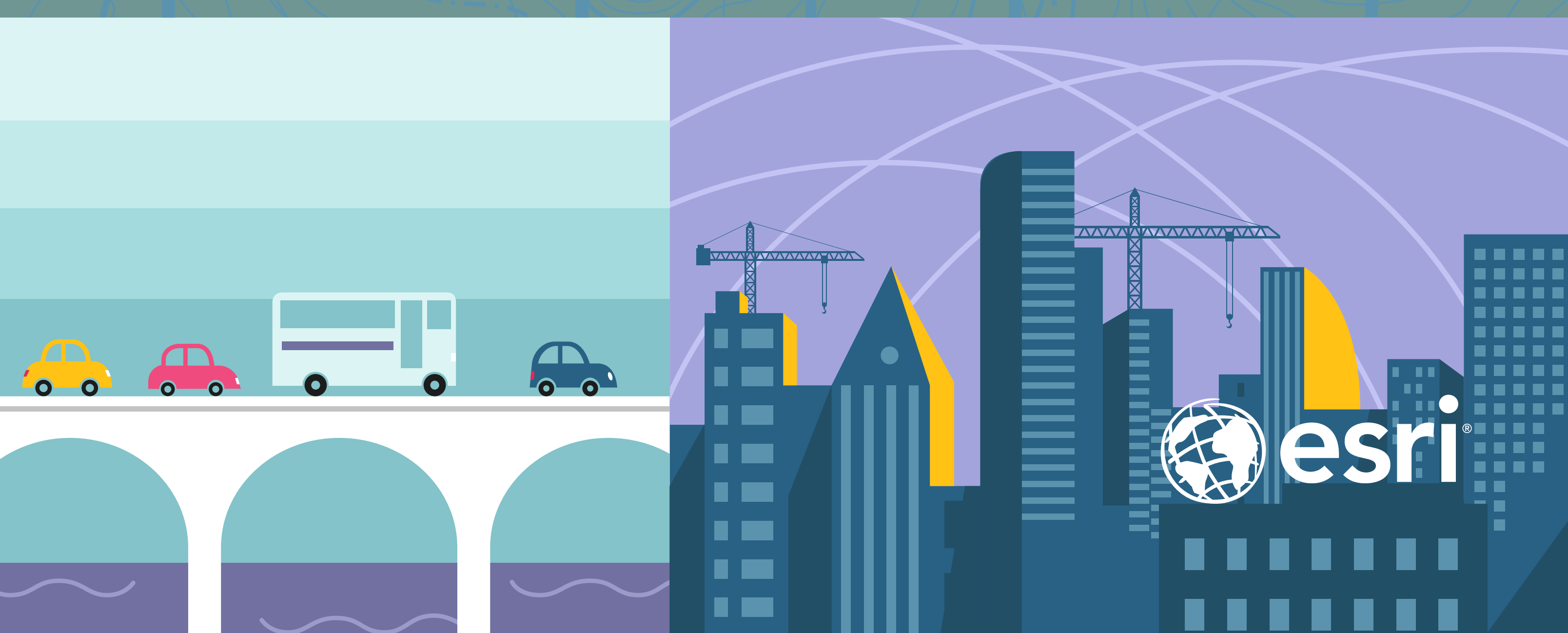
Winter 2015

ArcUser

The Magazine for Esri Software Users



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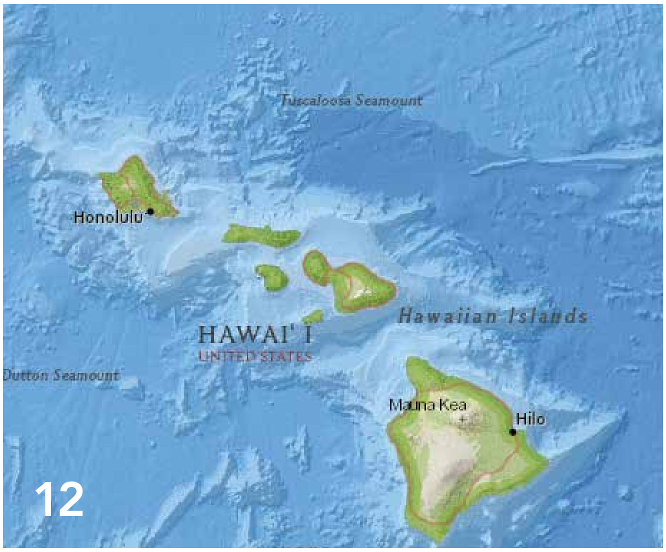

Focus

Feature

Special Section

A GIS of the World

Dec. 9, 2014 marked a milestone in our understanding of the world. On that day, the United States Geological Survey and Esri announced the release of the Global Ecological Land Unit (Global ELU) map. This amazing map, and the data layers that support it, are available from ArcGIS Online. They provide a common framework for understanding and communicating information about the earth. It can change the way we think about our world and (hopefully) the way we act.

The Global ELU map divides the earth's land surface into a grid of 250-by-250 meter squares, resulted in 3.5 billion cells. Four data layers—landform, climate, rock type, and landcover—were synthesized and classified into distinctive and meaningful georeferenced units. The medium scale of this grid fills the gap in our perspective that existed between fine-grained and macro views of the planet. Using ELU, scientists, planners, conservationists, and the public can access environmental information in a common framework that uses a common language and spatial unit.

The data layers that support the Global ELU map were created using a objective, repeatable methodology that incorporates big data methods. The product of a public/private partnership, the map also demonstrates the value of open data. Its foundation data was publicly available data that had already been shared by scientists and governments around the world. The data used was vetted by the ELU team as the best available at the time.

In the Global ELU map, we can see the coalescence of major trends in GIS over the past decade to fully realize one of the initial premises of GIS: collect once and use many times. In the 1980s, GIS focused on digitizing information and placing that data in centralized databases where it could be accessed and maintained.

GIS has changed radically since then. No longer database-centric—it has moved to the web where connected services in a federated, distributed environment bring data from different sources together, perform analysis dynamically, and make geoinformation available from any device at any time. Web GIS, an interconnected platform like the Internet itself, is manifested as ArcGIS Online.

Web GIS—with its maps, apps, and services—is creating a community of content that is accessible not only by GIS specialists and scientists but by knowledge workers of all types. This means that the conversation concerning the challenges facing the planet has widened from a technology discussion to a broader social interaction as more people can participate in it. GIS is becoming the framework for creating understanding that could just turn our current challenges into opportunities.

Monica Pratt

Monica Pratt
ArcUser Editor

editor's page

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Editorial Inquiries

Monica Pratt, *ArcUser* Editor
380 New York Street
Redlands, CA 92373-8100 USA
arcuser_editor@esri.com

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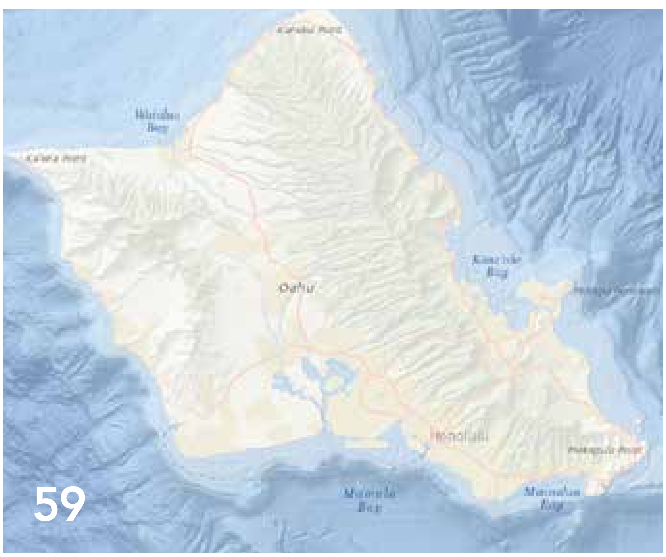


Integrating ArcGIS and SciPy

By Kevin Butler, Product Engineer, Esri Geoprocessing and Analysis Team

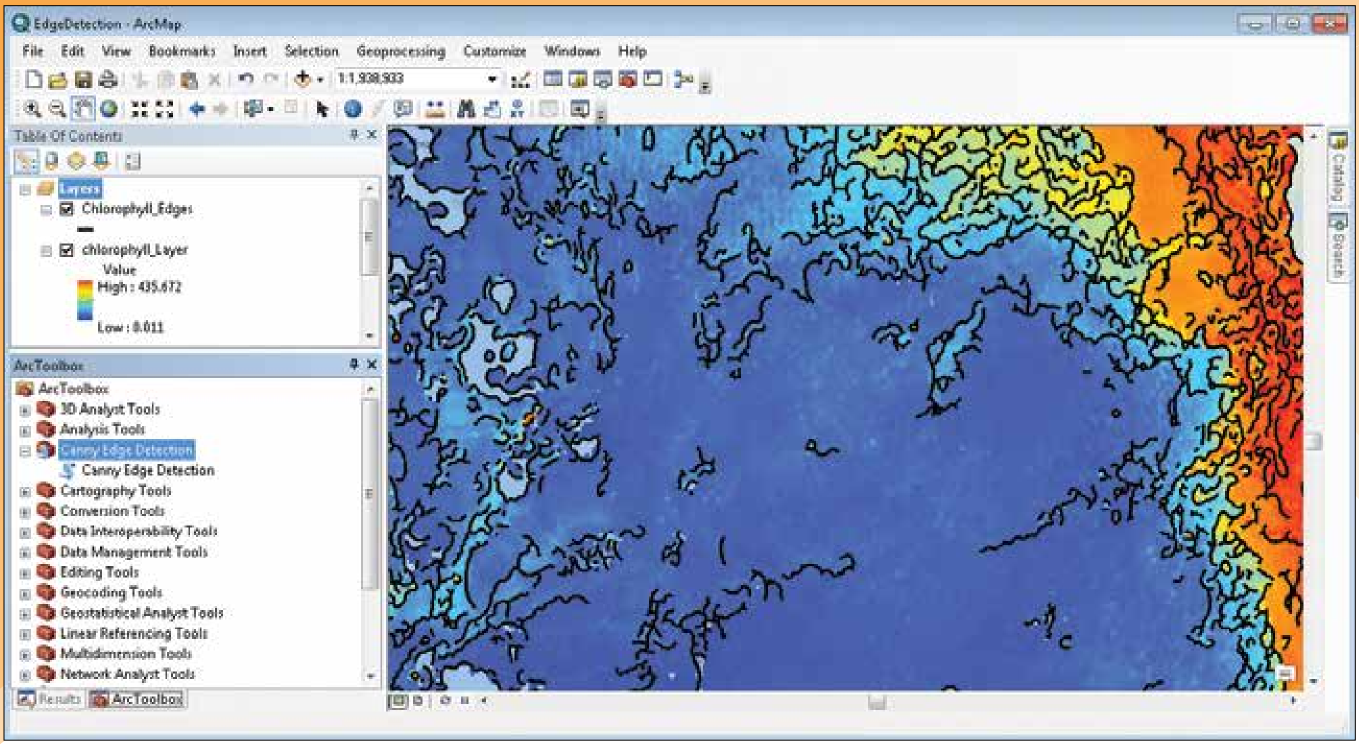
At the Esri Ocean GIS Forum in November 2014, Esri announced the integration of ArcGIS with SciPy, a software library that helps scientists, engineers, and GIS analysts perform custom scientific and technical computing.

