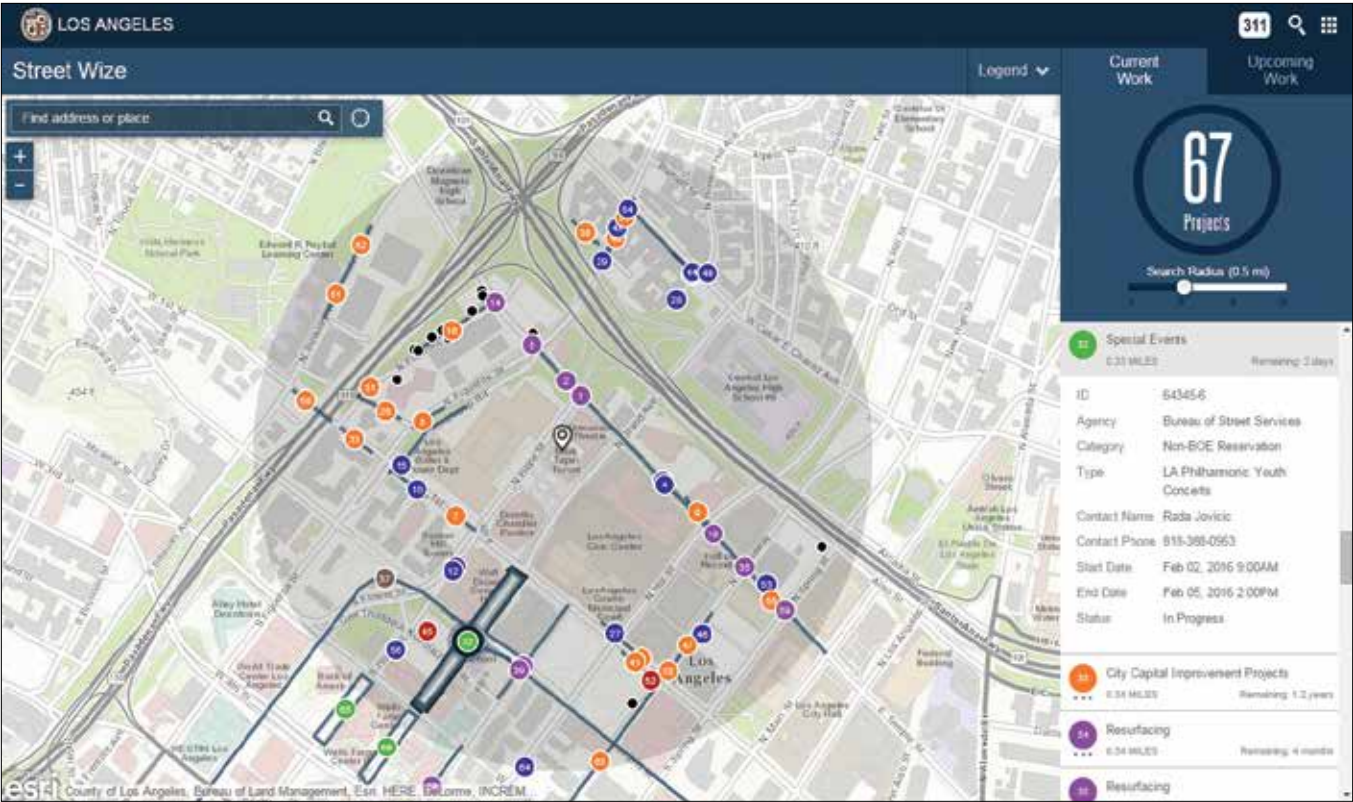
Garcetti underlined the value of GeoHub saying, "Almost anyone can benefit from the insights it puts at our fingertips." He used public safety response as an example of the value GeoHub brings to the city. If

GeoHub makes more than 500 layers of Los Angeles' map-based data readily available.



LA Mayor Eric Garcetti announced the launch of GeoHub. Esri president Jack Dangermond described the vision he and Garcetti share for bringing innovation to the city.





police officers, firefighters, or first responders have access to all the data all the time, instead of being limited to the information from the call, they can see the situation in a broader context. Having information about the presence of toxic substances, the location of sewer lines, and other information related to the location can make response more effective.

The value of GeoHub extends beyond services to other areas of government. The city's finance department can use GeoHub to see areas where economic

activity is thriving and areas that are not doing as well and determine how best to support both.

Maps can present more complicated data in a way that is more useful than spreadsheets. For example, the Street Wize app lets anyone—city staff, business, or citizen—track permit activity over time and space so that projects can be planned to avoid delays.

Some maps show how the city is reaching its goals. The Road to 2400 app displays the streets that have been paved since

Garcetti took office in 2013 when he vowed to pave 2,400 lane miles of streets.

GeoHub is groundbreaking, not just for Los Angeles but also for the world. It is the first time that data and maps have been put together in this way, and other cities, such as Paris, have expressed interest in this work. This approach to open data will change the way people, technology, and cities interact. "Suddenly we have geographic information coming together for everyone in an open and accessible portal," said Dangermond.

"Suddenly we have geographic information coming together for everyone in an open and accessible portal."

The Street Wize app lets anyone track permit activity over time and space.

The Road to 2400 app shows how many miles of street lanes have been paved since Garcetti took office in 2013.

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# Ten Surprising and Useful Ways to Use Story Maps

Esri Story Map apps let you combine authoritative maps with text, images, and multimedia content. They make it easy to harness the power of maps and geography to tell your story. Advocacy and outreach, virtual tours, and delivering public information are just a few ways you can use story maps.

While many uses for story maps are obvious, others are not. Here are 10 things you can do with story maps that you might not have thought of before.

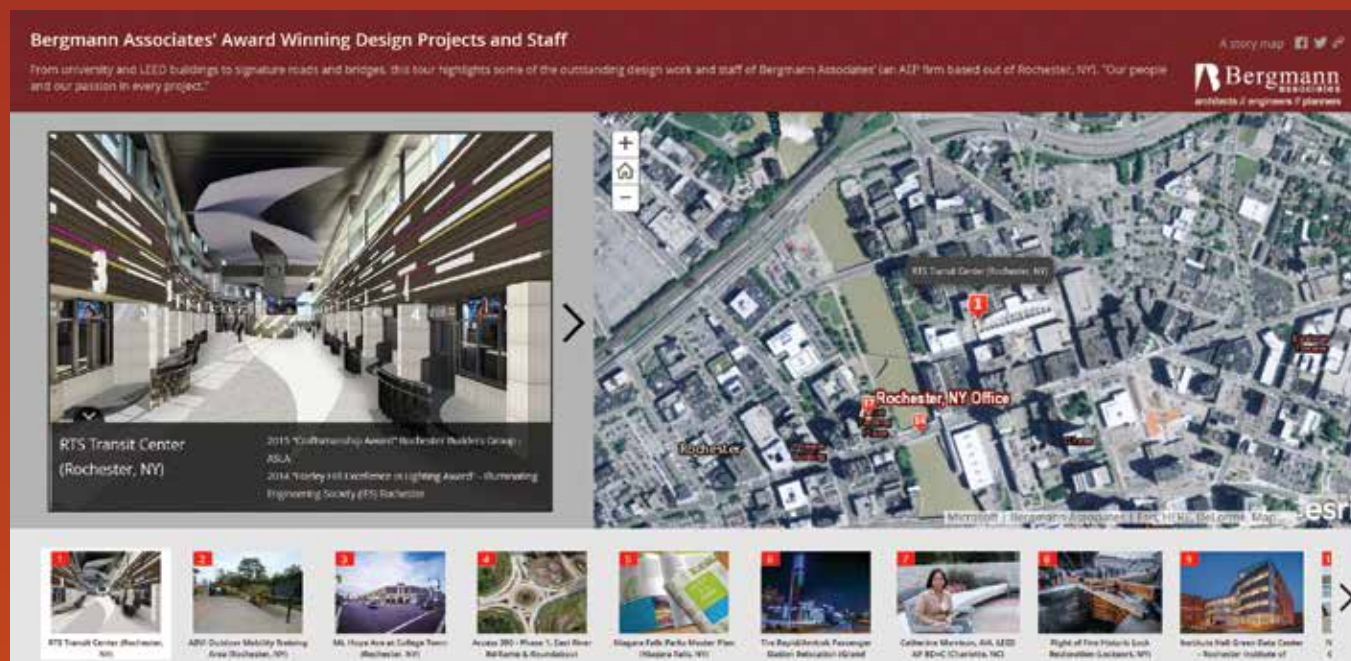
## 1 More Compelling Briefings and Presentations

When you want to use live maps during a briefing or presentation, a story map is a unique and compelling way to make your point without having to switch back and forth from Microsoft PowerPoint to a map or app. You can also export PowerPoint slides and use them in your story map.

## 2 Introduce Your Staff

Use a story map to introduce your staff to your customers or the public. The map can provide background information on staff members and demonstrates the expertise of your company.

Bergmann Associates showcases its portfolio of architectural, engineering, and planning projects using a story map.



## 3 Promote and Market Events

Attract attendees to your event with a story map that lets potential attendees explore event venues or attractions and can be embedded directly into the event website.

## 4 Showcase Projects or Business Activities

A story map can be used to showcase your business activities or projects whether your organization is in the public or private sector.

## 5 Interactive Annual Reports

Annual reports deliver a comprehensive summary of a business or an organization's activities throughout the preceding year. With story maps, reports can be enhanced with maps and lots of different media.

## 6 Multimedia Teaching Tool

A story map—especially the Story Map Journal app—is a great choice when you have lots of maps and media. Topics can be organized into sections and viewed sequentially.

## 7 More Engaging Resumé

You can introduce yourself using a story map as an interactive resumé. It is an especially compelling format for a GIS professional who can include examples of GIS work through interactive maps.

## 8 Effective Public Relations Tool

Elected officials who need to keep their constituency informed or charitable organizations that are rallying supporters for a cause can both benefit from story maps to effectively reach their audiences.

## 9 Dashboards That Show Current Conditions

Dashboards provide a heads-up display of information, often including live feeds, to show current events or conditions. Story maps can provide a current overview of a situation.

## 10 Dynamic Atlas

While a traditional atlas is a collection of maps bound in a book, a story map atlas can use dynamic rather than static maps and provide a framework for enhancing the atlas with rich text and interactive media.

### Summary

There are many other ways to use Esri Story Map apps to better meet your presentation, communication, or visualization needs. Use these suggestions as a springboard for your own creative use of story maps. Visit the Story Maps Gallery ([storymaps.arcgis.com](http://storymaps.arcgis.com)) to browse a large collection of examples.

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# Modeling Communications Coverage

By Mike Price, Entrada/San Juan, Inc.

### What you will need

- ArcGIS for Desktop (Basic, Standard, Advanced)
- ArcGIS Spatial Analyst extension
- Sample dataset from ArcUser website
- An Internet connection
- Intermediate ArcGIS for Desktop skills

This exercise models viewsheds from Toro Peak to determine visibility for individual locations that are part of a communications network used for an earthquake early warning system in the Coachella Valley in Southern California.

A real-time earthquake warning system requires comprehensive, line-of-sight, reliable, and redundant communication. Communication systems link ground motion sensors, data processing hubs, and critical facilities in real time to detect earth movement; filter and analyze data; and quickly warn impacted facilities, even before the arrival of the most damaging waves. This article teaches how to model a viewshed and determine visibility for individual locations.

The Coachella Valley is home to some 400,000 permanent and seasonal residents. Major active faults, including segments of the San Andreas fault system, intersect the Coachella Valley. Earthquakes occur throughout the region. In 2013, the California Governor’s Office of Emergency Services (Cal-OES) began a series of stakeholder meetings to develop an implementation plan for the California Earthquake Early Warning System (CEEWS). The statewide model represents a public/private partnership. Earlier, before 2010, the Coachella Valley Regional Earthquake Warning System (CREWS) was designed and is now in implementation.

This exercise uses the ArcGIS Spatial Analyst extension to model viewsheds from Toro Peak, which looks north and east into the Coachella Valley. Its 8,717-foot-high

summit is the highest peak in the Santa Barbara range.

### Getting Started

To begin this exercise, download the training data from the *ArcUser* website at [esri.com/arcuser](http://esri.com/arcuser). This dataset contains a clipped 30-meter digital elevation model (DEM) for a portion of the larger study area. The DEM is in Esri geodatabase raster format and is carefully reprojected to universal transverse Mercator (UTM) North American Datum 1983 (NAD 1983) Zone 11N.

Unzip the sample data archive on a local drive and open ArcCatalog to inspect the contents. It includes two file geodatabases, Topography.gdb and Facilities.gdb, and a collection of layer files. Topography.gdb contains the clipped and reprojected 30-meter DEM. Facilities.gdb includes three feature

classes: CREWS1 and Toro\_Peak1, both point layers, and Study\_Area, a polygon layer. Notice that Topography contains topo\_30, a file geodatabase raster dataset that does not have a hillshade. After inspecting these files, close ArcCatalog.

### Preparing Data for Viewshed Modeling

Start an ArcMap session, activate the ArcGIS Spatial Analyst extension. Navigate to \Palm\_Springs. Open Toro\_Peak\_Viewshed1.mxd, inspect it, and repair any broken data links.

Inspect the properties of the data. Verify that all data is registered in the UTM NAD 1983 Zone 11N and that horizontal and vertical units of measure are all meters. Right-click Study Area and choose Zoom to Extent.

Look at the thematic legend for Topography, 30 M and make it the active layer. Use the Identify tool to inspect the elevation values for the 30-meter cells. These cells contain floating-point values. Before investigating the source elevation grid for these cells, let’s update the map properties.