SciPy is an open-source library built using Python, the easy-to-learn, highly scalable, stable scripting language of choice for ArcGIS. Python is both a programming language and a collection of modules (small sections of code that perform some useful operations). For example, a Python module called math performs trigonometric functions and angular conversions. Python ships with a predefined set of modules that meet most general scripting needs. SciPy extends the basic functionality of Python by adding modules that perform functions useful to the scientific and engineering communities.

SciPy is not just one Python module but a collection of modules and is sometimes referred to as the SciPy Stack, which is composed of

- NumPy for numerical computation using arrays
- SciPy, a collection of numerical algorithms
- Matplotlib for 2D and 3D plotting
- Pandas for high-performance data structures
- SymPy for symbolic mathematics and computer algebra
- IPython, an interactive interface for quickly testing scripts
- Nose for testing Python code

NumPy and Matplotlib have shipped with the ArcGIS platform for the last several releases. Adding the remaining core packages fully integrates the SciPy Stack with the ArcGIS platform to make scientific and technical computing easier for users.



↑ Chlorophyll edges detected using filters provided by the SciPy multidimensional image processing module

While the SciPy Stack is open-source software and can be freely downloaded, it can sometimes be difficult to integrate with ArcGIS. The strength of SciPy lies in its integration of many software modules. Installing these modules can be time-consuming and error prone. For example, Pandas and Matplotlib may depend on a particular version of NumPy. If the correct version of NumPy is not loaded on your computer, Pandas and Matplotlib may not function as expected. Getting the correct versions of all the components of the SciPy Stack can be challenging. With SciPy integrated into the ArcGIS platform, all these interdependencies are taken care of for you.

Integrating SciPy with ArcGIS makes developing scientific and technical geoprocessing tools and scripts easier and more efficient. You won't have to start from scratch each time you begin solving a scientific or technical problem. The SciPy Stack represents tens of thousands of lines of useful code that have already been thoroughly tested and documented. The work of hundreds of other programmers can be leveraged simply by reusing code from a SciPy module.

There is another important reason that SciPy is being integrated with ArcGIS . This will ensure that any custom scientific or technical geoprocessing tools you create are shareable. One of the fundamental design goals of Esri's geoprocessing framework is the ability to distribute your tools among the ArcGIS community of users. If you develop a custom geoprocessing tool that depends on SciPy, you can share that tool as a geoprocessing package or a geoprocessing service and not have to worry whether the person you're sharing with has the correct version of SciPy loaded.

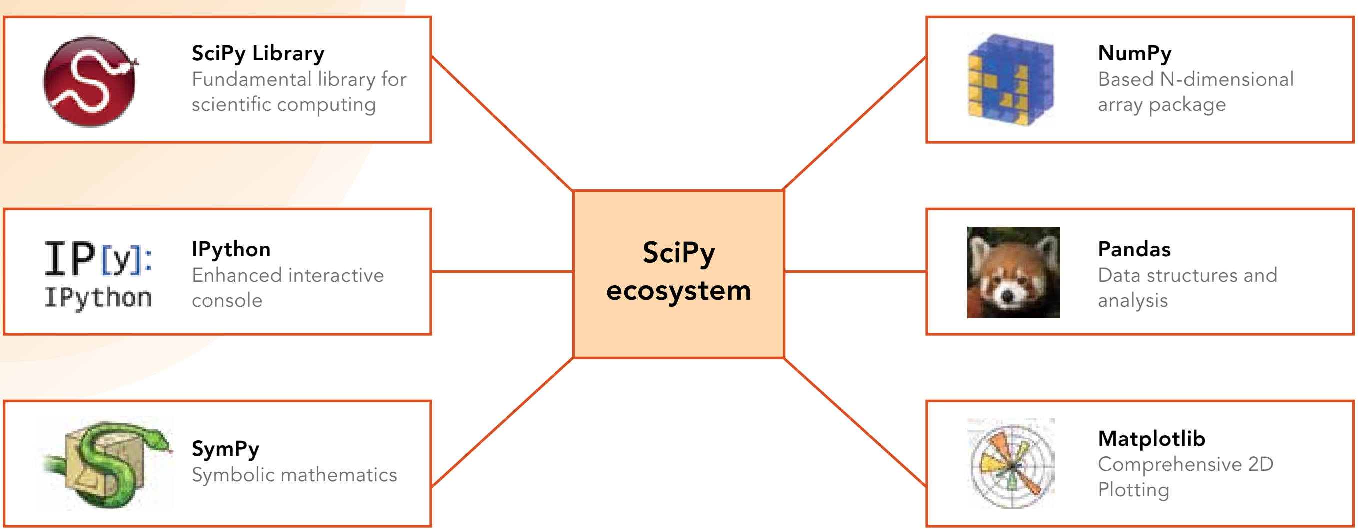
The possibilities for integrating SciPy with ArcGIS are really only limited by the imagination of the GIS community. Python, and by extension SciPy, is embedded in the ArcGIS platform to make automating repetitive geoprocessing tasks and extending the geoprocessing framework easier. For the scientific and engineering communities, extending the geoprocessing framework will be the more important part.

The SciPy Stack has so many rich functions that it is hard to imagine all the creative spatial problems that GIS users with scientific or engineering domain expertise will be able to tackle—but there are a few that come to mind. An atmospheric scientist may use the image filtering modules to delineate zones of horizontal transport of water vapor. A transportation geographer may use the Markov chain modules to simulate traffic flow. A geoscientist may use the symbolic mathematics routines to trace faults and model crustal movement. An ocean scientist may use the calculus module to calculate ocean dynamics. A fisheries scientist or resource manager may use the linear algebra modules to set a harvest quota for a fish stock.

SciPy will be integrated with ArcGIS through a staged release. It will be available for ArcGIS Pro with the 10.3 release as an optional install. (ArcGIS Pro is the premier application for visualizing, editing, and performing analysis that comes with ArcGIS 10.3 for Desktop.) At the 10.3.1 release, SciPy will be automatically installed with ArcGIS for Desktop.

SciPy is being integrated with ArcGIS Pro first because ArcGIS Pro has a 64-bit architecture and leverages threading to keep the user interface responsive and utilize additional CPU cores on the local machine, which is a very important feature when running computationally intensive scientific algorithms.

Future plans for SciPy and ArcGIS will depend on the scientific and engineering practitioners in the GIS community. SciPy is open-source software, so it grows and improves as users contribute new and/or improved code or modules. Newer versions of the SciPy Stack will be integrated and supported in future releases of ArcGIS and documented in the familiar "What Is New in ArcGIS" document that details each release.



↑ The SciPy Stack

Your to Accessing ArcGIS Wherever You Are

Named user credentials give you a unique, secure identity on the ArcGIS platform. Basically, a named user is a person licensed to use ArcGIS software. As a named user, you access the platform using permissions given by your administrator. You can join groups and access resources that you own or that have been shared with you.

What Does Identity Mean for You?

Your named user creditial is your identity on the ArcGIS platform. It lets you own something and share it with others. You can save items under your name and access them later. Keep items private until you're ready to share them with another person, another group, or the public. Your identity also keeps track of your favorites.

Your Identity Travels with You

Any privileges, from special to full administrative, are assigned using your identity. Your identity associates those privileges with you no matter where you are. Log in to any app on any device anytime and have access to the same maps, apps, data, and analysis. This portability functions in a similar way to identity in Salesforce, SharePoint, and SAP.

How It Works

As a named user, you get access to a comprehensive suite of apps and maps that come with the ArcGIS Online subscription. You can use these apps in your day-to-day work. These include

- Collector for ArcGIS
- Operations Dashboard for ArcGIS
- ArcGIS Open Data
- Web AppBuilder for ArcGIS
- Esri Maps for Office
- Esri Maps for SharePoint
- Esri Maps for Dynamics CRM
- Esri Maps for IBM Cognos
- Esri Maps for MicroStrategy
- Esri Maps for SAP BusinessObjects
- Esri Maps for Salesforce

Your identity provides access to purchased premium apps, such as ArcGIS Pro, Esri Business Analyst Online, and Esri partner apps.

One Login Unlocks Everything

Because ArcGIS supports identity, you can tie into other identity management systems. For example, you can connect ArcGIS to single sign-on systems so you log in once to access ArcGIS and anything else.

A World of Imagery Available through ArcGIS Online

The Living Atlas of the World, included with ArcGIS, gives you access to maps and layers from Esri, Esri partners, and thousands of ArcGIS users from around the world. These maps and layers cover a diversity of geographies from global to national to local and topics that range from land cover to live traffic. The Living Atlas is actively curated by Esri staff members who identify, select, and organize the most useful maps and layers so they are easily accessed.

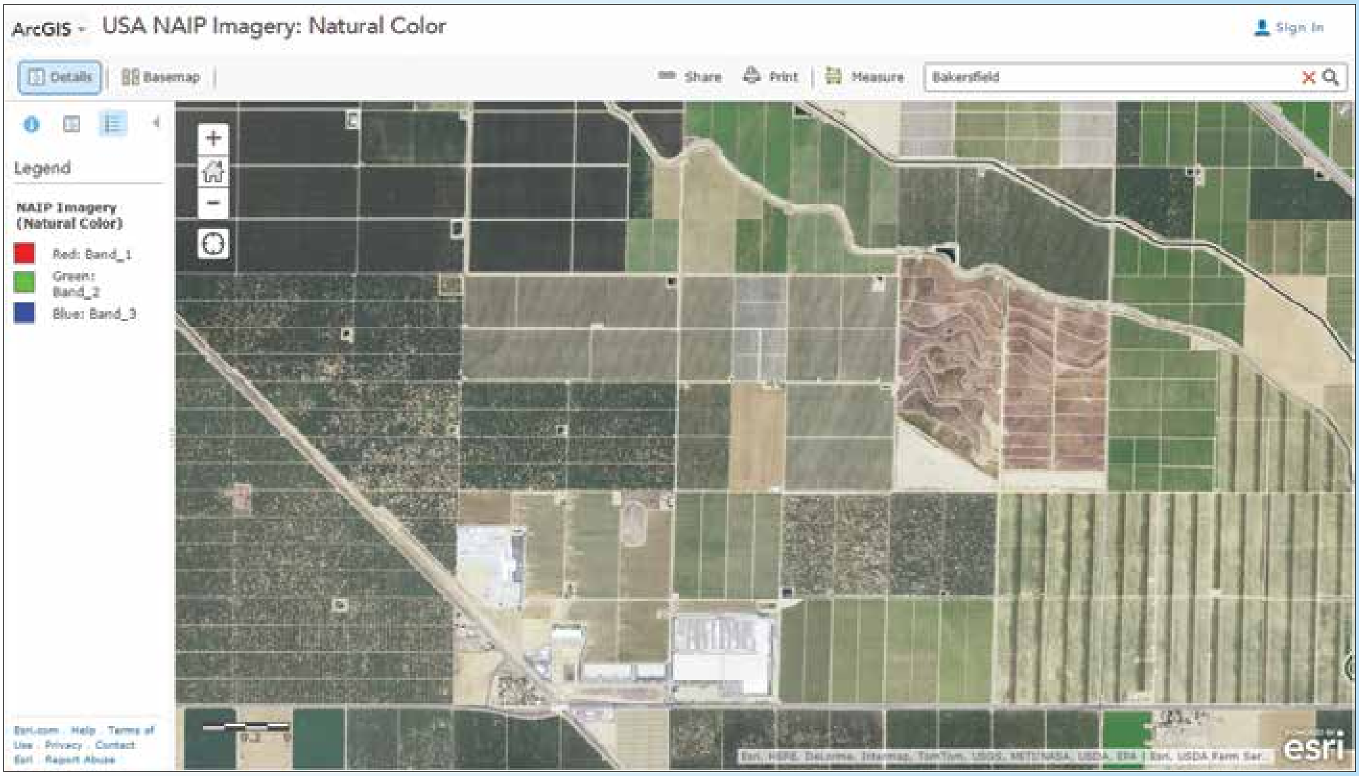
It is organized into categories: Imagery, Basemaps, Community Maps, People (various aspects of human geography), the Earth (e.g., landforms, elevation, geology, soils, oceans, climate, natural hazards), and Life (e.g., ecoregions, wetlands, vegetation, protected areas).

The imagery collection is one of the richest and most popular. It includes basemap, multispectral, temporal, and event imagery layers that support a variety of maps, applications, and use cases.

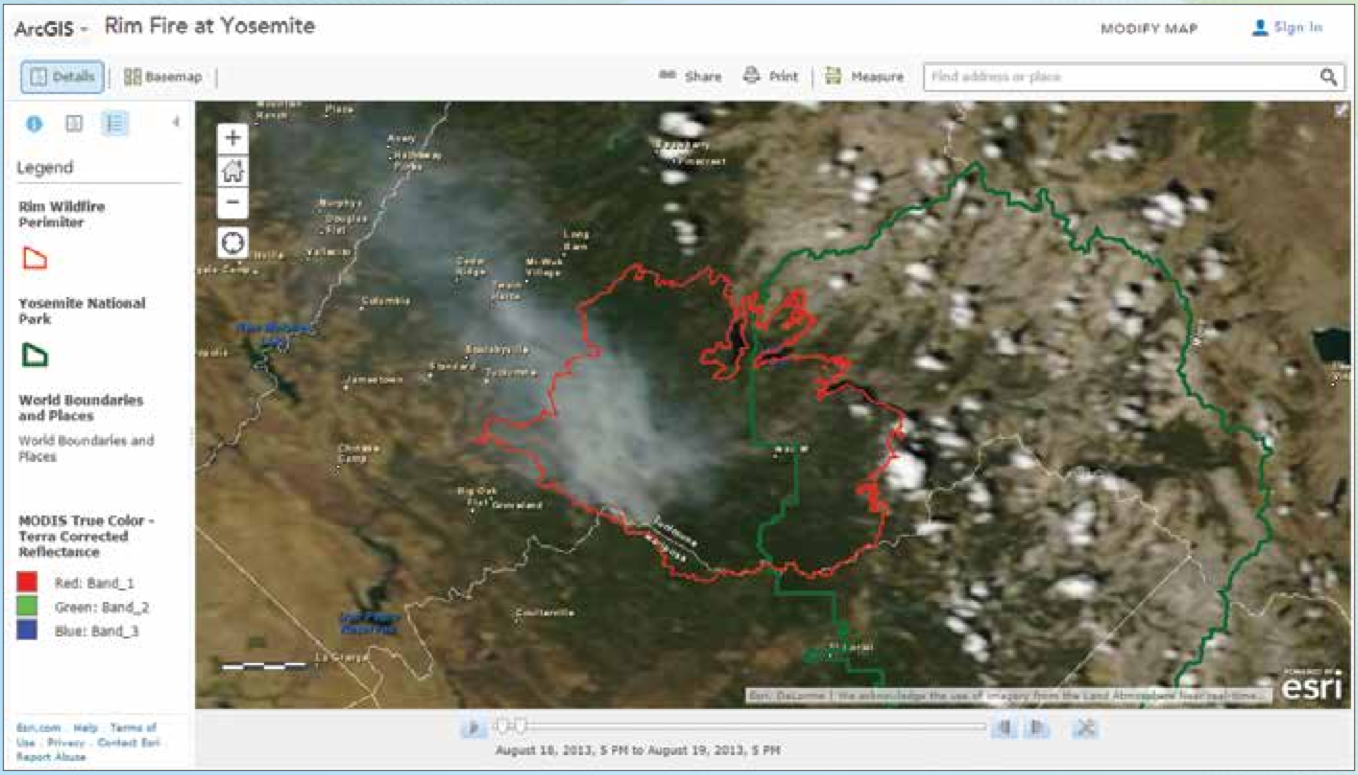
Basemap	Multiscale imagery maps optimized for high-quality display and performance
Multispectral	Dynamic raster layers that can be restyled to highlight specific characteristics such as healthy vegetation or impervious surfaces
Temporal	Dynamic raster layers with multitemporal information that can be manipulated with a time slider to understand change over time
Event	The latest available imagery both before and immediately after major events

Imagery Varies by Pixel and Temporal Resolution

The imagery available through ArcGIS is intended to support a range of use cases for visualization and analysis, whether you are



↑ NAIP high-resolution (1 m) imagery, which is refreshed on a three-year cycle, is available for the continental United States.



↑ Event imagery is the latest available imagery both before and immediately after major events such as the Rim Fire at Yosemite in 2013.

studying global climate change, performing vegetation analysis, or comparing potential site locations.

Global scale imagery is supplied to ArcGIS Online from two sources. The global 250 m (i.e., meter per pixel) Moderate-Resolution Imaging Spectroradiometer (MODIS) imagery from the National Aeronautics and Space Administration (NASA) is updated in its entirety on a daily basis. Global 15–30 m Landsat 8 imagery from the United States Geological Survey (USGS) is updated every 16 days. The best scenes in each update are automatically selected and archived.

Higher-resolution imagery is available for a large portion of the earth's landmass. Imagery at 1m resolution from the United States Department of Agriculture Farm (USFA) Service Agency (FSA) National Agriculture Imagery Program (NAIP) is available for the continental United States. Each state is updated at least every three years.

This imagery supplements the World Imagery basemap in ArcGIS Online, which includes 15 m or 2.5 m imagery for the world and high-resolution imagery of 1 m or better that covers approximately three-quarters of the world's landmass and more than 90 percent of its population. High-resolution imagery in the World Imagery basemap comes from a variety of commercial and contributor sources. Commercial sources include DigitalGlobe and Airbus. Contributor sources include jurisdictions at various levels such as the country of Denmark, state of Maine, and the city of Berlin. Esri selects and publishes the best available imagery based on image currency, resolution, and quality.