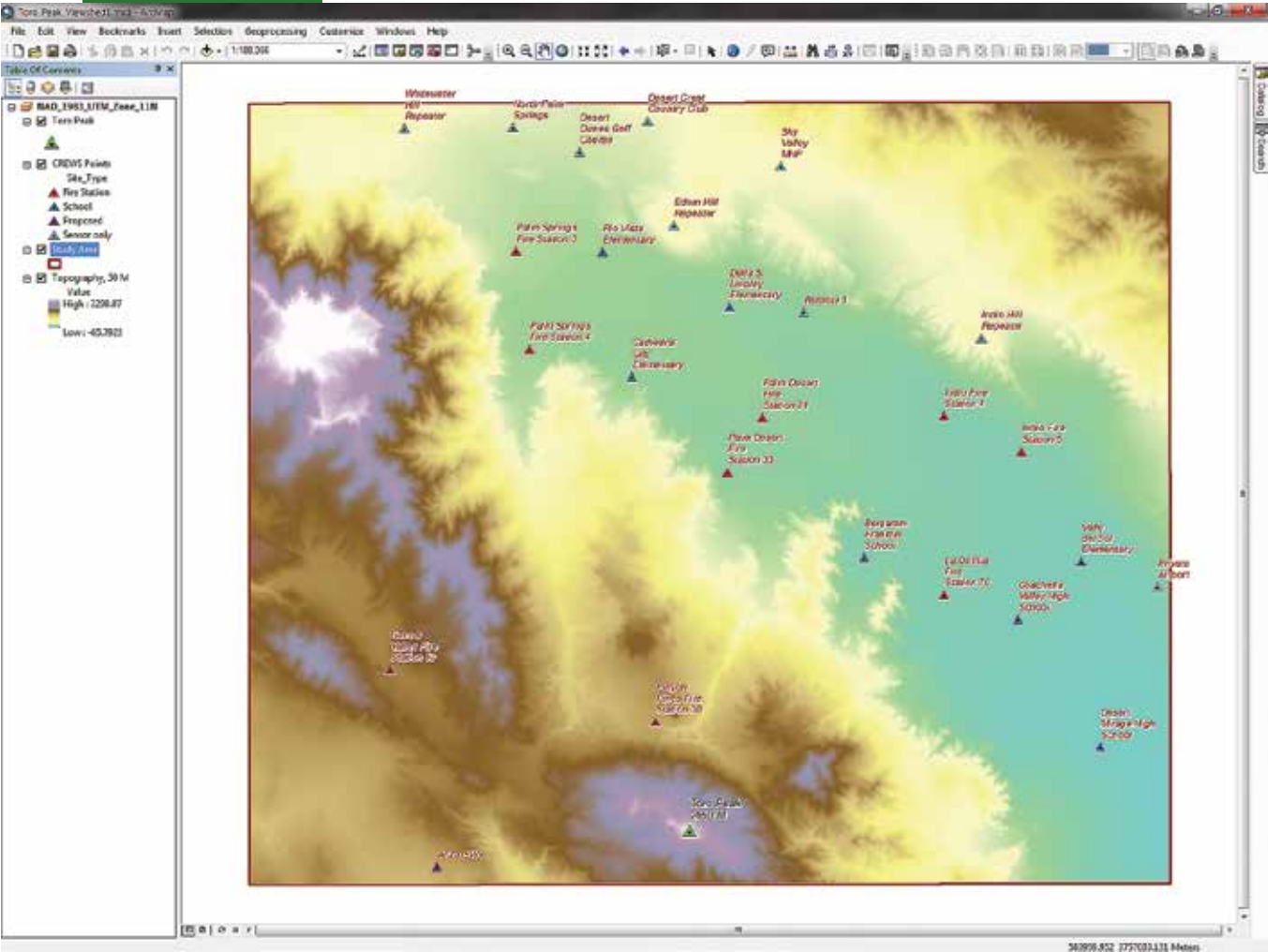
In the Standard menu, choose File > Map Document Properties. In the Map Document Properties window, under File, verify that the path to the document is correct. Name the map Toro Peak Viewshed, and copy Topography into the Summary and Description boxes. Type your name in the Author field. Under Credit, type USGS and CREWS. This data was obtained from several agencies and modified and standardized for this exercise. Under Tags, type Coachella Valley, Palm Springs, Viewshed and separate

the tags with commas. Set the default geodatabase to \Palm\_Springs\GDBFiles\UTM83Z11\Topography.gdb. Check the Pathnames box and create a thumbnail. Click OK to apply these updates and save the map.

### Setting Up the Geoprocessing Environment

In the Standard toolbar, choose Geoprocessing > Environments. In the Environment Settings dialog box, expand Workspace and set the Current and Scratch Workspace to \Palm\_Springs\GDBFiles\UTM83Z11\Topography.gdb. All the modeling results will be added to this geodatabase. Set the Output Coordinates and Processing Extent to Same as layer Topography, 30 M. Under Raster Analysis, set Cell Size to Same as layer Topography, 30 M and set Raster

The elevation raster for this exercise was downloaded from *The National Map* and reprojected to UTM NAD 1983 Zone 11N.



# Understanding Earthquake Early Warning Systems

In 2013, Mark S. Ghilarducci, the director of the California Governor’s Office of Emergency Services (Cal-OES), announced a year-long series of stakeholder meetings that created a blueprint for developing an implementation plan for the California Earthquake Early Warning System (CEEWS). Cal-OES is committed to support of public-private partnerships to develop statewide earthquake warning capability.

Regional partnerships—including the Coachella Valley Regional Earthquake Warning System (CREWS); the Imperial County Regional Earthquake Warning System (ICREWS); and Seismic Warning Systems, Inc., in Scotts Valley, California—are implementing and testing warning systems in Riverside and Imperial Counties.

## P Waves, S Waves, and Earthquake Warning

Earthquake advance warning systems detect the nondestructive primary waves (P waves) that travel quickly through the earth’s crust, in advance of the destructive secondary waves (S waves). The delay between the arrival of P waves and S waves controls the amount of advance warning that can be given. The interval increases the farther a location is from the epicenter of the earthquake. This interval generally ranges between 60 and 90 seconds for deep, distant, large earthquakes. An interval of one second for every two kilometers (km) from the quake’s origin is the rule of thumb.

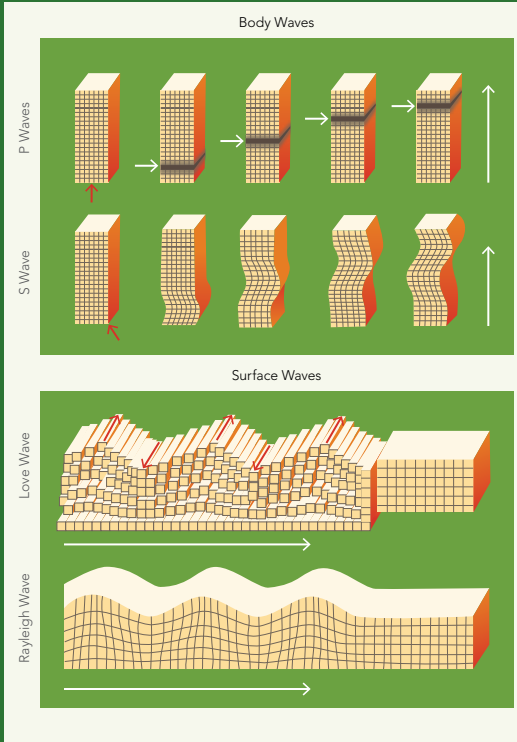
The effectiveness of advance warning depends on the accurate detection of P waves and the rejection of false-positive ground vibrations caused by local activity. Table 1 compares the characteristics of typical P waves and S waves.

## What to Do in a Few Seconds

Even a few seconds’ warning can provide enough time to take protective measures.

- Members of the public—wherever they are—should drop, cover, and hold on. If they are at home, they should turn off stoves. If they are driving, they should safely stop their vehicles.
- Emergency responders should automatically open fire station doors, turn on lights, automatically alert emergency responders, and prioritize response decisions.
- Those who provide medical services should stop delicate medical or dental procedures. Trauma centers should prepare for emergency arrivals. Emergency response plans with outlying facilities should be initiated.
- Utilities should protect power stations and distribution infrastructure from

- strong shaking.
- Affected industries should protect personnel and initiate safety shutdown procedures including isolating and protecting hazardous materials on-site.
- Businesses should move workers to safe locations and ensure elevator doors are open or are placed out of service. Sensitive equipment should be placed in a safe mode.



Earthquake Wave Type	Typical Velocity in Rock Material	Wave Character	Ground Motion	Relative Damage
P Wave	6 km/sec or 3.7 mi/sec	Compression wave—short wavelength, small amplitude	Generally up and down	Smaller damage radius, often causing less damage to structures
S Wave	4 km/sec or 2.5 mi/sec	Shear wave—long wavelength, long amplitude	Nearly always lateral (sideways)	Larger damage radius and greater effect, causing extreme damage in unconsolidated sediment

Table 1: P Wave and S Wave Characteristics



Analysis Mask to Study Area. Click OK and save the project.

## Elevation Data Quality and Local versus Global Data

The elevation raster provided for this exercise was downloaded from *The National Map* (viewer.nationalmap.gov/launch/). Because it has been reprojected to UTM NAD 1983 Zone 11N, the x, y, and z coordinates are all in metric units.

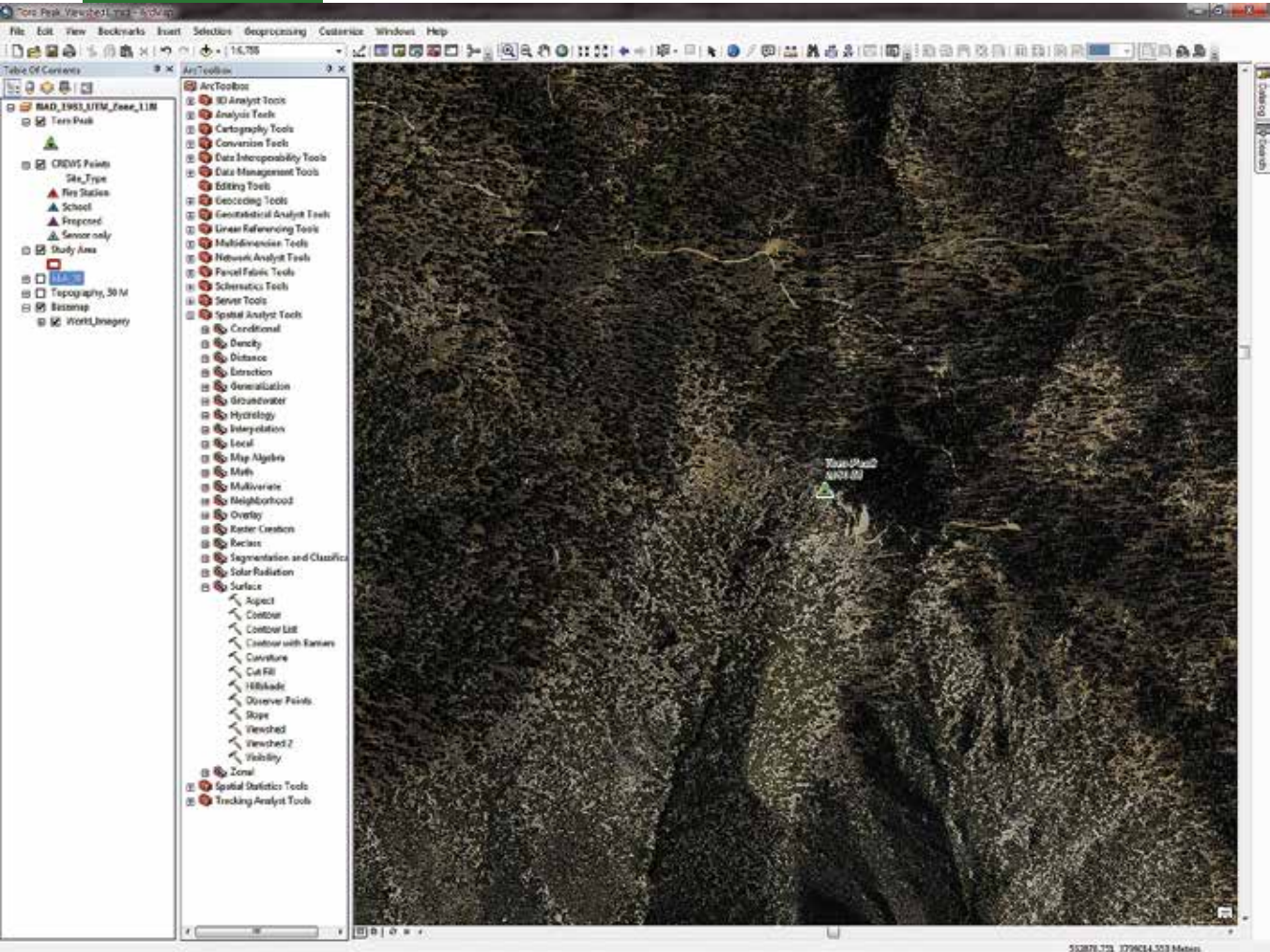
To replicate this exercise for another region in the United States, visit *The National Map* portal and download data for that area. Typically both 10- and 30-meter-resolution data is available. Although a 10-meter DEM would provide better resolution, it would be too large for this exercise, so a 30-meter

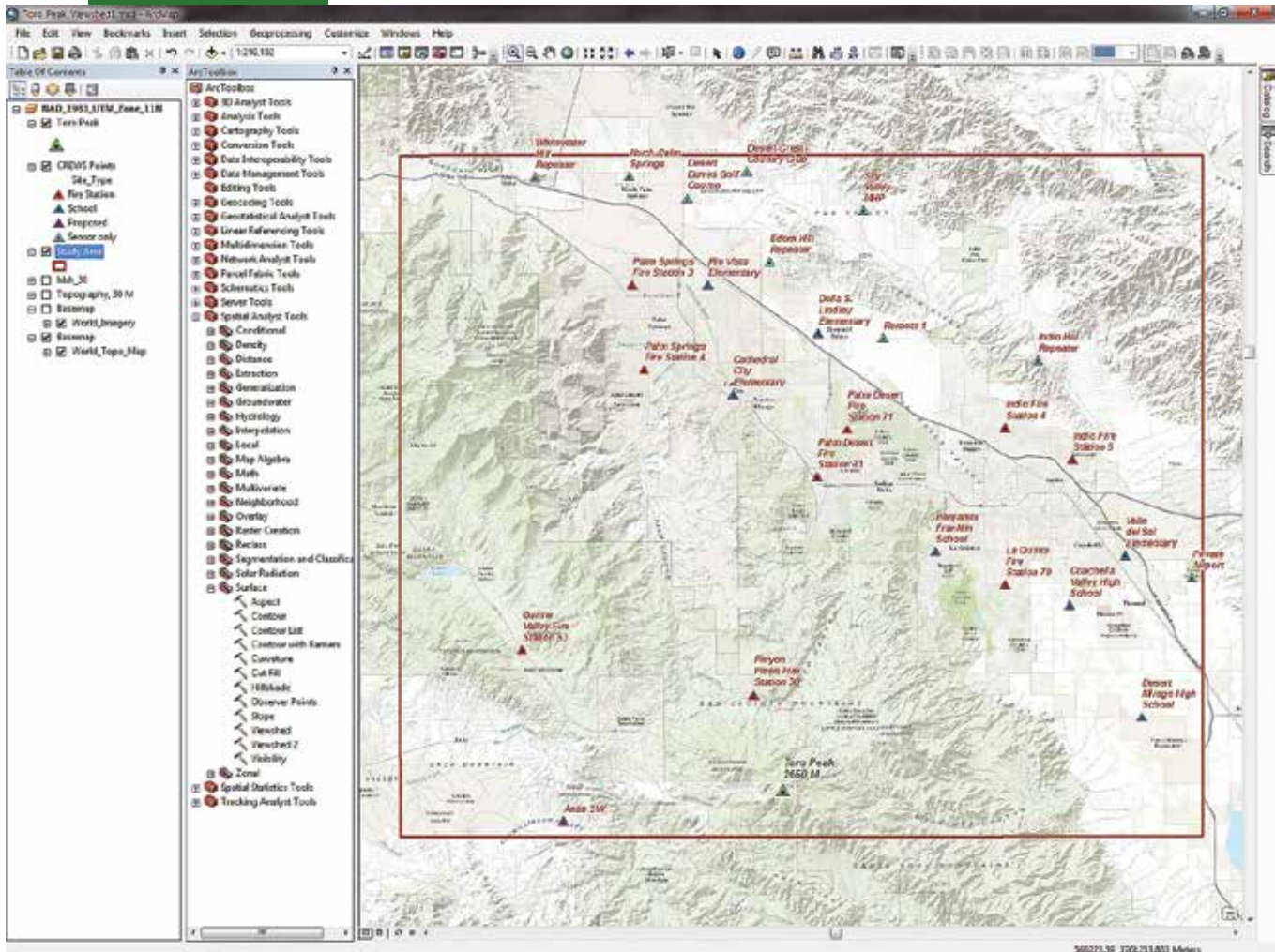
DEM is used instead. Data obtained from *The National Map* is provided in a geographic coordinate system with NAD 1983 as the horizontal datum. Seriously consider reprojecting any data you download for another area to a standard regional metric or imperial system, using the workflow presented in “Looking Good: Properly reprojecting elevation rasters,” which ran in the fall 2013 issue of *ArcUser*, which is available online at [esri.com/esri-news/arcuser/fall-2013/looking-good](http://esri.com/esri-news/arcuser/fall-2013/looking-good). If x, y, and z units are identical, it is not necessary to apply vertical exaggeration.

Let’s create a quick hillshade to assess the quality of this elevation data. Open ArcToolbox, expand the Spatial Analyst toolset, and locate the Surface tools. Open the Hillshade tool, set Topography, 30 M as

Set the geoprocessing environment for the project before performing any analysis to maintain an organized workflow.

After adding the Imagery basemap from ArcGIS Online, zoom to Toro Peak.





After adding the Topographic basemap, zoom to the extent of the Study Area layer to inspect the CREWS locations.

the Input raster, and store the output raster in \Palm\_Springs\GDBFiles\UTM83Z11. Name the output file hlsh\_30. Accept defaults for all other parameters, and click OK. Watch as the hillshade appears.

Zoom to Toro Peak, located in the south central portion of the study area. Use the Identify tool to check elevations on and near the Toro Peak point. The highest elevation cell on the peak contains a rounded value of 2,648. This 3D point is only one meter above the raster surface. Save the map.

Using Online Basemaps

High quality basemaps are available from ArcGIS Online if you are connected to the Internet. Verify that you have an Internet connection and click the drop-down next to the Add Data icon in the Standard toolbar. Select Add Basemap and preview the available maps.

Select Imagery, and wait patiently as recent high-resolution imagery loads as a basemap layer. All basemap layers load at the bottom of the table of contents (TOC).

Zoom in until the scale is approximately 1:6,000, and study the transmitter point. The antenna is on the northwest corner of the structure that contains the communication equipment. The tower, located at the top of the mountain, faces north toward the Coachella Valley.

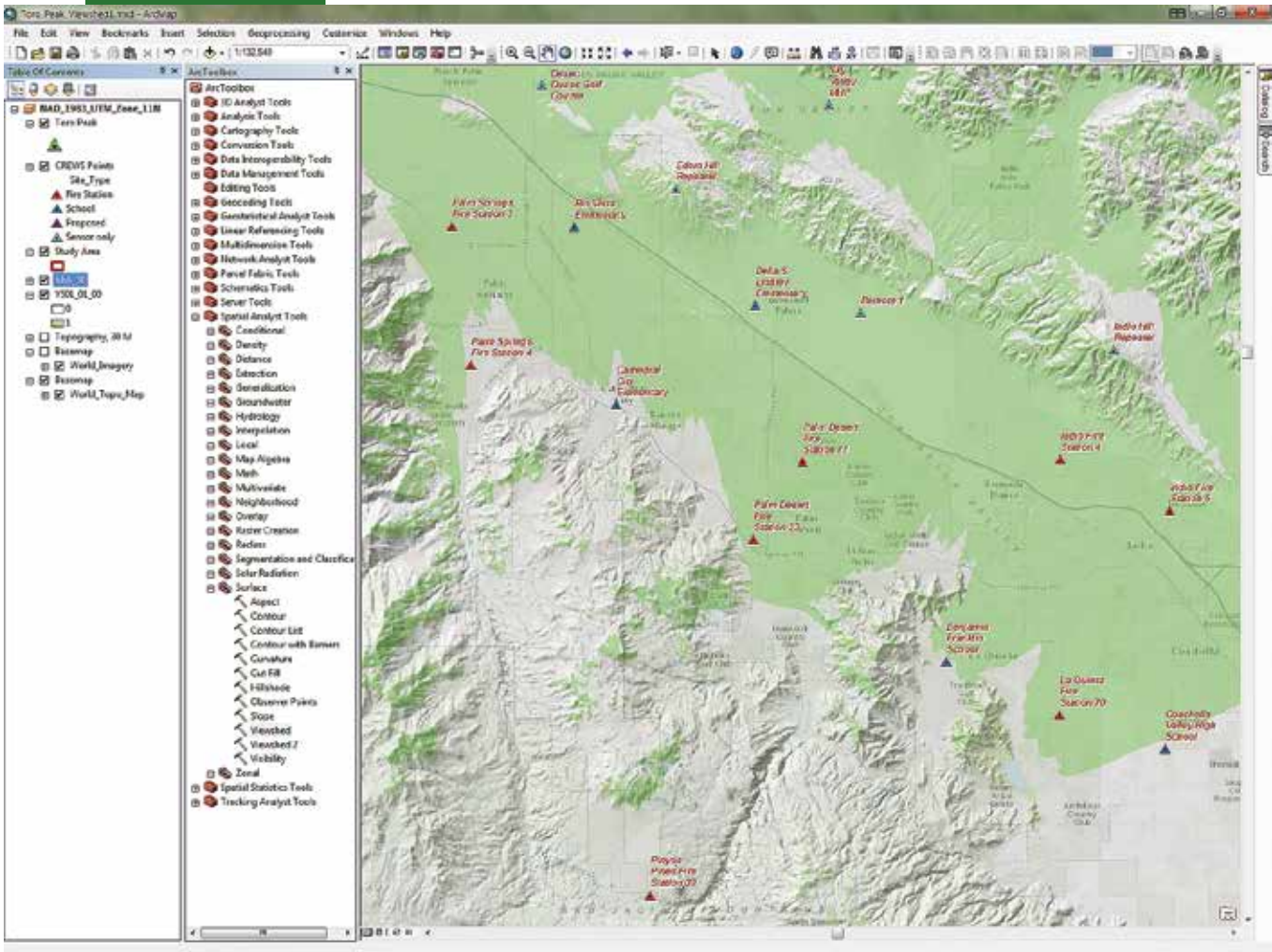
Right-click on the Study Area layer and choose Zoom to layer. Uncheck but don't remove the World\_Imagery basemap, and turn off the hlsh\_30 and Topography, 30 M layers. Reopen the Basemap gallery and select Topographic. World\_Topo\_Basemap will be used for the rest of the exercise. After the new basemap loads, save the project.

Explore the CREWS points. Study the

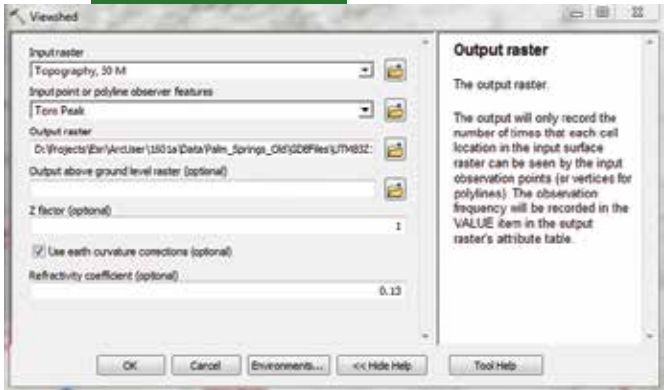
relationship of CREWS sensor and facility points relative to topography, streets, and political boundaries. Most CREWS points lie within one of the Coachella Valley municipalities: Palm Springs, Cathedral City, Rancho Mirage, Palm Desert, and Indio. CREWS points include schools, fire stations, and raw sensor locations.

Several sensors, including one proposed location, are at high elevations. When an earthquake occurs, sensors need to quickly collect and stream seismic data to one or more communication facilities, where it will be processed and alerts generated. Alerts are sent to essential and critical facilities either by wireless communication or via the Internet.

Since instantaneous communications are essential, CREWS points should be in the line-of-sight viewshed of a major communications hub. Toro Peak's location and elevation



The output from the original Viewshed tool shows which CREWS locations are visible, evaluated as though the antenna height is the same as the height of the raster.



Perform a simple visibility analysis for the communications network with the original Viewshed tool.

suggest that it might be an excellent location for such a hub, as it could "see" most or all CREWS points. Let's model the Toro Peak viewshed with the Viewshed and Viewshed 2 tools in the Spatial Analyst toolbox.

The Original Viewshed Tool

For many years, the Spatial Analyst extension provided a Viewshed tool that can be used to create a simple viewshed. In ArcToolbox, expand Spatial Analyst Tools and choose Surface Tools > Viewshed. Set

the Input raster to Topography, 30 M. Set Input points or polylines to Toro Peak. Name the Output raster VS01\_01\_00. This output naming convention references the original Viewshed tool (VS01), the observation elevation (i.e., antenna height) to 01, which is one meter above the elevation raster, and the surface height to 00, which is not readily available in Viewshed).

Since all units are meters, leave the z factor as 1. Check the Use earth curvature corrections box and click OK.

When the Viewshed tool loads, ArcGIS assigns standard pink and green colors to the cells. A nonvisible cell has a value of 0 and is pink, and a visible cell has a value of 1 and is light green. In the TOC, place VS01\_01\_00 below hlsh\_30.

To standardize the legend and hide nonvisible cells, use symbology from the Viewshed\_1

# Partnerships Provide Earthquake Warning in California

**Earthquake early warning systems** notify affected populations of an imminent earthquake. Although this warning may be given only be a few seconds in advance of the event, those seconds can give people enough time to take protective measures and limit person and property damage.

The Coachella Valley Regional Earthquake Warning System (CREWS) is the first of several regional early warning systems to be implemented in Southern California. It is a partnership between the Coachella Valley Association of Governments (CVAG) and Seismic Warnings Systems, Inc. Agency partners include 12 cities in the CVAG, three school districts, the Coachella Valley Emergency Managers Association, and the Eastern Riverside County Interoperable Communications Authority. Private partner Seismic Warning Systems develops and deploys earthquake detection, analysis, and notification technology.

In the Coachella Valley, CREWS will provide earthquake early warning services to 4 emergency dispatch centers, 90 schools, 37 fire stations, four health care facilities, 7 police stations, and 3 tribal emergency operations centers.