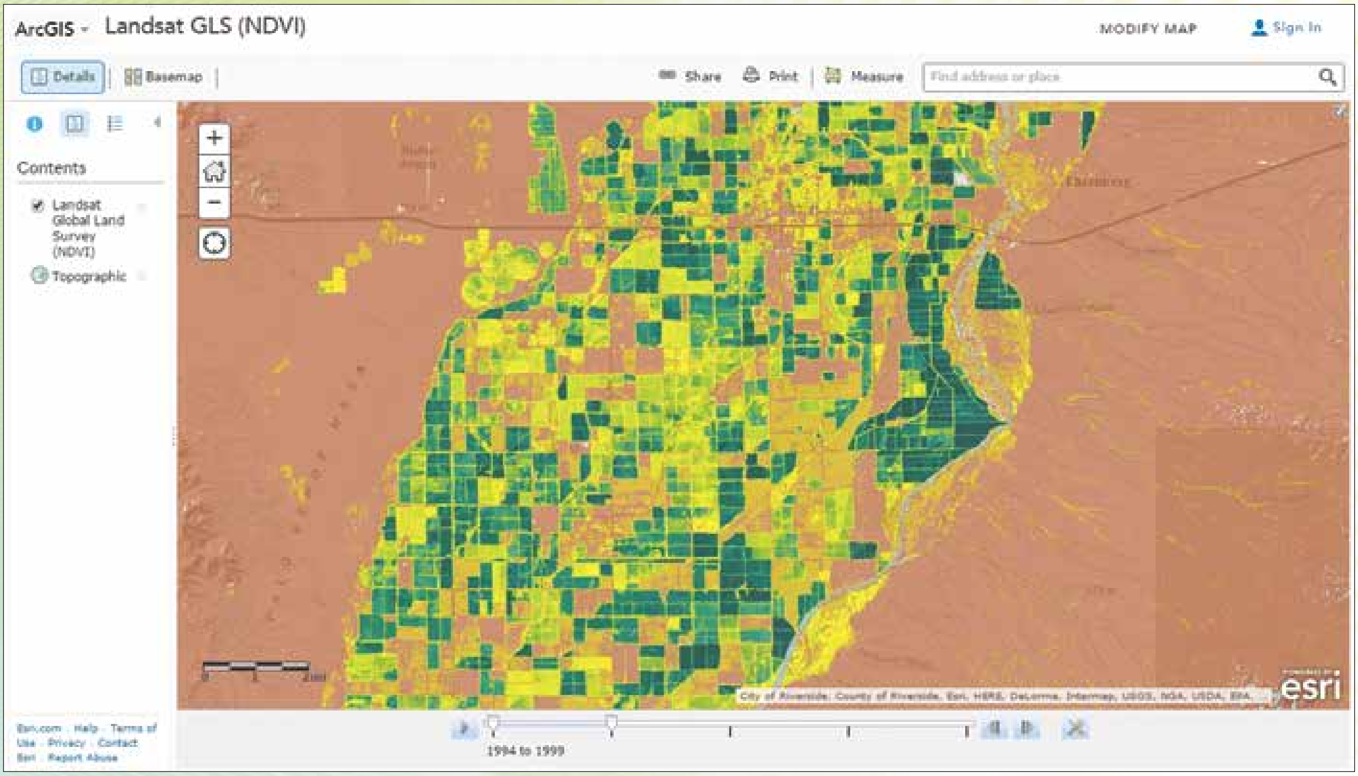
If the image layers already available in ArcGIS Online don't meet your specific requirements, premium image layer packages can be licensed through ArcGIS Marketplace (marketplace.arcgis.com). These premium packages include imagery from DigitalGlobe, RapidEye, and a unique new offering from Airbus that lets you select individual scenes from its growing archive of 0.5 m imagery or task a new scene to be acquired in a time frame you specify.

More on Key Imagery Offerings

These descriptions summarize key imagery offerings currently available through ArcGIS Online.

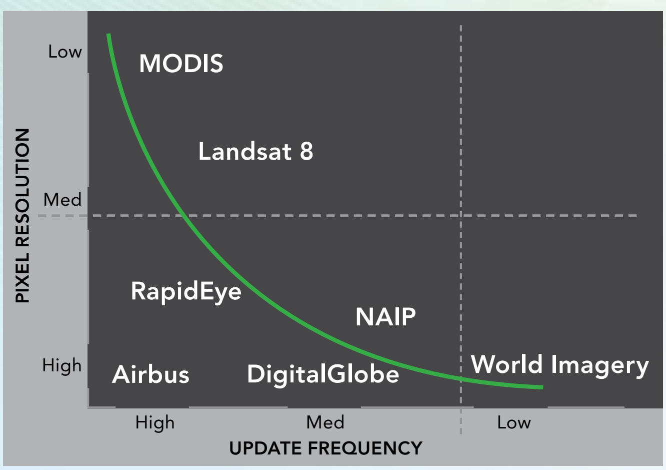
World Imagery

This popular basemap provides 1 m or higher-resolution satellite and aerial imagery for many parts of the world and lower-resolution satellite imagery worldwide. The map includes 15 m TerraColor imagery at small- and mid-scales and 2.5 m SPOTMaps Imagery for the world. The map features 0.3 m resolution imagery in the continental United States and parts of western Europe supplied by DigitalGlobe. Additional DigitalGlobe submeter imagery is available for portions of South America, eastern Europe, India, Japan, the Middle East and North Africa, South Africa, Australia, and New Zealand. Submeter Pléiades imagery is available in select urban areas globally. Built with the best available data from a variety of sources, the World Imagery basemap includes local authoritative data provided by many users through the Esri Community Maps Program. It is freely available to all ArcGIS users.



↑ New Landsat 8 scenes are collected every 16 days. Esri-hosted maps and layers are updated on a daily basis with the latest and best scenes.

↓ ArcGIS Online makes a wide range of imagery available in range of resolutions and undate cycles.



US NAIP Imagery

Maps and layers built using NAIP high-resolution (1 m) imagery for the United States provide access to the most recent NAIP imagery for each state, which is based on a three-year cycle (currently 2010–2013). It is updated annually as new imagery is made available. This imagery is published in four bands (RGB and near infrared) where available with the option to display the imagery as false color to show the infrared (IR) band or display the Normalized Difference Vegetation Index (NDVI), which shows the relative biomass of an area. NAIP imagery is available to users with an ArcGIS Online subscription, but its use accrues no credit fee.

Landsat 8 Imagery

Maps and layers featuring recent Landsat 8 scenes cover the landmass of the world and are used for visual interpretation. Landsat 8 collects new scenes for each location on earth every 16 days. Esri-hosted maps and layers are updated on a daily basis with the latest and best scenes (i.e., those with limited cloud cover) from the USGS. Landsat 8 imagery is available to users with an ArcGIS Online subscription, but its use accrues no credit fees.

MODIS Imagery

MODIS maps and layers feature 250 m resolution imagery for the world is updated on a daily basis. These services provide access to a subset of the NASA Global Imagery Browse Services (GIBS), a set of standard services for delivering global, full-resolution satellite imagery. These maps and layers are freely available to all ArcGIS users.

View, Use, Contribute

Get familiar with the imagery layers available through the Living Atlas of the World. Visit goto.arcgisonline.com/imagery to view imagery layers and maps and see how you might use them. If you have more current or higher-resolution imagery you believe would improve the World Imagery basemap, visit goto.arcgisonline.com/community-maps or e-mail communitymaps@esri.com.

Using ArcGIS Online Elevation and Hydrology Analysis Services

By Jian Lange, Product Manager for Spatial Analysis, Esri

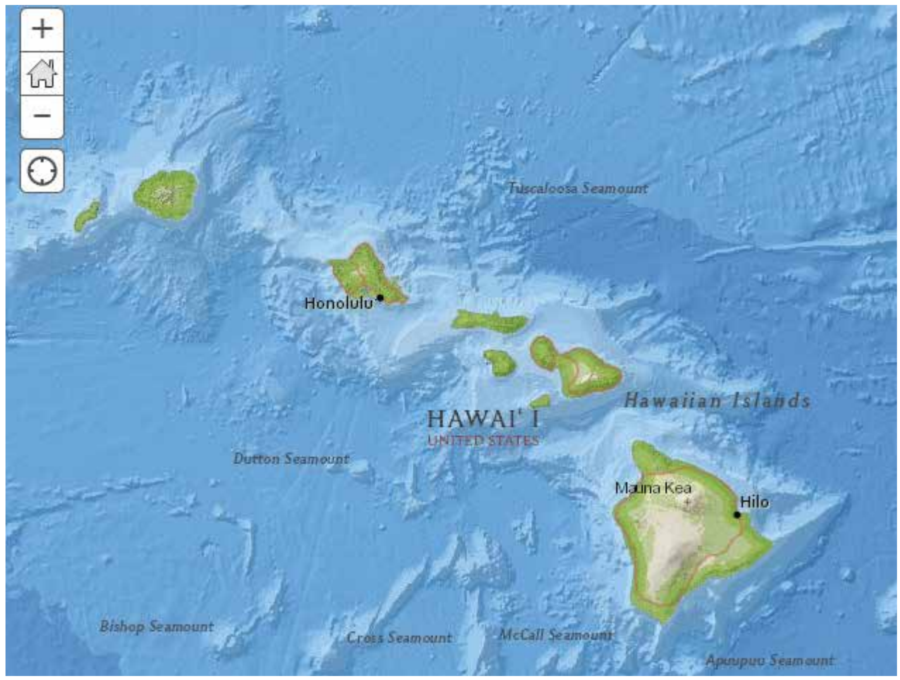
Curated, authoritive elevation data, coupled with analysis tools, is now available via ArcGIS Online. Elevation analysis is readily accessible across the ArcGIS platform in ArcGIS Online web maps, in ArcGIS for Desktop, and incorporated in custom web clients.

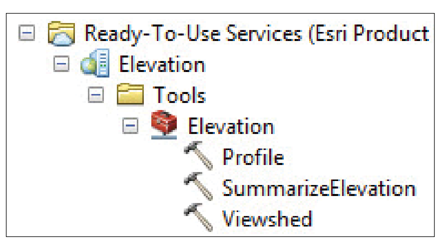
Elevation analysis is essential for many GIS applications including those for natural resource management, conservation, agriculture, transportation, construction, flood risk management, and national security.

Traditionally, running analyses, such as drawing an elevation profile of a track, required a user to locate an available and appropriate elevation dataset. This could be a time-consuming process. Often elevation data is only available from individual government agencies and may come in a variety of formats and in a range of resolutions.

To perform more advanced analysis, such as to delineate watersheds or to trace water flows, additional work preprocessing elevation data to make it suitable for hydrological modeling and analysis was required. The process of deriving hydrologically-enforced elevation data requires rigorous methods and quality checks, significantly increasing the complexity of this type of analysis.

With the ArcGIS Online Elevation and Hydrology Analysis Services, which were made available in the ArcGIS Online December 2014 update, users can now perform these analytical tasks quickly and easily without having to collect, maintain, or update terabytes of base data on local machines.





↑↑ ArcGIS Online web map of the Hawaiian Islands

↑ ArcMap Ready-To-Use Services

What Are These Services?

ArcGIS Online Elevation and Hydrology Analysis Services are hosted by Esri. Both services are accessible through the ArcGIS platform when an Internet connection is available. This means users can retrieve elevations or calculate viewsheds for any point in the world using just a web browser.

In addition to hosted elevation and hydrologic data, ArcGIS Online also furnishes a collection of related analytical tools as geoprocessing services. ArcGIS Online users can perform elevation and hydrologic analysis in a web app and answer questions such as

- What is the elevation along a particular path?
- What is the slope of a road?
- Which areas are visible from an observation tower?
- What direction and path will water flow from a certain location?
- What are the origins of water that arrives at a specified location?

A key benefit of using these services is that all data used for analysis is hosted and maintained by Esri in one place. This data is already preprocessed and optimized for fast web service performance, and its worldwide coverage is available in different resolutions.

Using ArcGIS Online Analysis Services

ArcGIS Online Elevation and Hydrology Services are available as part of the Esri Living Atlas of the World. The services, accessed through the ArcGIS platform, are available to all ArcGIS Online organizational users, ArcGIS for Desktop users, and users

↑ Map of Hawaiian Islands with Elevation Profile

of other web clients.

Here are just a couple of examples that demonstrate how these services are used. In just a few steps, these services can be used to generate an elevation profile and a viewshed and perform a watershed analysis.

Elevation Profile

In the first example, an elevation profile is created using the Elevation Profile template. This template, available in the ArcGIS Online web mapping application template gallery, is a configurable web application template that will display the elevation profile for a selected feature or a measured line along with a web map.

To create the web application to generate an elevation profile for the Hawaiian Islands, simply open an ArcGIS Online web map and use the National Geographic basemap. Zoom to the Hawaiian Islands, and then save and share the map with the public or with members of a group. In the Share dialog, choose MAKE WEB APPLICATION. This will invoke the template gallery. Choose the Elevation Profile template.

Templates can be previewed, published, or downloaded to tweak and publish them on a local server. Alternatively, the template can be configured and then published as a hosted application via an ArcGIS Online account.

After selecting the Elevation Profile template, the Hawaiian Islands web map will display. Click the measure icon, then draw a line across the map and finish it with a double mouse click. The elevation profile for the path will be returned and displayed in the panel below the map.

Notice that ocean bathymetry is also included in the global elevation service, so ocean area profiles can be derived. The Elevation Profile template can be used with any publicly shared map.

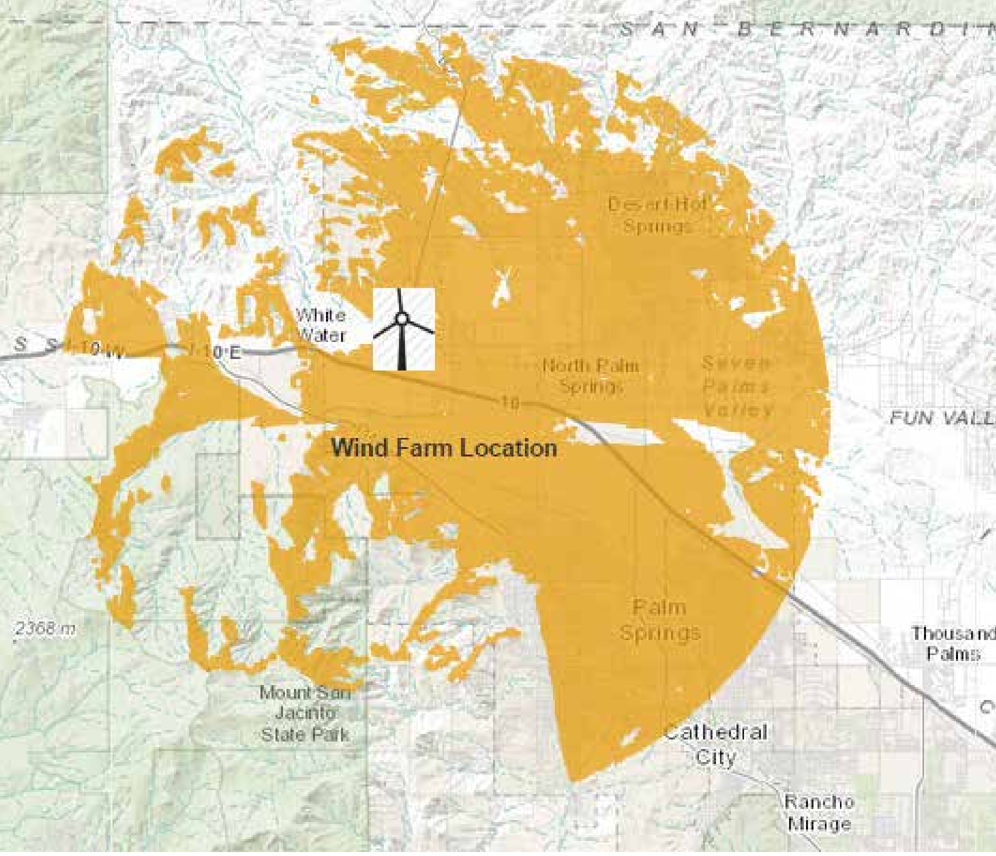
Visibility Analysis

There are two ways to look at a viewshed. A viewshed is an area that is visible from a given location based on elevation values. A viewshed can also be the area from where the location can be seen.

Either way, determining a viewshed can be important in determining the value of real estate, the location of telecommunications towers, or the placement of military forces.

In illustrated example, viewshed analysis was used demonstrate the visual impact of a proposed wind farm. This analysis determined the areas where the wind farm would be visible. A form of renewable energy, wind energy is perceived as being environmentally friendly, but wind farms can be seen for miles and can be unappealing to neighbors.

Starting with a web map in ArcGIS Online that shows the proposed wind farm location as a feature layer, the feature layer name was right-clicked and Perform Analysis selected. Using the Create Viewshed tool on the Perform Analysis menu,the areas from which the wind farm can be seen were identified. This tool allows the height of the observation point to be included in the analysis. Also, areas greater than a specific distance can be excluded, and in this case, areas more than 9 miles away from the wind farm location were excluded.



← Visible areas from the proposed wind farm

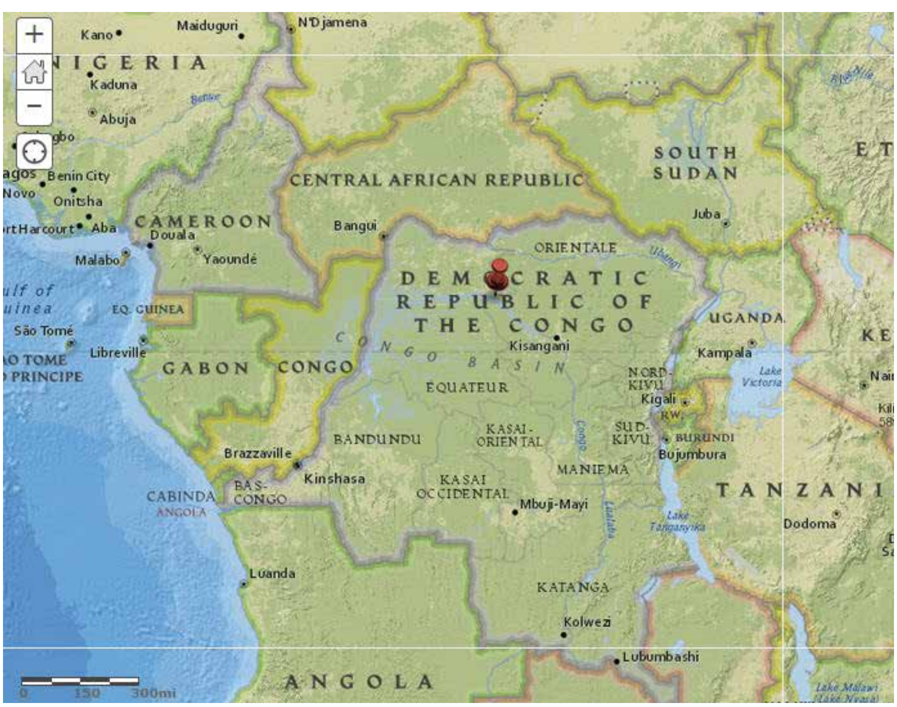
The output from this viewshed analysis shows areas from which the wind farm will be visible. This result can be enhanced by using the Enrich Layer tool, also available in ArcGIS Online, which will provide detailed demographic information about these affected areas.

Performing Watershed Analysis

A watershed is the area of land that drains rainwater or snow into one location such as a stream, lake, or wetland. Watersheds can provide drinking water and thus are an important part of an ecosystem. If the watersheds are polluted, drinking water will likely be contaminated.

In the example illustrated, the Create Watersheds tool included with the ArcGIS Online Hydrology Services, was used to delineate watershed areas that drain into a given stream section in Africa.

The starting point was an ArcGIS Online web map that uses the National Geographic basemap. After zooming to the Republic of Congo in Africa, a base location on the Congo River was placed as a Map Notes layer. This base location was used to identify catchment areas or watersheds. After right-clicking the Map Notes layer and choosing the Perform Analysis menu, the Create Watersheds tool was selected. The default settings were accepted and Run Analysis selected. The result displayed the delineated watershed area.