The Imperial County Regional Earthquake Warning System (ICREWS) is a public-private partnership between Imperial County and Seismic Warning Systems with support and backing from the State of California and FEMA. Initial ICREWS include Imperial County Fire Department, Imperial County Sheriff's Office, the Cities of Brawley and El Centro, Calexico Fire and Police Dispatch

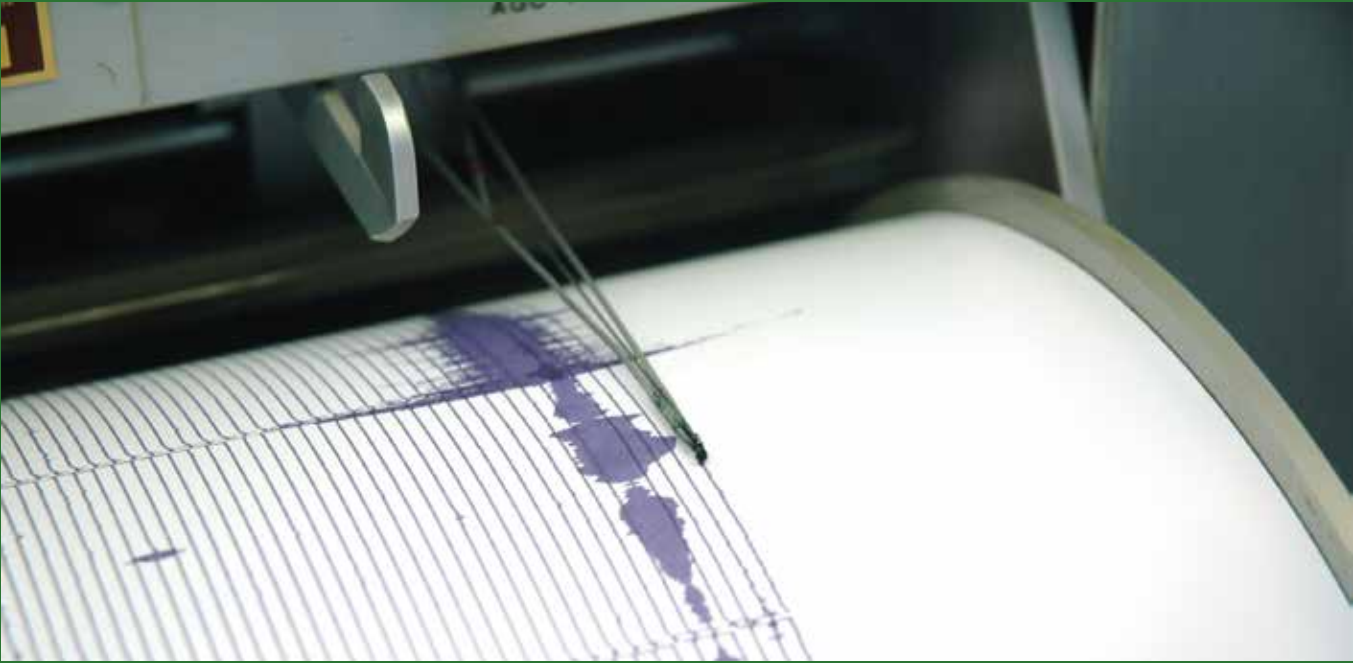
Centers, Calipatria Fire Department, El Centro Regional Medical Center, and Pioneers Memorial Hospital.

CREWS and ICREWS protects first responders, hospitals, water facilities, and critical government assets by quickly transmitting warnings of dangerous earthquakes before the earth starts shaking.

Fast, sustainable communication between sensors, data centers, and critical facilities are essential to an earthquake warning system. The High Performance Wireless Research and Education Network (HPWREN) is a project of the Applied Network Research group at the San Diego Supercomputer Center, University of California, San Diego. HPWREN supports Internet data applications in research, education, and public safety. Seismic Warning Systems is a Tier 1 member of HPWREN.

HPWREN provides collaborative, Internet-connected cyber infrastructure. It supports a high-bandwidth wireless data network in San Diego, Riverside, and Imperial Counties in areas that are typically not well served by other data networks. Backbone nodes, typically sited on mountaintops such as Toro Peak, connect areas that are often hard to reach in the remote Southern California backcountry. HPWREN data transmission is essential to both CREWS and ICREWS.

This article interprets and presents information originally provided online by ICREWS, HPWREN, the US Geological Survey, and Seismic Warning Systems.



on your computer, it will be used to enhance the performance of the Viewshed 2 tool.

Zoom to the Study Area layer, return to Surface tools, and open Viewshed 2. Set the Input raster to Topography, 30 M and name the Output raster VS02\_21\_05. By raising the 5-meter Toro Peak antenna to 21 meters, it will be above all CREWS points. Expand and review Viewshed parameters. Accept all defaults and expand and study Observer parameters. Set Surface offset (the CREWS points) to 5 meters and set Observer offset to 20 meters to place (virtually) a 20-meter antenna on Toro Peak and 5-meter antennae on all CREWS points. Save the project and click OK to model Viewshed 2. These are complex calculations that may take a while to process.

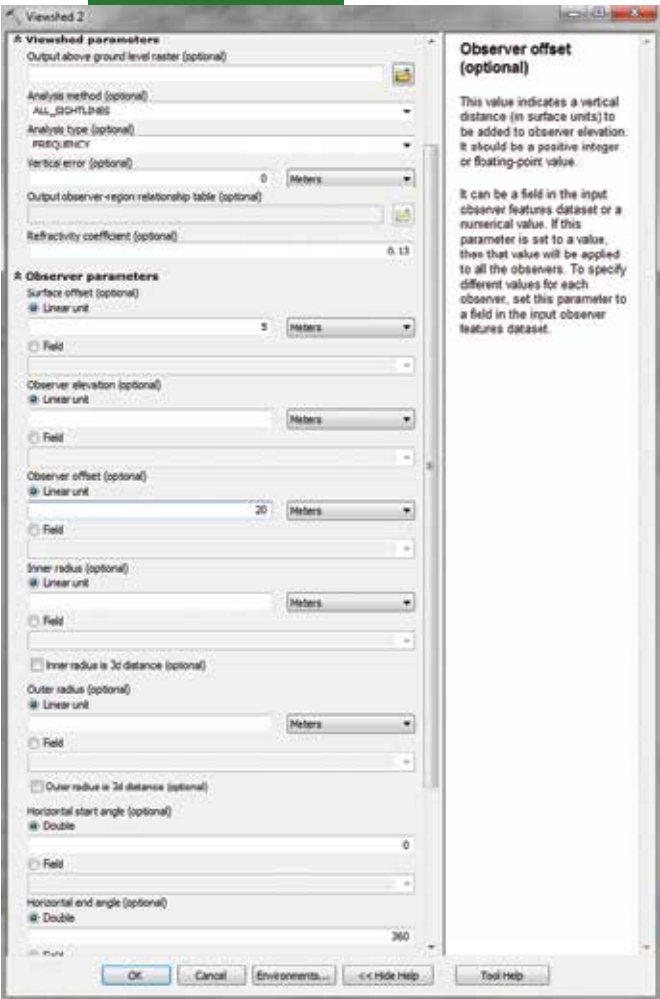
When VS02\_21\_05 loads, move it immediately below SV01\_01\_00. Open Properties, click Symbology, and set the classification to Unique values (*this is very important*). If asked to create an attribute table, click Yes. While still on the Symbology tab, use Viewshed 2.lyr to apply Dark Navy symbology. Set transparency to 60 percent, click OK, and save again.

Inspect the relationship of VS01 and VS02, especially in southern areas. Notice that Fire Stations 30 and 53 are now visible, as is the proposed sensor Anza SW at the Benjamin Franklin School, which is very close to visible, but several other schools and Fire Station 3 are still not visible. Unfortunately, the hills immediately south of the Coachella Valley floor are too high to expose these points. Save the project.

## Converting a Viewshed Raster to a Polygon Feature Class

For some mapping and analysis, polygon representations of Viewshed perimeters are very useful. Let's convert VS01\_21\_05 to a polygon feature class. In ArcToolbox, locate the Conversion toolset, choose From Raster > Raster to Polygon. Set VS02\_21\_05 as the input raster, set the field as Value, and name the output raster VS02\_21\_05\_p (*p for polygon*) and store it in Topography.gdb. Click OK to continue and place the filled polygon above hlsh\_30.

Rename the viewshed polygon Viewshed 21, 5. The numbers represent the Toro Peak and CREWS antenna heights. Instead of applying transparency to this viewshed polygon, apply a No Color or Hollow fill color and a 2 point ultra blue outline. Save again.



The Viewshed 2 tool uses geodesic methods and determines each cell's visibility by applying a line-of-sight test between the target and each observer that can incorporate the heights of each.

## The New Viewshed 2 Tool

In 2015, the Viewshed 2 tool was added. It includes several significant improvements over the previous Viewshed tool. Viewshed 2 is available with a Spatial Analyst or 3D Analyst license. It determines raster surface locations that are visible to a set of observer features using geodesic methods. Each cell's visibility is determined by a line-of-sight test between the target and each observer. If an observer can see the target at the cell center, the cell is considered visible. Nonvisible cells are assigned NoData. When modeling visibility, the tool always considers the curvature of the earth and does not have a z-factor parameter.

The tool exposes many new user-defined variables, including observer and viewed object heights above an elevation raster, maximum and minimum modeling radii, and viewshed azimuth constraints. If a graphics processing unit (GPU) is available

layer file. In the TOC, right-click VS01\_01\_00, open Properties, and select Symbology. Verify that Show is set to Unique Values and open Import. Browse to (Palm\_Springs)\GDBFiles\UTM83Z11 and select Viewshed 1.lyr. Click OK to apply symbology. The visible cells are now Leaf Green. Next, click Display and set transparency to 60. Transparency allows the underlying basemap to display below the Viewshed. (To see the visible cells even more easily, turn off the basemap layer.) Save the project. Zoom in to southern Palm Springs and study the viewshed.

Palm Springs Fire Station 3 is just inside the Toro Peak viewshed, but Station 4 is not. Pinyon Pines Station 30 and several schools are also outside the modeled viewshed. Now, let's use the Viewshed 2 tool to raise antennae and see if visibility improves. Turn off VS01\_01\_00 and save the map.

Let's select all CREWS points that lie inside the enhanced visibility area. In the Standard menu, choose Selection > Select by Location. Accept the default Select features from method and specify CREWS Points as the Target layer. Set Viewshed 21, 5 as the source layer and specify the Intersect the source layer feature method. Do not check the box next to Apply a search distance. Click OK to select visible CREWS points. Open the CREWS Points attribute table and inspect selected records. With a 21-meter antenna on Toro Peak and 5-meter antennae on all CREWS sites, you could have 21 selected site records out of 26 total sites. Switch the selection and study the five nonvisible sites. The project is finished, so save it.

Seeing Hidden Stations

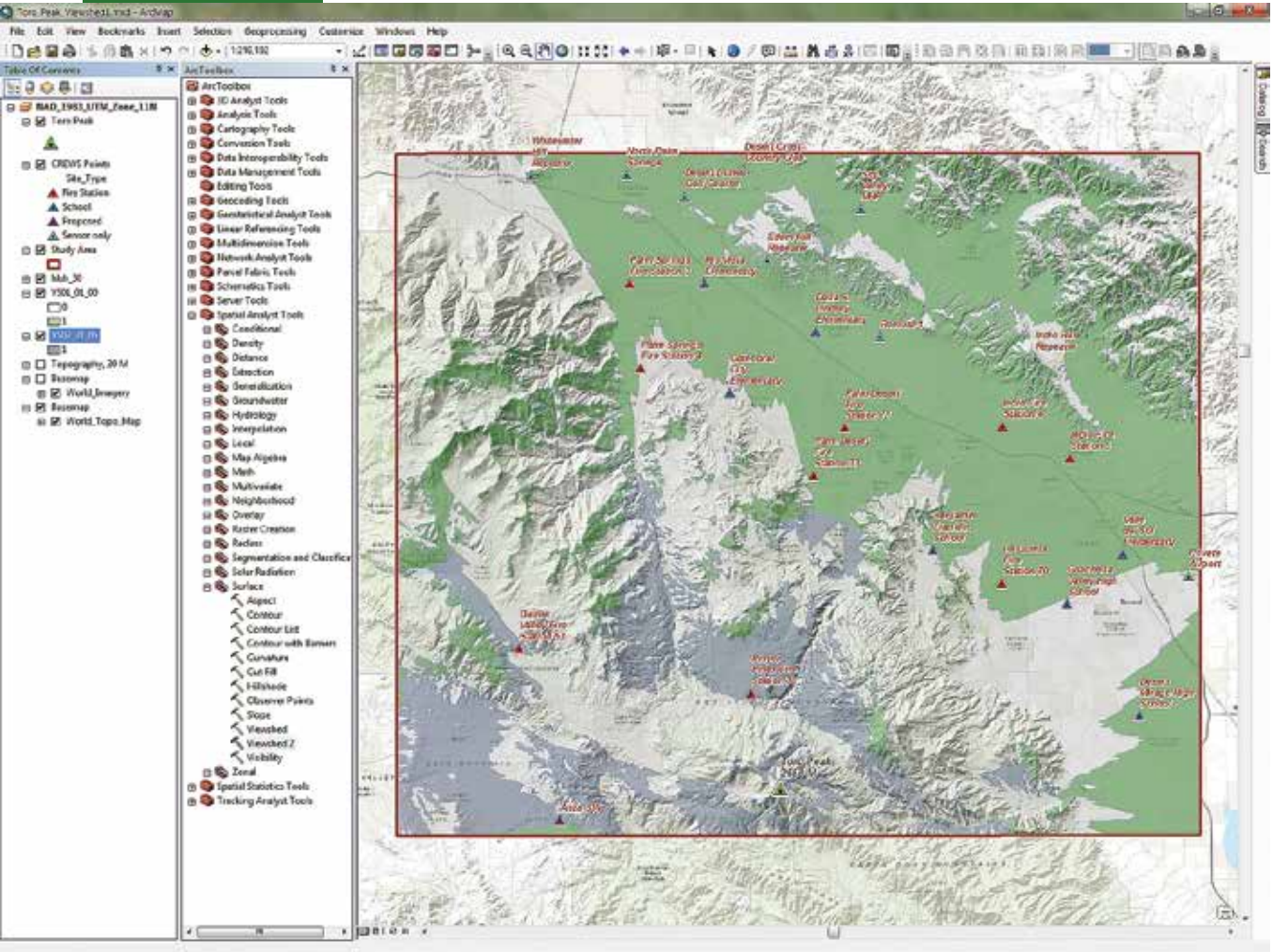
The Visibility 2 tool showed that 21 of 26 CREWS points with 5-meter antennae are visible from a 21-meter high antenna on Toro Peak. Review all nonvisible points to consider other methods to efficiently “see” them. Notice the three repeater sites in the north. Perhaps they can see the five hidden sites. It might be possible to raise the Toro Peak antenna to see one or more sites or install higher antennae on certain CREWS locations. If you experiment with antenna height, you will likely find that topography immediately south of the Coachella Valley floor is too rugged to overcome with higher antennae. Repeaters or land links could be the answer, although the time interval might be too great to provide the desired warning window.

Get ready for earthquakes by developing and practicing a readiness plan. For more earthquake safety information, visit [www.ready.gov/earthquakes](http://www.ready.gov/earthquakes).