↑ ArcGIS Online web map of the Congo River

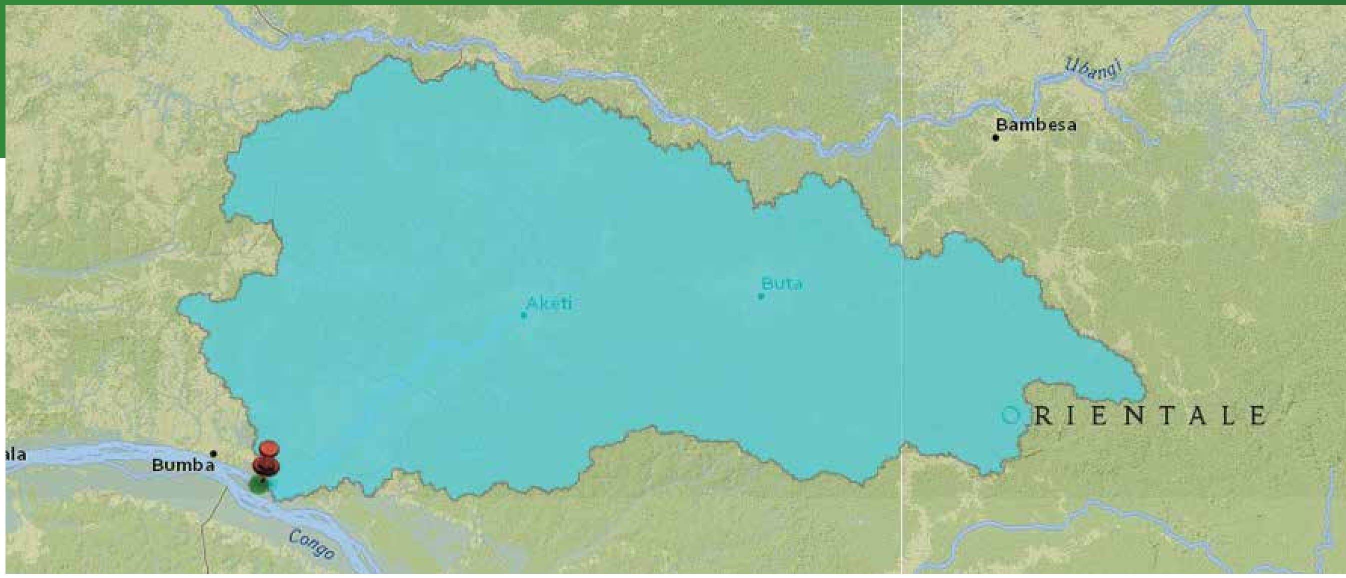
Ready-To-Use Services

The prevous examples show how to access the Elevation and Hydrology Services using an ArcGIS Online web map. In ArcGIS for Desktop, these analysis services are also easily accessible as Ready-To-Use Services. Ready-To-Use Services give direct access to ArcGIS Online analysis services such as Network Analysis Services as well as elevation and hydrology services.

Access them by simply logging in to an ArcGIS Online organizational account from ArcGIS for Desktop. At the bottom of the Catalog window, expand Ready-To-Use Services, click the Elevation connection, and then the Tools folder, and Elevation toolbox. From the tools displayed, double-click a tool to open it, and run it just like any other geoprocessing tool. These tools can be used directly in ModelBuilder models and Python scripts just like any other tool.

Develop Web Apps Using Elevation Layers

In addition to using the Elevation and Hydrology Analysis Services directly in an ArcGIS Online web map or in ArcGIS for Desktop, developers can use the available REST API to embed these analysis services in customized web applications. Additional information for developers



↑ Watershed area from the specified location on the Congo River

and samples can be found at Esri's developer website (developers.arcgis.com).

Data Sources

The elevation and hydrologic data included with ArcGIS Online Elevation and Hydrology Analysis Services are maintained, hosted, and updated by Esri. This data comes from a number of authoritative sources and grows through the Community Maps Program. As new areas and better resolutions are made available, they will be included in these analytical services.

Elevation data for these services come from the US Geological Survey (USGS), US National Geospatial-Intelligence Agency (NGA), the US National Aeronautics and Space Administration (NASA), and other authoritative sources. The data is furnished in a spherical coordinate system with units of arc seconds. To translate arc seconds, commonly used metric approximations for data from these sources are listed.

- 10-meter (1/3 arc-second) resolution elevation raster for the continental United States from the USGS National Elevation Dataset.
- 30-meter (1 arc-second) resolution elevation raster for the continental United States, Canada, and Mexico from the USGS National Elevation Dataset.
- 90-meter (3 arc-seconds) resolution elevation raster for the land surface of the world between 60 degrees north and 56 degrees south from the Shuttle Radar Topography Mission (SRTM).
- 1,000-meter (30 arc-seconds) resolution elevation raster for the world from the General Bathymetric Chart of the Oceans (GEBCO).

The hydrology services in the United States are based on the NHDPlus Version 2.1 database, which Esri has preprocessed and optimized for analysis performance as web services.

NHDPlus V2.1 was produced by the Environmental Protection Agency's Office of Water in partnership with the USGS and released in 2013. The NHDPlus V2.1 data is considered the most authoritative hydrologic dataset for the United States.

For the rest of the world, the data is based on HydroSHEDS data, which is high-resolution elevation data obtained from NASA's SRTM.

Summary

ArcGIS Online Elevation and Hydrology Analysis Services, part of the Esri Living Atlas of the World, can be used within the ArcGIS platform using an ArcGIS Online web map, in ArcGIS for Desktop, or in other web clients through the use of the REST API.

Before these services were available, users had to gather and prepare elevation data, and then find the right analytical tools to perform the analysis tasks. With the ArcGIS Online Elevation and Hydrology Analysis Services, performing common analytical tasks on elevation and hydrologic data is quick and easy and eliminates the need to collect, maintain, or update an authoritative set of base data.

Esri will continue providing hosted analytics against curated data so users can more quickly create results that are more correct than could often be obtained by users on their own. Esri believes this is a pattern that will continue to grow with other data and other analytics.

About the Author

Jian Lange is an Esri product manager. She is responsible for various aspects of ArcGIS spatial analysis products, including business planning, road maps, requirements, and management.

Nabataean Architecture and the Sun

A landmark discovery using GIS in Petra, Jordan

By Tom Paradise and Christopher Angel, University of Arkansas

The authors are associated with the King Fahd Center for Middle East Studies, an interdisciplinary program in the Fulbright College of Arts and Sciences at the University of Arkansas that is dedicated to the study of the modern Middle East. This article describes their work at the classical city of Petra, located in southern Jordan, which has been designated as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site.

Steven Spielberg filmed the final scenes of the 1989 movie *Indiana Jones and the Last Crusade* in Petra, Jordan. Its fame has secured the so-called Rose Red City a place on tour itineraries and lists of must-see destinations. Since the film's release, the annual number of visitors to Petra has surged from 30,000 to nearly 1,000,000.

Over the past 25 years, a team of researchers from the University of Arkansas has investigated the diverse landscapes of Petra. After initially examining the deterioration of sandstone architecture in the 1990s with UNESCO, the team expanded its work to include the effects of tourism on tomb humidity, reconstructions of catastrophic flooding, Bedouin urban morphology, and synoptic mapping of visitors in the valley. As part of a broader research plan, the team implemented a parkwide geoinformatics plan to bridge elements of geology, pedology, and climate with social sciences that included geography, archaeology, and urban studies along with tourist demographics and cultural heritage management and policy.

When research in the early 1990s identified possible solar alignments in the Urn Tomb *[one of the Royal Tombs in Petra]* and the meticulously aligned east–west orientation of the hewn obelisks on Jebel Madhbah, it spawned new hypotheses and directions for research using complex analyses and implementing GIS.

Structures and urban plans that were created to align with solar events and phenomena have become important markers of advanced society, theology, and engineering at prominent sites such as Stonehenge, Chaco Canyon, Abu Simbel, and Machu Picchu. Architecture was oriented so sunlight would fall on and/or enter these monuments on the sunrises or sunsets of the solstices and equinoxes.

Evidence of sun worship has been found at sites and in sacred texts of cultures and societies for thousands of years. The sun is a

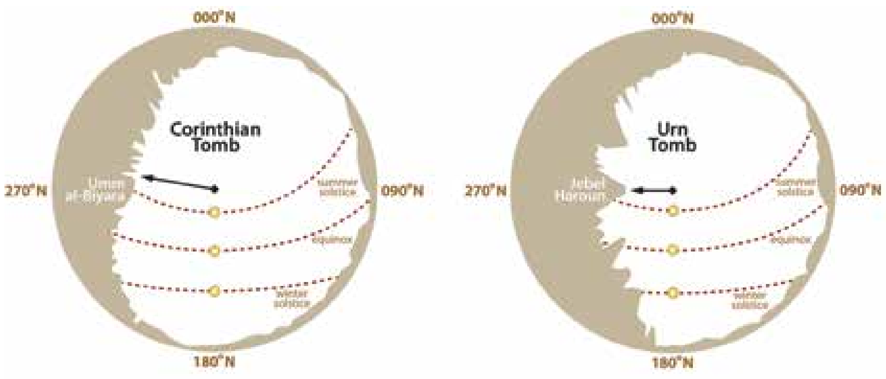
← Urn Tomb is sited at the base of Jebel Khubta (facing 270°N). On the summer solstice and equinox sunsets, sunlight illuminates the far corner niches of the main chamber.

theme that connects numerous global traditions. Ancient societies have built stone circles, megalithic temples, and buried vaults that aligned with the sun on the solstices and equinoxes.

Some of the earliest communities and societies have identified earth-sun relationships as significant markers for the annual march of seasons and their related growing cycles. These celestial markers of the seasons evolved into days of worship and benchmarks for yearly events, holidays, and religious events.

Over the past decade of research at Petra, it was determined that during the sunsets on the summer and winter solstices and autumnal and vernal equinoxes, sunlight entered the far reaches of the Urn Tomb chamber, precisely illuminating carved niches at the rear of the chamber. Either the Urn Tomb was hewn and oriented specifically to accommodate the penetrating sunrays, or the façade and portals were modified to permit this solar alignment.

In either case, this phenomena was not arbitrary. It was a calculated engineering feat that was accomplished 2,000 years ago. To understand earth-sun relationships that were used in Nabataean architectural orientation, it is vital to implement horizon diagramming with aspects of precession, nutation, and refraction, in conjunction with topographical and geographic data. The incorporation



↑ Horizon diagrams of the Corinthian and Urn Tombs, representing the marker solar paths. These two adjacent tombs have distinctly differing horizon markers during the summer solstice sunsets where the sun sets on the prominent horizon features of the towering plateau of Umm al-Biyara (Corinthian Tomb), and the famous burial site of Aaron, Moses' brother, on Jebel Haroun (Urn Tomb).

of a GIS enabled this advanced analysis in Petra, and the findings were revolutionary.

Investigating terrestrial and astronomical relationships using GIS presents a few challenges. The majority of GIS analyses are well suited for terrestrial, topographic, and distributive analysis along two- and three-dimensional landscapes. However, it is currently difficult to integrate astronomical data in a GIS, especially when calculating and representing historical astronomical events.

One of the authors, Christopher Angel, the Arkansas project GIS coordinator, combined these analyses with astronomical data by merging the ArcGIS Python library (ArcPy) with the highly accurate PyEphem library, which adequately accounts for changes in precession, nutation, and refraction. *[PyEphem provides basic astronomical computations for Python.]* However, it is difficult to determine the validity of these relationships without geospatial visualization. Therefore, it was also necessary to reveal these relationships using the matplotlib library *[which provides 2D plotting capabilities]*.

The order of processing was simplified by gathering the spatial attributes for each structure, analyzing potential terrestrial obstructions by generating a horizon diagram and overlaying celestial pathways for specific astronomical events within the specified time frame. Using ArcPy in conjunction with PyEphem and matplotlib, the team developed a script that uses vector point data to extract topographical data from a digital elevation model (DEM) in order to analyze celestial pathways in a horizon diagram.

Celestial Pathways

The key to this research was to identify the celestial pathways that cross Petra's skies, then and now. These tracks were generated by defining observer locations based on the spatial attributes (elevation, latitude, and longitude) for each point. In this case, PyEphem uses 1 January 50 BCE as a start date to identify each solstice and equinox. The returned date was used to determine the previous rising and the next setting times for that day. Within these time constraints, it was possible for the research team to emulate the passing of time by adding five minutes to the previous solar rising and return and both the azimuth and the altitude of the sun throughout that day.

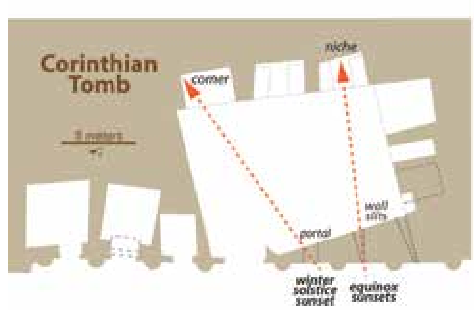
These values were then incorporated onto each horizon diagram that represented the astronomical event's rising and setting locations.

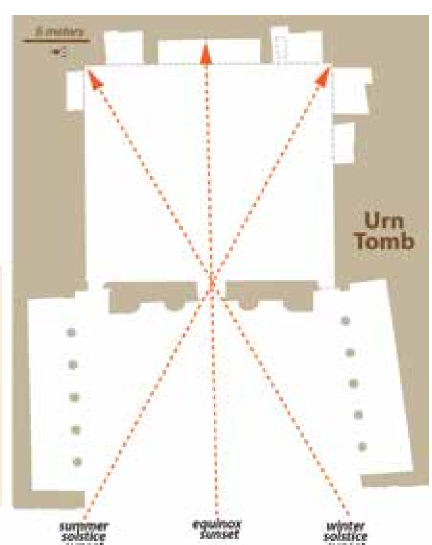
An urban study such as this often considers the amount of energy investment required by a particular early society to construct an oriented structure within the greater urban landscape. Considering the nature of the rock hewn structures across Petra, topography must have been paramount to the Nabataeans. Augmenting the physical landscape's natural properties to fit within a society's cultural preference requires considerable energy investment.

Assessing this investment may divulge the importance of a structure's orientation over another. For the geographer, the energy requirements for shifting a terrain's natural slope and azimuth are quantified as costs. Identifying these costs allowed the team to reinforce the validity of a structure's intentional orientation and alignment.

In addition to energy investment, analyzing the limiting costs of terrain (i.e., elevations, flood zones, man-made barriers, and structural visibility within the urban landscape) yielded further evidence concerning a structure's importance within the larger urban landscape. If a large amount of energy was required for a monumental structure, it can be assumed that the visibility and accessibility to the structure would be higher—a significant finding in this research. Petra's

→ Plans of the Corinthian and Urn Tomb chambers illustrating the paths of incoming sunlight on solstices and equinoxes. The sunlight enters the Corinthian Tomb through distinctive wall slits and doorways in the tomb facade. While in the Urn Tomb, the sunlight enters through the central doorway. Not only do both tomb facades face prominent solstitial sunset points on the horizon but also display remarkable (and engineered) internal illumination on the same solstitial sunsets.





structural alignments were not arbitrary but part of a larger resource, urban, or cosmological plan.

Implications

In past research, the majority of alignment methodologies simply tabulate the rise/set azimuths alongside structural orientations in the form of a table. Although this is useful for statistical analyses, it abandons the geographic and topographical realities on the ground and their relationship to practical space and theoretical place.

By representing this data using conventional geographic tools such as horizon diagrams and ArcGIS maps, not only can investigators identify and divulge possible relationships, but they can also identify topographical obstructions that might limit fields of view then (and now). Using innovative geomatics (GIS, cartography, remote sensing, and GPS) across Petra and the region, it is now easier to explore large datasets and inaccessible sites.

The team at the University of Arkansas is currently adapting these tools and scripts to successfully analyze other types of astronomical/celestial data, such as lunar and astral relationships, in the hopes of revealing more relationships between celestial pathways, structural orientations, landscape, and large urban patterns.

It was the use of GIS-generated horizon diagrams in this research that also enlightened the Arkansas team to other celestial relationships across Petra. Not only was solstitial and equinoctial illumination revealed in various tomb chambers and monuments but sunset and sunrise horizon landmarks were also identified.

For example, it was found that on the summer solstice, the sun sets directly atop the highest point of the plateau of Umm al-Biyara when viewed from the Corinthian Tomb and atop the revered peak of Jebel Haroun (where Moses' brother Aaron is buried) from the Urn Tomb. These critical relationships were previously unknown in Nabataean research. The use of GIS, in conjunction with conventional horizon diagramming, revealed these architectural relationships in Petra.

Prior alignment studies have been criticized as having been based solely on few, key locations across a particular area chosen specifically to support the hypothesis at hand. This study, however, utilized all of Petra's primary sites in the hopes of examining a broader foundation for Petra's urban form.

In this study, however, the Arkansas team was able to comparatively and holistically investigate a multitude of structures in a single process to identify alignment relationships. This has enabled the team to make a stronger case for the intentional orientation and alignment of structures built in Nabataean Petra. These findings have proved invaluable when used in tandem with other spatial methodologies and datasets commonly integrated in the social sciences.

Although these methods rely more on empirical analysis rather than the intentions of architects, authorities, and planners in these early societies, they enable the researchers to examine these complex questions that facilitate and encourage a deeper understanding of classical period urban morphologies. This may then link to social theories of early urban space, or even more profound discussions of cosmology and theology during Petra's heyday 2,000 years ago.

The veneration of the sun can be found manifested in architecture across hundreds of years and thousands of miles. The sun—our source of life and light—is crucial to an ageless and ancient spirituality that is fundamental to architecture and urban planning, cosmology, and theology and a spiritual core that often guides and defines communities, societies, and culture. At the tomb-temple of Newgrange, Ireland (c. 3200BP), the large earthen mound is aligned with the rising sun so that the inner chamber is flooded with sunlight only on the winter solstice. At the hewn temples of Abu Simbel, Egypt (1244 Before Present [BP]), only the inner vault is illuminated on the shortest day of the year. At the Great Mayan Temple in Dzibilchaltún, Yucatán, Mexico, the rising sun illuminates and passes through its great portal only on the equinoxes. While at Stonehenge in the United Kingdom, it is the rising sun on the summer solstice that marks an important marker at the Heel Stone (and its missing partner stone).

This veneration of the sun and an understanding of agricultural cycles may be the basis of many aspects of Petra's urban, structural, and monumental orientation and alignment, but it also may be the key that leads us to a better awareness of Petra's cosmology and spiritual essence and is made possible in part through the use of innovative GIS technologies.

For more information, contact Tom Paradise at paradise@uark.edu or Chris Angel at cangel@uark.edu.

About the Authors

Tom Paradise PhD, a professor of geosciences and Middle East studies at the University of Arkansas, specializes in stone architectural deterioration, geomorphology, cultural heritage management, and geospatial visualization and geomatics. He has worked in Petra since 1990, and his research and expertise have been sought by international agencies including the US State Department, UNESCO, and ICOMOS and a number of Mediterranean governments including Italy, Morocco, Tunisia, Egypt, Turkey, and Jordan.

Chris Angel MA, a PhD candidate in environmental dynamics at the University of Arkansas, specializes in classical period and vernacular urban morphology, geomatics, and Middle East and North Africa geography. His research has included Bedouin town and village form, Roman and Nabataean city planning, and arid lands cultural and regional geography. He currently works in the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas.

Benchmarking Disaster Recovery Using Collector for ArcGIS

By Daniel Morath and Christopher Emrich, Hazards and Vulnerability Research Institute

An interdisciplinary research and graduate and undergraduate training center studying the recovery of the New Jersey Coast following Superstorm Sandy used Collector for ArcGIS and significantly improved the efficiency of its field data collection processes.

Superstorm Sandy impacted the coasts of New York and New Jersey in a fashion not seen since the 1903 Vagabond Hurricane. Storm surges of more than eight feet, coupled with more than 11 inches of rainfall and wind speeds nearing 90 mph damaged or destroyed more than 72,000 homes and businesses across the coast of New Jersey. In the blink of an eye, decades of Jersey Shore history were washed out to sea by Sandy's wrath, leaving a swath of destruction from Sandy Hook south to Downe Township.