Acknowledgments

This exercise includes elevation raster data downloaded from *The National Map* portal and facility and sensor point data from the Coachella Valley Regional Earthquake Warning System. It also used ArcGIS Online basemaps provided by Esri. Special thanks to Blake G. Goetz, regional director/IHUB director for Southern California Earthquake Warning System. Special thanks also to Seismic Warning Systems, Inc., for invaluable guidance on program scope and modeling needs.

Use the Raster To Polygon tool to convert the output from the Viewshed 2 tool to a polygon representation of the viewshed perimeters.



*“I have been able to apply my new expertise to projects back home in Nigeria, and I am working on my Ph.D. in hydrology, looking at more water management issues.”*

**– Damilola Eyelade '12**

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# Manage ArcGIS Online Credits Effectively

By Brendan O'Neill, Esri Education Specialist

**Brendan O'Neill** works with many colleges and universities around the world. The challenges faced by administrators of ArcGIS Online organizational accounts at these institutions are similar to those faced by administrators elsewhere: managing many users who come and go and whose roles need to be changed while keeping costs in check. O'Neill has developed answers to common questions and provides best practices for administering ArcGIS Online organizational accounts.

**What is a credit?**

**How many credits does an Esri Story Map app use?**

And perhaps most important:

**How do I keep my users from spending all my credits?**

These are all common questions. Credits are the currency in ArcGIS Online. The storage and processing you do in ArcGIS Online takes place on servers. This storage and processing is not free, hence the need for credits, a mechanism to account for this activity.

Many of the things you do in ArcGIS Online consume few or no credits. When you create an Esri Story Map app, for example, you are only charged for storage. Access to Esri's configurable application templates is completely free. Unless you are working with very large amounts of data, the number of credits consumed by storage is quite small—less than 15 credits per year for 1 GB of file storage.

Services, such as tile caching, geocoding, and analysis, consume more credits, but even these are quite reasonable when you are working with small datasets. If you are doing heavy processing with more data, do that processing in ArcGIS for Desktop using either ArcGIS Pro or ArcMap and publish your results in ArcGIS Online. Local processing is free. You will only consume

credits for storage in the cloud. Promoting this workflow can drastically reduce credit consumption by your organization.

In addition to promoting credit reducing workflows, administrators have three main ways to control credit consumption in ArcGIS Online: creating custom roles, generating organizational statistics, and assigning credit quotas.

## 1. Create Custom Roles

With custom roles, you can control user access to credit-consuming activities in ArcGIS Online. For example, generating tile services at multiple scales over a large geographic area involves a lot of processing and generates a large amount of data to be stored in ArcGIS Online. This will consume a large number of credits up front. The storage of several GBs of data will chip away at your credits over time. Consequently, you may want to consider assigning users a custom role that disables tile generating capabilities.

## 2. Generate Statistics

Use the View Status dashboard to monitor the activity in your organization. You can filter credit consumption activity over time and export statistics so that you can work with it in a spreadsheet. This is useful for identifying any spikes in activity so that you can take action, either by reaching out to users or even disabling accounts.

## 3. Assign Credit Quotas

A new administrative tool for assigning credit quotas is extremely helpful in keeping your organization's credit usage in check. You can assign credit limits that apply specifically to tile generation, GeoEnrichment, geocoding, and analysis services. Credit quotas do not apply to item storage, and limits can be adjusted at

any time. Credit quotas can be assigned to groups, roles, or individual users. When a user reaches the predetermined credit limit, that user will still be able to access content but won't be able to use the services previously listed until an administrator assigns a new quota of credits.

## Understanding Credit Budgeting

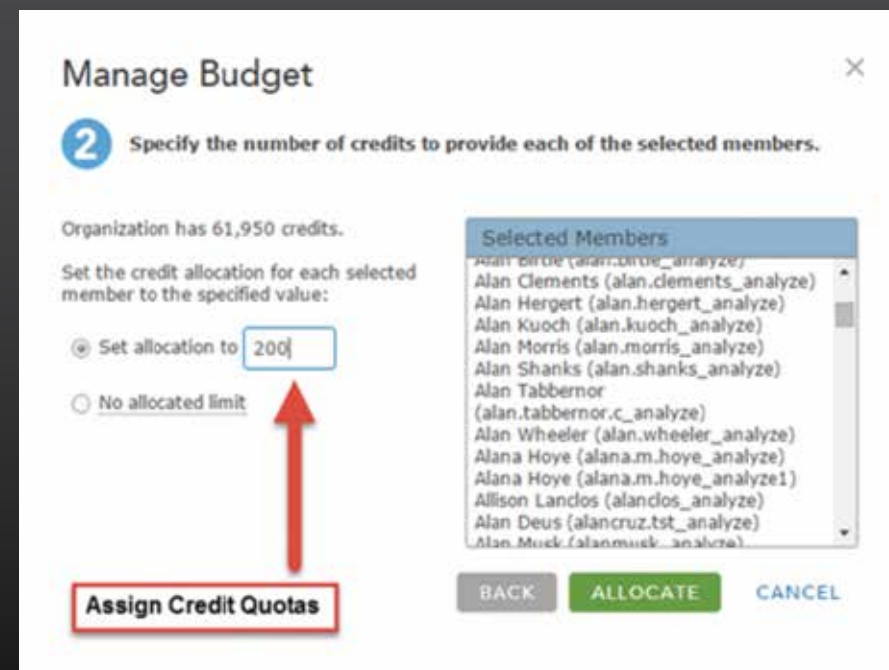
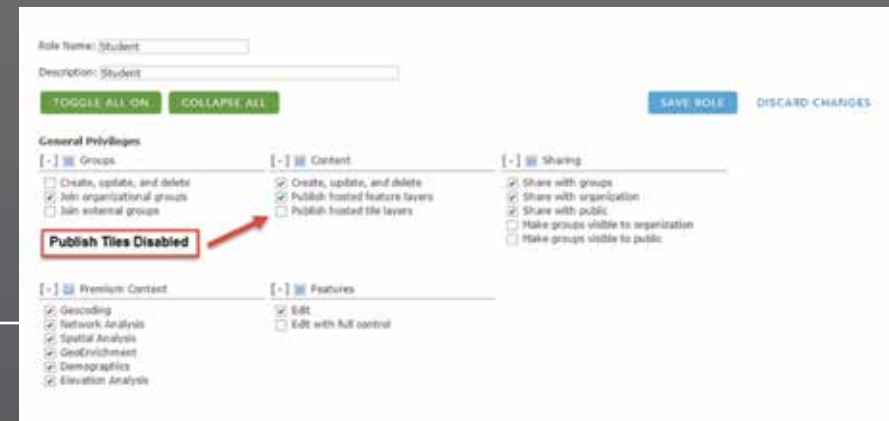
The ability to assign credits was the most requested enhancement to ArcGIS Online. The ability to restrict the number of credits an individual or group of users can consume lets you extend access to more ArcGIS Online functionality without the risk of a user singlehandedly spending all your organization's credits. The ability to allocate credit quotas to users is a major breakthrough for any ArcGIS Online administrator, regardless of the type of organization. The following FAQs explain how credit budgeting works.

## How can users spend their credits?

Credits allocated to users are *only* spent using tile generation, GeoEnrichment, geocoding, and analysis services. Credits spent publishing features or storing items are not subtracted from individual credit limits. Those credits are subtracted from your organization's total instead. Use the View Status dashboard to keep an eye out for users who have particularly large and costly items.

## What happens when a user exceeds the credits allocated?

An email will be sent to that user and the administrator notifying them that no more credits are available for that user. The user can access content but won't be able to use tile generation, GeoEnrichment,



Custom roles let you control user access to credit-consuming activities in ArcGIS Online.

The View Status dashboard lets you monitor credit usage in your organization.

You can control credit use with credit quotes, which assign a specific credit limit to a role and notify you when that limit has been reached.

geocoding, or analysis services until the administrator allocates more credits.

## How can I assign more credits to a user who has exceeded his allotment?

Allocate more credits to the user using the workflow shown in the online video *ArcGIS Online Budgeting and Allocation* at [www.youtube.com/watch?feature=player\\_embedded&v=8ErbbKpY-f8](http://www.youtube.com/watch?feature=player_embedded&v=8ErbbKpY-f8). Instead of searching for the user by group, you can search by name and assign more credits to a specific user who has exceeded the set limit.

## How many credits can I allocate to my users?

When managing your credit budget, you can choose to give them access to the organization's total allotment of remaining credits, or you can set a limit for each user of any value up to that figure. Allocations may be modified at any time.

**Note:** The total of individual credit budgets may exceed your organization's total number of available credits. For example, if I have an organization with five users and 1,000 credits, I can set individual budgets of 250 credits, which would total 1,250 credits. This is possible because individual and organization credit limits are managed independently. The budget prevents any one user from spending more than 250 credits, but ArcGIS Online treats all organizational credits as a pool. If the organization still has credits available and a user has not reached the assigned credit limit, more credits are available to the user.

Using these tools and best practices will help you understand and manage credit use so that you can concentrate on what counts—empowering your users to solve spatial problems with amazing maps and applications.

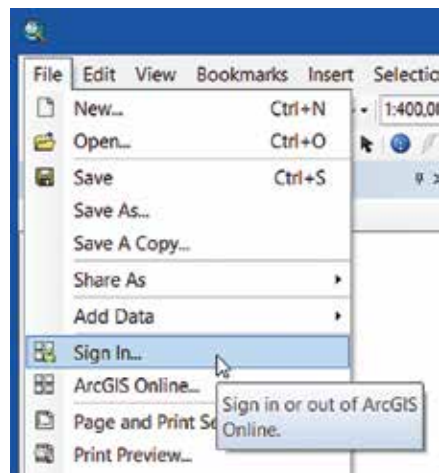
# Use Tile Packages to Save Credits

By Bern Szukalski, Chief Technology Advocate

You can publish your maps and data as hosted web layers on ArcGIS Online. These hosted services come in two types: feature layers and tile layers. Tile layers support fast visualization of large datasets using a collection of pre-drawn map images or tiles.

You can use ArcGIS for Desktop (either ArcMap or ArcGIS Pro) to build tiles for a map document and store them in an easily transferable tile package (.tpk file). You can share a tile package on ArcGIS Online and publish it as a hosted tile layer. This workflow allows you to build tiles using your own computing power rather than your ArcGIS Online credits. It is a very economical way to create hosted tile layers for your mapping needs. To use this method and publish a hosted layer, you will need publishing privileges in your ArcGIS organizational account.

You will need publishing privileges in your ArcGIS organizational account.



## Create Tile Packages Using ArcMap

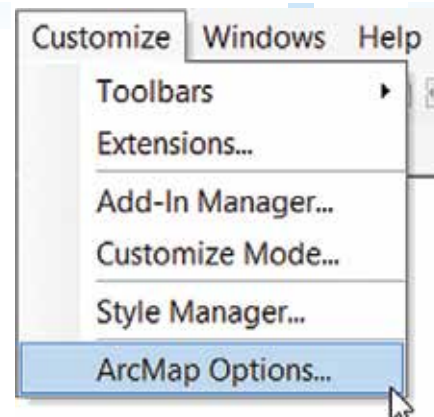
Open ArcMap and choose File > Sign In to your account if you have not done so already.

Author the map as you want it displayed in the hosted layer.

Choose File > Share As > Tile Package. In the Tile Package dialog, specify the desired options for where the package will be saved, its tiling scheme and format, its level of detail, and the item description.

You can choose to upload the tile package directly to your ArcGIS Online account or save the tile package locally and upload it later. You can also choose the tiling scheme and format. If you are unsure, accept the defaults. Set the highest level of detail desired for tile creation. This setting determines the scale at which tiles will be displayed and will change the size of the tile package. The higher the level of detail, the more tiles will be created, and the larger the package will be. The item description includes the required information for creating the tile package and will display information that has been added to the Map Document Properties.

Create the tile package. Click Analyze to check for any errors or warnings, and make any changes needed. Click Share to create the tile package.

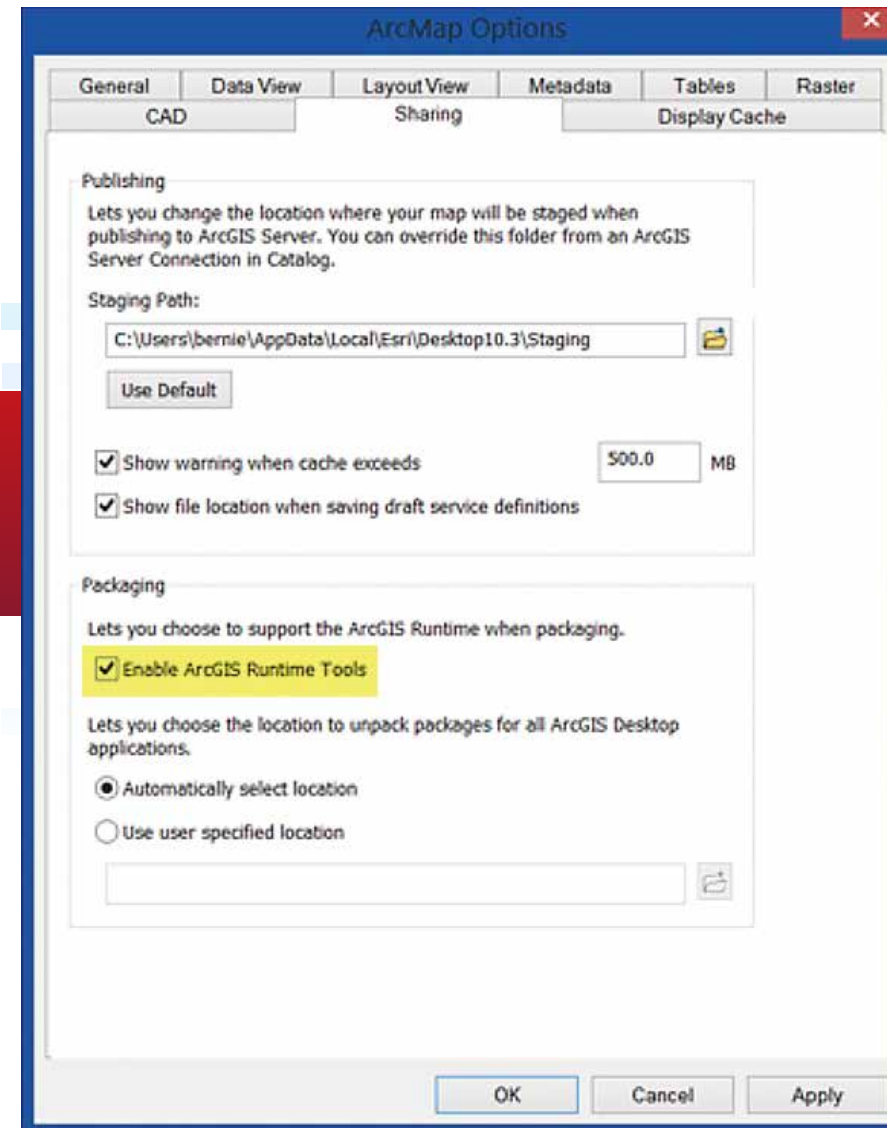


Enable Share as Tile Package, available from ArcMap Options on the Customize menu.

**Note:** Tile packaging in ArcMap occurs in-process, meaning that ArcMap will be busy until the tile packaging is complete. Tile package creation can take a few minutes or many hours (even overnight or longer), depending on the extent of the data and level of detail specified.

## Create Tile Packages Using ArcGIS Pro

Open ArcGIS Pro. Click Sign In (located in the upper right-hand corner) to access your ArcGIS Online organizational account if you have not done so already.



On the Sharing tab, check the box to Enable ArcGIS Runtime Tools.

## Author the Map as You Would Like It Displayed in the Hosted Layer

To open the Create Map Tile Package tool, click Tools on the Analysis tab. If the tool is not already in your recents or favorites, locate it using Search in the Geoprocessing pane. You can add the tool to your Analysis Gallery for easy access.

Create the tile package by completing the information and options in the Create Map Tile Package tool pane, then click Run. The tool runs in a separate process, so you can continue to work in ArcGIS Pro. Check the notification area in the tool pane for successful completion.

## Add Tile Package Items

Once you've created the tile package, there are three methods you can use to add it to your ArcGIS account.

## Upload Tile Packages Using ArcGIS Online

1. Sign in to your ArcGIS Online account.
2. Go to My Content. Click Add Item and choose From my computer.
3. Browse for the tile package, enter a title and tags, and click Add Item. Note that you can choose to either publish the tile package immediately upon upload or upload the item and publish it later. When attempting to upload tile

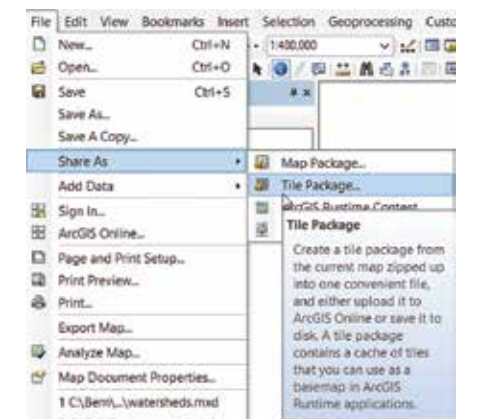
packages that exceed 1 GB, you will see a message warning, "File too large." In this case, upload the package using ArcGIS for Desktop as described in the following section.

## Upload Tile Packages Using ArcMap

Ensure that you have signed in to your ArcGIS account.

Open the Share Package geoprocessing tool. Click Geoprocessing, then choose Search For Tools. Type "share package" and locate the Share Package (Data Management) tool.

In ArcMap, specify the desired options in the Tile Package dialog.



Upload the tile package by browsing to and choosing the tile package from its location on disk, completing the required and optional information, and clicking OK. The tile package item will be uploaded to My Content.

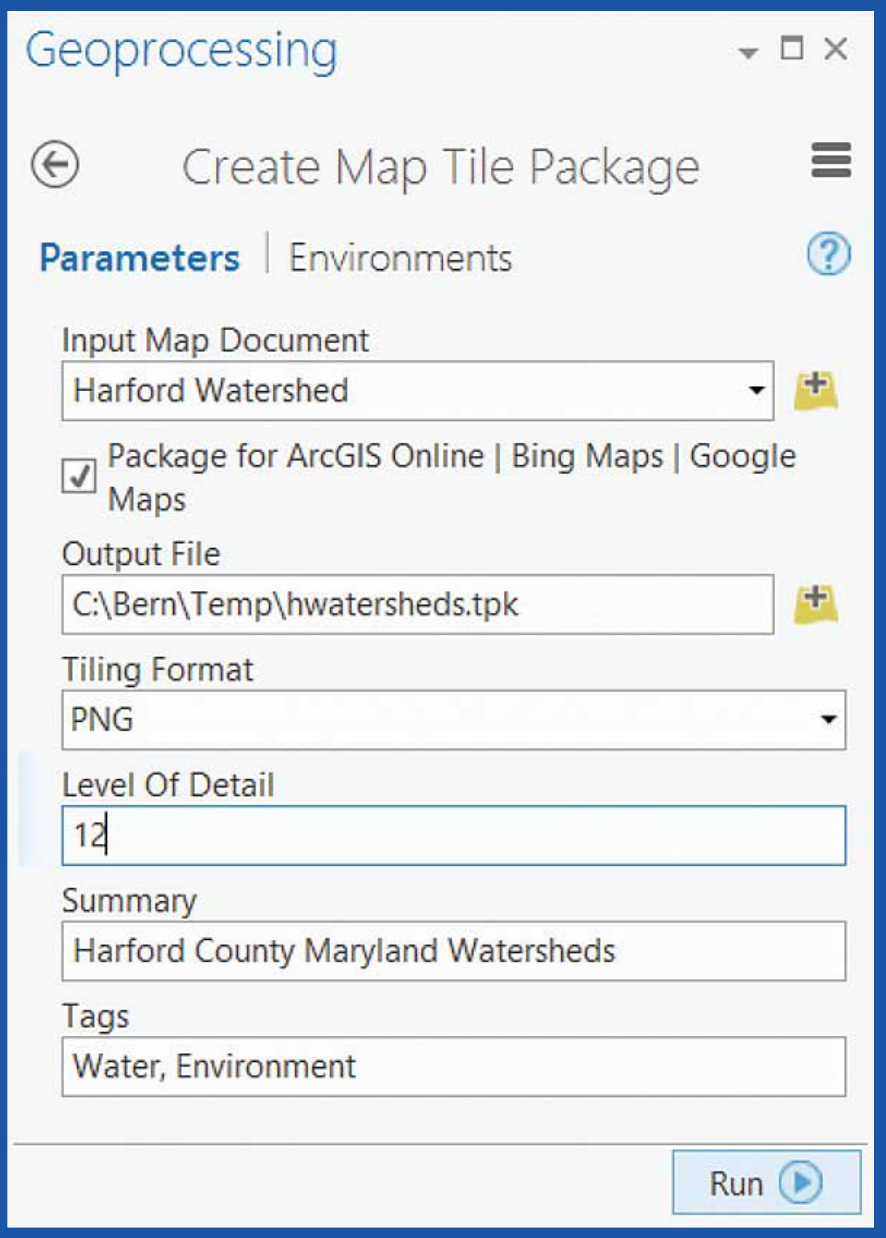
Upload Tile Packages Using ArcGIS Pro

Ensure that you are signed in to your ArcGIS Online account.

Locate the Share Package tool. On the Analysis tab, click Tools. In the

Click the Analysis tab.

Then search for the Create Map Tile Package tool



Complete the information in the Create Map Tile Package pane.

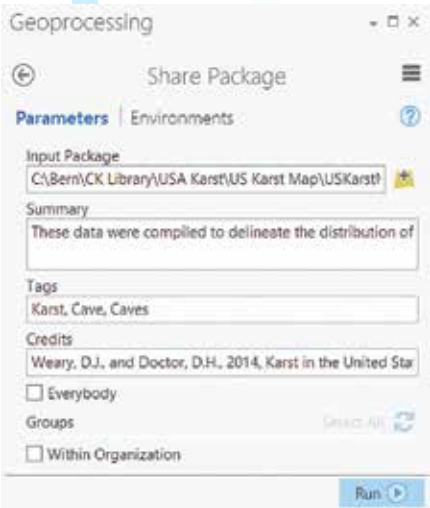
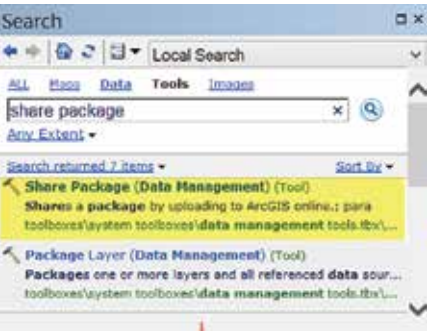
Geoprocessing pane, type “share pack- age” in the Search window to locate Share Package (Data Management).

Upload the tile package by browsing to the package location on disk, completing the required and optional information, and click- ing Run to execute the tool. The tile package item will be uploaded to My Content.

Publish Tile Package Items

If you have not previously published the tile package, open the item details and click Publish. Note that you will need

Locate the Share Package tool under Data Management in ArcMap



After uploading the tile package, it will appear in My Content.

publishing privileges to create hosted layers. Publishing Tiles will display until hosted tile layer publishing has completed.

Summary

Using the computing power available to you from ArcGIS for Desktop to create tile packages minimizes credit consumption for publishing hosted tile layers. Although credits are consumed for tile package stor- age, once a tile package is published, you can delete the tile package item to further minimize credit consumption.



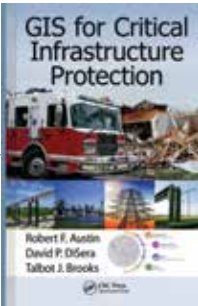
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# GIS Bookshelf



## GIS for Critical Infrastructure Protection

By Robert F. Austin, David P. DiSera, and Talbot J. Brooks

The target audience for this book is twofold: GIS professionals who need a foundation in critical infrastructure protection (CIP) and professionals working in CIP who are unfamiliar with the application of GIS to their field. This includes CIP professionals who work in government or private sectors. After introducing the theory that undpins the use of GIS for CIP, four case studies illustrate the effective application of GIS in responding to natural and man-made disasters. Theory and practice cover not only the types of infrastructure that immediately come to mind, such as bridges and transportation networks, but also cyber-based, banking and financial, and other types of systems that play a vital role in the economic and physical well-being of populations. The authors are all past presidents of the Geospatial Information and Technology Association (GITA) and have both academic credentials and real-world experience. CRC Press, 2015, 250 pp., ISBN 978-1-4665-9934-5

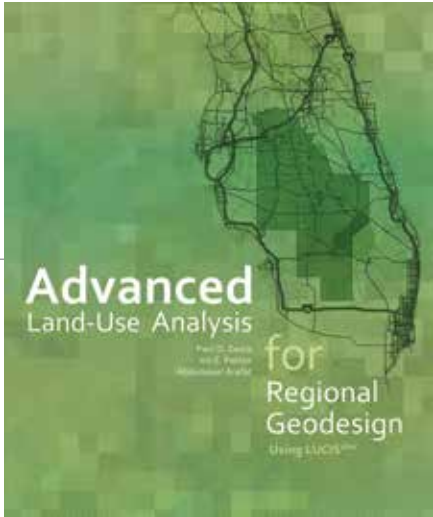


## ArcGIS Blueprints

By Eric Pimpler

GIS professionals who have some experience in developing applications for ArcGIS for Desktop can learn how to enhance those development skills. This book shows how to automate processes and improve productivity using ArcPy and other Python modules and build tools that access REST services to download data. The author is the founder and owner of GeoSpatial Training Services and has more than 20 years of experience teaching GIS and open-source technology. He has written several other books on the use of Python with ArcGIS including *Programming ArcGIS with Python Cookbook*, second edition. Packt Publishing, 2015, 356 pp., ISBN: 978-1-78528-622-3

# Applying Geodesign to an Increasingly Crowded World



Tools of technology, particularly GIS, are coming into play to prioritize land use among agriculture, conservation, and urban uses, and to resolve conflict as population pressures increase.

*Advanced Land-Use Analysis for Regional Geodesign—Using LUCISplus*, a new book published by Esri, is a guide for land-use planners, analysts and advanced GIS students who want to explore a real-world methodology for applying geodesign using Esri’s GIS tools.

Land-Use Conflict Identification Strategy (LUCIS) is a methodology for analyzing land-use suitability and resolving land-use conflicts. It places a high priority on input from citizens and incorporates community values into plans.

This process was described in a 2007 Esri Press book, *Smart Land-Use Analysis: The LUCIS Model—Land-Use Conflict*

*Identification Strategy*, by Paul D. Zwick and Margaret H. Carr of the University of Florida. This more recent book is coauthored by Zwick and two students of Zwick and Carr, Iris E. Patten and Abdalnaser Arafat.

The LUCISplus in the title refers to the inclusion of new automation tools and methodologies for addressing complex planning scenarios that include factors such as affordable housing and transportation planning. LUCISplus analysis tools are powered by Esri’s geoprocessing framework and make extensive use of ModelBuilder.

*Advanced Land-Use Analysis for Regional Geodesign: Using LUCISplus* teaches planning and visioning concepts and walks readers through a methodology for identifying potential land-use conflicts and making smarter land-use decisions using specialized methods and tools. Chapters describe how this methodology is applied not only to traditional planning in urban areas but also in evaluating conservation and agricultural preservation needs; understanding the special requirements of planning on tribal lands; and modeling natural disasters especially as they relate to climate change and sea level rise.

Zwick is the former director of the GeoPlan Center and a professor of urban and regional planning at the University of Florida. Patten is an assistant professor in the School of Geography and Development at the University of Arizona. Arafat is an assistant scientist for the Shimberg Center for Housing Studies at the University of Florida. Esri Press, 2015, 380 pp., ISBN: 9781589483897 (print) ISBN: 9781589484337 (e-book).

## Share Your Story in ArcUser

Write an article for ArcUser magazine. Tell the GIS world how your organization saved money and time or acquired new capabilities using GIS. Share your GIS management insights or your expertise in extending the GIS functionality of Esri software.

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# THE REAL MAP MAN

By Carla Wheeler, ArcWatch Editor

A few years ago, geographic knowledge paid off for Shane C. Matthews. The Esri cartographer was hiking in the rugged Mount Evans Wilderness Area in Colorado. Because he was familiar with the trail, Matthews had set out without a map or compass. However, when the trail he was following fizzled out, he didn't panic.

"I knew the whole watershed was spilling into Bear Creek, so if I followed the stream, I would eventually hit that creek and could get my bearings from there," said Matthews. And that's exactly what happened. "It worked out fine," said Matthews. "My background is in physical geography, so that is what I relied on without getting too nervous."

That incident notwithstanding, Matthews and maps typically go hand in hand. The 45-year-old Virginia native and outdoorsman earned a bachelor of science degree in geography from Appalachian State University in North Carolina. He worked at the National Geographic Society from 1999 to 2011. As a production cartographer there, he created and edited map products. Later, as a product manager, he oversaw development of the Trails Illustrated Topographic Recreation Maps and Adventure Travel map series.

Matthews joined Esri in 2011 as a cartographic specialist. He recruits organizations to provide content, including imagery, for use in the Living Atlas of the World, a vast and evolving online compilation of authoritative maps, apps, Esri Story Map apps, scenes, and layers on a wide variety of themes. This collection has approximately 4,000 basemaps; imagery; historical maps; story maps; and maps with information on demographics, lifestyles, boundaries, the landscape, traffic, transportation systems, and earth observations (e.g., precipitation, snowfall, and earthquakes).

## It's a Massive Undertaking

Matthews and others reach out to Esri partners, distributors, and government organizations worldwide and request authoritative data to add to the atlas. According to Clint Brown, director of product engineering at Esri, Matthews is helping spearhead the effort to encourage ArcGIS technology users to contribute to and use Living Atlas of the World content. "We are building the GIS of the world collectively," Brown said.

Such a huge, cooperative effort needs people like Matthews. In addition to having a great affinity for maps, Matthews is a people person. "I enjoy talking to people, and I like to look at maps all day," said Matthews. "I like talking about maps and evangelizing maps and creating maps when I can."

## Growing Up Spatially Aware

Matthews was raised with his younger brother, Ryan, in Richmond, Virginia. The city is steeped in Revolutionary War and Civil War history. During the Revolutionary War, Benedict Arnold, the famous American defector, led British troops in a successful attack on the city in 1781. Richmond was the capital of the Confederate States during the Civil War.



His parents, Tom and Joyce, weren't geography buffs but they nurtured their elder son's interest in history. When Shane and Ryan were both in grade school, Tom took them to Jamestown, Williamsburg, Appomattox, and other historical sites.

Visiting historic sites and monuments near his hometown helped Matthews better understand the geographic context of the events that had occurred there. "I was really interested in history," he said. "Being able to visit these places and see them was really awesome."

Looking back, Matthews says that the military commanders were, in a way, geographers. "They had to have a sense of the lay of the land, the topography and how to negotiate that, and the easiest way [to get] to places and the easiest way to get out," he said.

While weekend outings to historic sites helped Matthews understand where he lived relative to other places in Virginia, a road trip to see his grandparents in Columbia, South Carolina, introduced him to maps.

"Back then, the speed limit on the interstate was 55 miles per hour. It would take forever to get there—eight hours," Matthews recalled. "My dad kept an atlas in the back of the car. Maybe it was because I was wondering how long I would have to deal with this, but I would pick up the atlas and look at the signs, and then use the map to figure out where I was and how long it might be before this trip was over. I think that's when I became a lover of maps."

However, years would pass before mapping as a profession entered Matthews's consciousness.



### Dirt, Rocks, and Trees

Just an average student in high school, Matthews was unsure what he would do with his life. He drifted through several colleges and jobs waiting tables before enrolling in Appalachian State University in Boone, North Carolina. His parents had moved from Richmond to Salisbury, North Carolina, and Matthews liked to hike in the mountains around Boone.

Matthews might have never ended up in Evergreen if he hadn't attended Appalachian State University, which required students to take a physical geography course called Soils, Vegetation, and Landforms to graduate.

"We called it Dirt, Rocks, and Trees," Matthews said. "That course dealt with geology and geomorphology, weather and climate, how mountains are formed, how rivers and watersheds behave, and how the physical environment works. For some reason, I found that fascinating."

Matthews was hooked. He became a geography major and started making As instead of Cs. He even took a GIS course that introduced him to *ARC/INFO*, Esri's early command-line-based GIS software.

He still loves the mountains and enjoys living today in Evergreen, Colorado, with his wife Natalie—also a geographer—and their son. "I just think flat's boring," he said. "I like the beach. I like the desert. I like things with visual appeal. I like some topography in my life."

### Becoming "Map Man"

After a stint as a data analyst and geographer for the Western Piedmont Council of Governments, Matthews moved to Evergreen, where he took a job as a seismic data specialist for the United States Geological Survey (USGS).

The National Geographic Society hired him as a cartographer in 1999 to work on the society's recreational trail and adventure maps. During a dozen years there, he learned map production from top to bottom. He gathered the locations of rivers, trails, parking lots, and restrooms from land management agencies, assigned line styles and specifications to editing maps, and placed the information in a GIS as part of the initial production process. Later, Matthews took on a managerial role. He supported the budgeting process and provided information for press releases about the maps that were created in the Colorado office.

Matthews uses many of the skills he acquired at National Geographic in his work for Esri. Currently he focuses on acquiring authoritative imagery from all over the world. For example, he and his team are working with Imagem Geosistemas e Comércio Ltda. (Esri's distributor in Brazil) to obtain high-resolution imagery of the venues for the 2016 Summer Olympics. He's also the editor of *Esri News for the Living Atlas Community*, an email newsletter that keeps readers up to date on the content that is constantly being added to the Living Atlas of the World and how that content is being turned into useful web maps and apps.

### Promoting Geography

Matthews lives and breathes geography, which is why he finds the waning of geographic literacy among Americans alarming. Learning geography is not just about knowing where places are located on a map, said Matthews. "Understanding geography," he said, "means having a good understanding of different cultures, countries, economies, and social systems."

He recently heard about the 2015 report issued by the United States Government Accountability Office that said that almost 75 percent of eighth graders scored at levels below proficient in geography. "It's disappointing," said Matthews, who says social studies and geography were core subjects when he was in school. "It seems that's lost its importance to educators or the folks who design the curriculum. I'm not sure why."

So he's doing his part to counter the trend. Matthews said he will soon be a volunteer with the Outdoor Lab Foundation, based in Lakewood, Colorado. The nonprofit organization gives all sixth graders in Jefferson County, where he lives, the opportunity to spend one week living in a camp, learning outdoor skills such as trail building, and applying academics in a wilderness setting.

Matthews said he would like to help the kids build the trails, and then teach them how to create Esri Story Map apps of the trail system, with points of interest along the way highlighted with photographs and videos.



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### Raising a Geo-Jedi

At home, Matthews does his best to make sure his son, Miller, knows his geography. The toddler's reading list includes *Here's a Map on My Lap!* and the *National Geographic Kids Beginner's World Atlas*.

Matthews and Miller spend time putting together a world puzzle that has 24 pieces emblazoned with flora and fauna. "I usually put it together, and he likes to rip it up," Matthews said, laughing.

But Matthews believes that on some level, the information sinks in. He and his wife put a globe outside their son's bedroom. When Miller is brushing his teeth, Matthews will point out countries on the globe. "He will recognize a place that I showed him, even days later."

Before his son was born, Matthews found a special map online. A friend, who works for the website, presented Matthews with *The Miller Cylindrical Projection* map that now hangs in the boy's bedroom. That really delights his dad.

Map was one of the first words Miller learned. "The poor kid is destined for a life of geography," said Matthews, who is a kind of geo-Jedi master to his son. "The satisfying thing is when I wake him up, he points to the map and says *map*. I don't think he appreciates a map as an information product, but I think, eventually, he will get that. I have already brainwashed him. He's my young apprentice."

# THE LONG WALK

ArcGIS and Harvard's Center for Geographic Analysis help tell the story of an epic global adventure.

By A. J. Mangum

It's the middle of the night in Baku, Azerbaijan. American journalist Paul Salopek sits in his room in a cheap hotel—a former shoe factory—where he's at work on a story about his encounters with people along the contested border between South Ossetia and the former Soviet Republic of Georgia. As 3:00 a.m. approaches, Salopek reconstructs a scene in which an old woman passes him a bowl of food through the concertina wire marking the boundary separating Georgia and the breakaway region. The simple tableau adds a layer of what Salopek calls "human texture" to a piece set against a complex backdrop of long-standing and violent conflict.

Salopek is three years into the Out of

Eden Walk, an eight-year journalistic project in which he's retracing—on foot—the path of prehistoric human migration. In the process, he is writing about the people he meets and the cultures he experiences. Salopek's journey began in January 2013, in Ethiopia—widely considered by archaeologists to be modern humanity's point of origin—and has, thus far, taken him north, across the Red Sea to the Arabian Peninsula and into the Levant and the Caucasus. From Azerbaijan, Salopek will travel east, across Asia, then cross from Siberia to North America, and continue south, ultimately arriving at the southern tip of Chile, some 21,000 miles from his starting point in east Africa.

Embracing a "slow journalism" approach—with narratives built on impromptu encounters and the quiet, daily lives of his subjects—Salopek produces articles and photography for the project's website ([www.outofedenwalk.com](http://www.outofedenwalk.com)) and for *National Geographic* magazine. Geospatial data figures heavily in Salopek's storytelling. Maps serve as illustrations for many of his dispatches, while stand-alone maps offer substantive sidebar material that puts his travels and experiences in a clear geographic context, a narrative element Salopek considers vital.

"This is a journey through four dimensions," the journalist says, referring to both the project's historical emphasis and the

Pulitzer Prize-winning journalist Paul Salopek walks through Azerbaijan as part of his eight-year, round-the-world adventure retracing, step-by-step, on foot, the path of human migration. Photo by Rufat Gojayev, courtesy of Paul Salopek

*The Greatest Walk* depicts the path of prehistoric migration. Salopek will spend eight years retracing the 21,000-mile route from east Africa to the southern tip of South America. Photo courtesy of Harvard University Center for Geographic Analysis

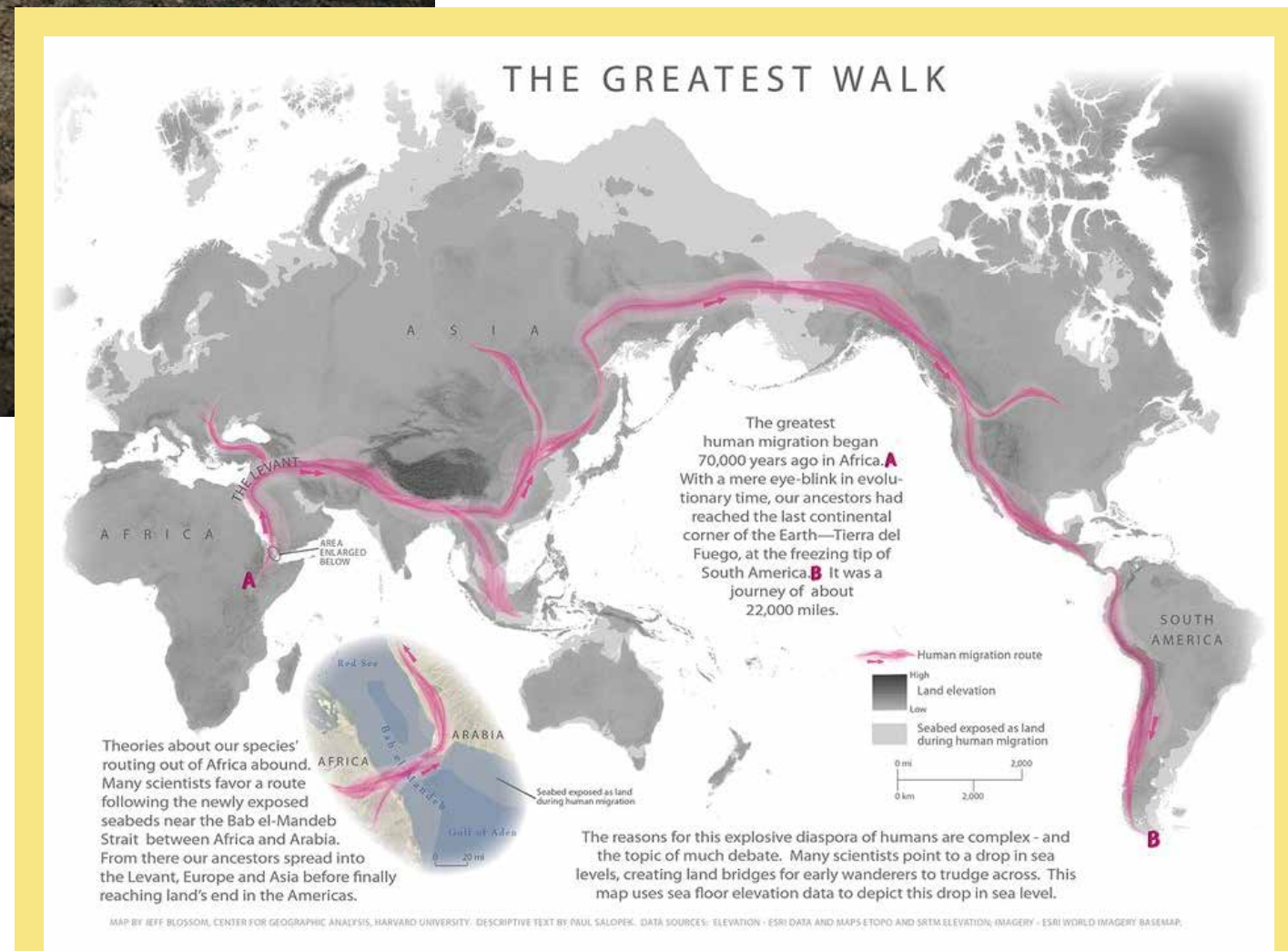
timeline of his own journey on foot. "It would be poorer if it lacked navigational aids to the storytelling."

Mapping for the Out of Eden Walk is produced using the ArcGIS platform by Harvard University's Center for Geographic Analysis (CGA), a service-oriented institution that promotes geospatial thinking and technology within the Harvard community. Jeff Blossom, a senior GIS specialist with CGA, serves as the project's chief cartographer.

"Our mission is to support research and education that uses geographic information," Blossom says. "[*The Out of Eden Walk*] is education focused, with a great deal of entertainment value. The maps

and photography are intriguing, and Paul's writing style is incredible. With his 'slow journalism' element—inviting people to take an introspective look at the world—[*the Walk*] is right on target with what CGA does: using maps to educate people."

CGA occupies a small set of ground-floor offices in Harvard's Knafel Building, a modern glass-and-terra-cotta structure a couple of blocks from the campus hub of Harvard Yard. The center, which opened in 2006, offers GIS consulting, training, and tool development for the university's students, faculty, and staff. With a team of 10 full-time GIS specialists, CGA's efforts range from the creation of maps as instructional aids to geospatial data management





The image is a composite. The top left shows a map of the Out of Eden Walk route, starting from the Mediterranean coast and heading east through the Middle East and Central Asia. The map is color-coded by region. The top right features a quote from Jeff Blossom: "Anyone with a computer and Internet access can make a map and tell a story." Below the quote is his name and affiliation: Jeff Blossom, Harvard University Center for Geographic Analysis. The bottom half of the image is a photograph of a man in a blue shirt and brown vest, wearing sunglasses, standing behind a stand filled with pomegranates. He is holding a pomegranate in his right hand. The background is slightly blurred, showing more pomegranates and a colorful striped umbrella.

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Other ideas come spontaneously, a reality that Salopek embraces, given the ways in which geopolitical realities complicate a global journey.

"Borders and politics are the biggest obstacles to walking [around] the world," Salopek says, "not predators or glaciers or droughts as was the case with our ancestors who first left Africa. I've been blown way north into central Asia because of visa delays. So be it. It's part of the journey."

Blossom uses ArcGIS for Desktop, ArcGIS Online, and Esri Story Map apps to build thematic maps for the Out of Eden Walk. Among the most prominent maps he's created for the project is its stagesetting graphic, *The Greatest Walk*, which illustrates the path of prehistoric human migration, set against an image of the ground surface that would've been exposed 70,000 to 100,000 years ago, an effect Blossom achieved by using Esri's bathymetry and topography layer to expose mapping of the earth's terrain between sea level and 100 meters below sea level. Subsequent storytelling maps detail specific chapters of regional history on the Out of Eden route.

"Paul wanted a map that told the story of how civilizations have been pushing each other back and forth through [the Levant] since Neanderthals and *Homo sapiens* first met," Blossom says. The result, a multimedia effort called *Turbulent Origins* was created using ArcMap among other programs. It illustrates "how civilizations have struggled for territory, from Mesopotamian wars to current conflicts."

Other thematic maps place Salopek's journey against the backdrop of a region's history. Blossom used ArcGIS Online to create an interactive map of Saudi Arabia, contrasting Salopek's path through the country with historic Muslim pilgrim routes and the campaigns of British

The Donors' Map recognizes supporters to the Out of Eden Walk's Kickstarter campaign. Each supporter sponsors a mile of Salopek's route. Map courtesy of Harvard University Center for Geographic Analysis

Pomegranates for sale in Zaqatala, Azerbaijan. Photo by Paul Salopek

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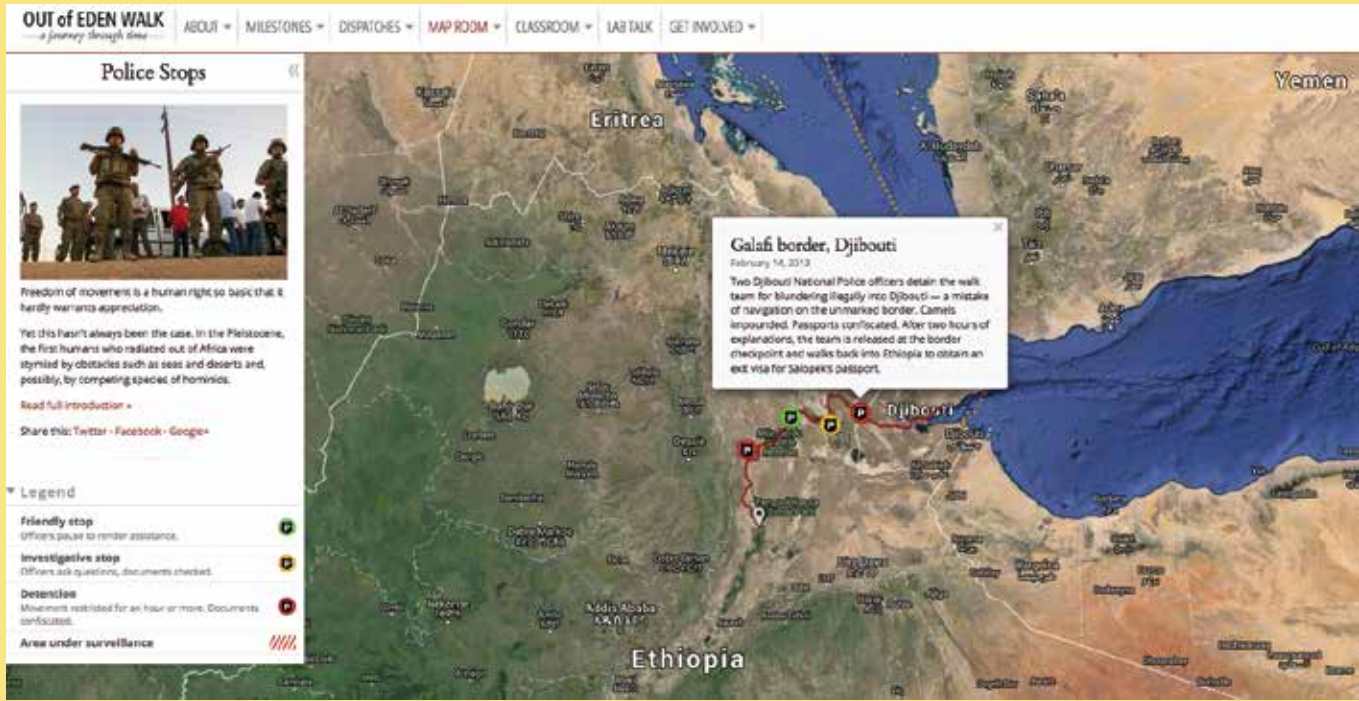
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archaeologist and military officer T. E. Lawrence, the famed Lawrence of Arabia.

The project's financial supporters are recognized in another of Blossom's efforts. The Out of Eden Walk has grant funding from the John S. and James L. Knight Foundation, which supports journalism and media innovations, but has also earned grassroots backing through a Kickstarter campaign. Each donor can sponsor a mile of Salopek's route. Using ArcGIS Online, Blossom created a donors' map highlighting sponsored sections of the walk. Segments are labeled with donors' names.

Blossom's other assignments from Salopek have included maps examining the timeline of prehistoric human migration, the challenging topography of Ethiopia's Afar region, and the highlights of walking through such cities as Jerusalem; Tbilisi, Georgia; and Jeddah, Saudi Arabia.

From the perspective of GIS professionals, Blossom says, the Out of Eden Walk has offered a powerful illustration of the discipline's utility as a journalistic tool. The ability to link a story, an interview, or a particular moment to a specific point on the globe, he says, dramatically empowers storytellers.

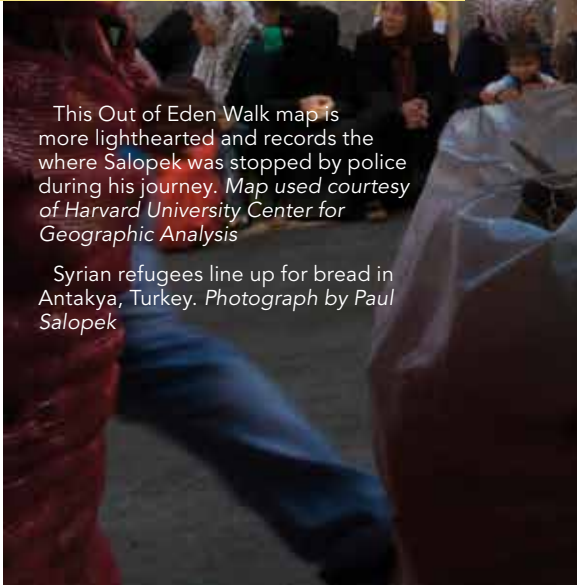
"The biggest impact I see is the promotion of the map as a way to tell stories," Blossom says. "And that's not just for GIS professionals. Anyone with a computer and Internet access can make a map and tell a story."

Blossom's work with the Out of Eden Walk has inspired him to create tutorials on such topics as geotagging smartphone photos and using a smartphone's GPS functionality to create data for use in story maps. These efforts are aimed at both professional journalists and amateur storytellers.

Such cartographic elements, Salopek asserts, provide readers with the benefit of greater context—geographic, geopolitical, and historical—with the net effect of bringing an audience closer to a journalist's subjects. Whether he's writing about the cultural importance of pilgrimage route or the ways in which Somali piracy hampers scientific research in the Indian Ocean, Salopek adds that a strengthened sense of place provides a layer of storytelling that would be difficult to replicate without GIS mapmaking tools. Geospatial angles, he finds, contribute to the complexity that makes a story more compelling.

This Out of Eden Walk map is more lighthearted and records the where Salopek was stopped by police during his journey. Map used courtesy of Harvard University Center for Geographic Analysis

Syrian refugees line up for bread in Antakya, Turkey. Photograph by Paul Salopek



"[This] is an experiment to increase mindshare online," Salopek says, "not via the usual levers—clickbait, jellybean journalism—but by trying to hook an audience into longer-form, more immersive storytelling. Things get more complex. And that's the way it should be."

### About the Author

A. J. Mangum is a writer and editor based in Colorado.



## Harvard's GIS Hub: From Nowhere to Everywhere

Prior to the 2006 launch of Harvard University's Center for Geographic Analysis (CGA), on-campus GIS support was nearly nonexistent, said Wendy Guan, the center's executive director.

The school has no geography departments, so when research or teaching strategies called for the creation or analysis of geospatial data, GIS tools and methodologies were mostly out of reach.

In an effort to remedy this situation, Harvard's Peter Bol, a professor of East Asian languages and civilization and now a university vice provost, led two years of brainstorming sessions with senior faculty. The resultant consensus: Harvard needed an on-campus GIS institution. CGA was born.

"Our center approached its mission from a low-key service angle," Guan said. "We didn't open our doors and claim we were leading GIS science or doing cutting-edge research. We started with a professional staff of just three, all focused on providing service."

CGA's first project was modest but vital: the creation of a help desk that would address clients' questions about finding geospatial data, conducting field surveys, structuring analyses protocols, designing maps, and otherwise incorporating GIS into academic work.

"In the beginning, we saw a flood of social scientists and humanities

professors coming to us for help with mapping and analysis," Guan said. "We joked that other departments needed us but just didn't know it yet."

Initial client interest, particularly from Harvard's schools of design, but also from the history, anthropology, sociology, and public health departments, soon led the center to broaden its services beyond that simple help desk. Now staffed by 10 full-time GIS specialists and broadly employing the ArcGIS platform, CGA provides project consultation, offers customized training for clients, and has created a number of on-campus GIS training courses on topics such as mapmaking, the use of ArcGIS Online, and—for graduate students—the application of geospatial perspectives in critical thinking. The center's on-campus client base has also expanded, reaching beyond audiences in the humanities and social sciences.

"A few years in, the business school embraced us," Guan said, "and we're now developing strong connections with the engineering school." CGA is building its capacity for raster-based analysis and exploring 3D functions in ArcGIS Pro.

While CGA serves the Harvard community, its products and tools are generally made available online at [www.gis.harvard.edu](http://www.gis.harvard.edu) and include seminars, workshops, maps, and downloadable project data.

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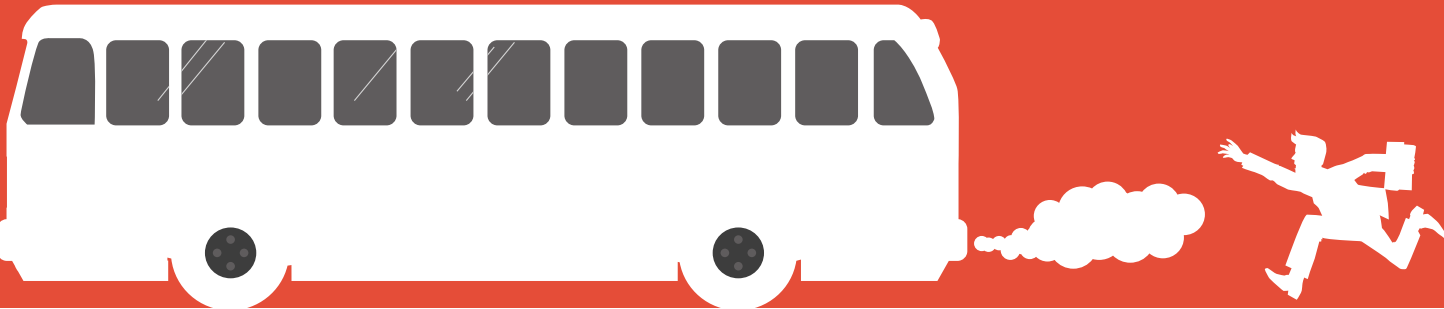
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