The process of recovering from Sandy began almost immediately with a Presidential Disaster Declaration and promises of a return to normalcy. However, the truth is that recovering from a hurricane is a long-term process. The Hazards and Vulnerability Research Institute (HVRI) at the University of South Carolina has been at the forefront of long-term recovery assessment and tracking since the catastrophe brought on by Hurricane Katrina in 2005. Its mission includes the creation of new methods and metrics to assist all levels of government with preparedness, response, and recovery from disasters.

Continuing this mission, researchers from HVRI visited the New Jersey coast in recurring six-month intervals—beginning at the six-month anniversary of Superstorm Sandy in April 2013—to collect field data on the visual indicators of housing reconstruction. Field teams captured data on a sample of parcels in recovering neighborhoods and photographically documented evidence of the reconstruction progress made at each location.

This spatial data provides the empirical basis for developing neighborhood-level recovery mapping. It is the first step in answering questions pertaining to differential drivers or obstructions of recovery between places. Collecting, organizing, and

← HVRI researchers evaluated housing reconstruction in Lavallette, New Jersey, using the Collector for ArcGIS app.

analyzing a vast catalog of field recovery data is a daunting and time-consuming process that required significant coordination and personnel hours to finalize a dataset after each trip to the field.

The Shortcomings of Disconnected Data Collection

Data collected in the field included the geospatial location of each recovery parcel; photographic evidence of its recovery status; and tabular attributes of recovery at each location that indicated the numerical recovery score assigned, damage cause, for-sale status, occupancy status, and building characteristics (i.e., roof, walls, floors, foundation).

Prior to May 2014, field teams collected each piece of data separately using a handheld GPS unit, laptop computer, and GPS-enabled camera. Researchers pieced together data components post hoc in a tedious and time-consuming process that required several weeks to produce a complete dataset.

In addition, coordination between multiple offline field teams and the upkeep of collection units was difficult. HVRI's field teams are composed of 6 to 14 researchers who collect data concurrently across the expansive study region. Methods for allocating work and evaluating data collection progress were inefficient and sometimes resulted in miscommunication, unsystematic routing, duplication of work, and inconsistent or incomplete recovery data.

A New Approach to Mobile Data Collection

Given these challenges, HVRI identified the need for a coordinated approach to field data collection. The institute believed that Esri's Collector for ArcGIS app presented an integrated mobile solution that would help reduce the inefficiencies of disconnected data collection. As a cloud-based service facilitated through ArcGIS Online, the Collector app allows multiple users to simultaneously collect and send data to an online feature service that is capable of storing and displaying spatial, photographic, and tabular (form/attribute) data in one location.

Preparing the dataset for mobile collection was easy and could be completed by one person using ArcGIS for Desktop. Creating a geodatabase with defined domains allows users to populate feature attributes from a coded set of choices. This produces consistency throughout the dataset.

In the Collector app, coded values are selected using a simple drop-down box. For example, when evaluating housing reconstruction at a parcel, field personnel assign a recovery score based on a predefined scale that ranges from 0, which indicates no recovery, to 4, which indicates full recovery.

In addition to setting database domains, using thematic symbology also improves consistency and efficiency in the field. Color-coding the recovery points based on their collection status (an attribute that can be changed in the field) enables field units and project managers (sometimes in another state or country) to easily track the overall progress of data collection. Red points indicate areas to be collected, green points show where data collection is complete, and blue points indicate that the data has been cross-checked for quality control and completeness. Enabling attachments on the feature class allowed photos taken in the field to be stored directly with the associated parcel.

To make the layer available in the Collector app, the symbolized feature class was published as a feature service on the HVRI ArcGIS Online site. From ArcGIS Online, the dataset was combined with other ancillary layers (neighboring parcels, roads, a basemap) and saved as a web map.

When making the map, the GIS technician could customize the editing experience by making only certain layers editable, thus preventing features on other layers from being deleted. Once the map is saved, it can be accessed for editing on a mobile device via the Collector app. Edits made to the feature service in Collector are backed up in the cloud, circumventing the threat of data loss from hardware failure or human error.

HVRI's initial development of the Collector dataset took just seven days from inception to field deployment. To quickly familiarize the staff with the new technology and ensure proper implementation, the HVRI designed a local pilot dataset and conducted two field training sessions that let staff practice data collection and pose questions. These sessions not only provided an opportunity to train HVRI staff in the use of the Collector app but also created an opportunity to uncover small issues with the feature service and make appropriate edits before deploying a production Collector app in the field.

An Improved Field Experience

Using Collector for mobile data collection significantly improved the efficiency of HVRI field personnel. Instead of carrying multiple pieces of equipment into the field, staff members needed only an iPad with a mobile data connection and GPS capability, which served as an integrated data entry device that also supplied photography and navigation. In rural areas of the study region, where data connections were unreliable, field units used Collector's disconnected →

↑ Superstorm Sandy damaged 72,000 homes and businesses across the coast of New Jersey like these houses in Union Beach.

Photo courtesy of Wavian/Flickr

editing to download maps to the iPad and work offline and later synced the map when a connection became available.

The collaborative, cloud-based platform provided in ArcGIS Online created an opportunity for multiple users to simultaneously create, edit, and upload data. Deploying this technology for the collection and analysis of disaster recovery data enabled the team to streamline the long and arduous a process of in-situ data collection, QA/QC, analysis, and reporting.

Using Collector for ArcGIS and ArcGIS Online took a process that initially took 8–10 weeks from initial development to final product and turned it into a process that took much less time and effort—just two weeks from start to finish. Budget savings were realized when data collection time was reduced by 50 percent, effectively shrinking personnel deployment costs. Ancillary benefits identified during beta testing included the ability to track field team progress minute by minute so that teams could be rapidly redirected based on their progress. Real-time data updates effectively increased field team coordination as they traveled across the study area and decreased data collection issues and the need to reroute to capture missing data points.

Finally, the cloud-based data collection and storage available through the Collector app meant data QA/QC and review of data by nondeployed base personnel occurred in near real-time, resulting in finalized and complete, quality-controlled data within one day of initial collection. The integration of field data into a single product significantly reduced the burden of postprocessing. Furthermore, the dataset produced in the field is compatible with ArcGIS for Desktop, enabling simple integration with previously collected datasets.

Using Collector and ArcGIS Online allows HVRI to easily integrate field data in a single product and reduce the amount of equipment needed in the field. It provided a real-time snapshot of progress that enabled coordination of field personnel as well as nondeployed base personnel who could perform real-time QA/QC. It significantly reduced the time and cost associated with field data collection.

The true value of the Collector app was demonstrated in three key ways: time savings; error reduction; and standardization of storage, display, and analysis. The streamlined process of building, deploying, and editing recovery data with the Collector app realized a 50 percent time savings for field personnel and an 80 percent savings in cost and effort for base personnel associated with QA/QC, analysis, and results display. Streamlining the process not only saves time and money during more restrictive budget periods but also facilitates the more rapid infusion of results into products and future research planning.

About the Authors

Daniel Morath is a research associate at the Hazards and Vulnerability Research Institute and a doctoral candidate in the Department of Geography at the University of South Carolina in Columbia.

Christopher Emrich, PhD, is the associate director of the Hazards and Vulnerability Research Institute and a research associate pofessor in the Department of Geography at the University of South Carolina, Columbia.

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Online Maps Help Sempra Make Smarter, Quicker Decisions

Recently, Sempra Global, a holding company for Sempra Energy, found a way to expedite its internal communications; facilitate more rapid conversations; and make smarter, quicker business decisions.

Sempra Energy generates, transmits, and distributes energy for more than 31 million customers worldwide. Sempra Global manages diverse assets such as pipelines, wind turbines, liquefied natural gas terminals, and hydroelectric generation facilities.

Maps are a key resource at Sempra Global, which maintains data on its assets and projects in ArcGIS. Maps created in PDF or JPEG format by the company's GIS team have long been used to share that data with Sempra engineers, managers, senior vice presidents, and directors, especially in presentations and meetings.

However, static maps don't always show the extent or detail needed to answer specific questions that came up in meetings. To get the answer might require going back to the GIS team and requesting a new map.

"If someone wanted to see information in greater detail, we would have to start a whole new map request," said Joel Griffin, senior GIS analyst for Sempra Global. "I didn't like the sense I was hoarding all this valuable information."

Griffin needed to know how to bring the maps to life so that everyone, whether they were trained in GIS or had never heard of GIS, could access and analyze the maps in real time.

Griffin convinced the IT department to get his team an ArcGIS Online subscription. The subscription was part of an enterprise license agreement (ELA) with Esri. With it ,Griffin's team could create real-time, interactive web-based maps to supplement the static maps Sempra had been using.

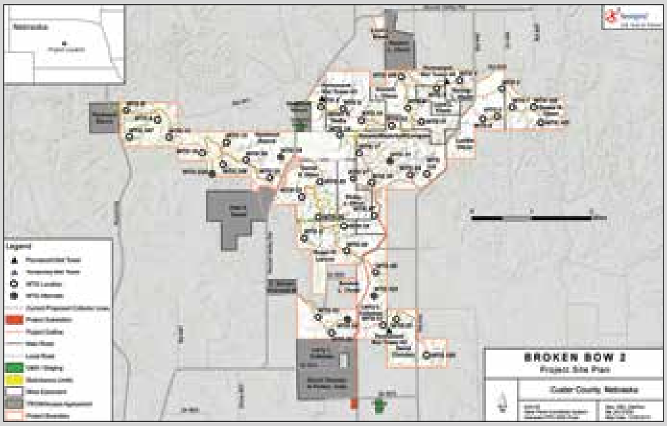
Now, if someone in a meeting wants to get a closer look at a transmission pipeline or find out more information about it, this is accomplished simply and immediately by zooming or clicking on a web map. No need to request another map.

Eliminating these map requests freed Griffin and his team to improve the quality of Sempra's data. This quickened and strengthened business decisions.

Sempra Global capitalized on the additional benefits that come with an ELA. Access to maps and data could be controlled. Users were authorized to access only those maps and data related to their projects, which improved security. The GIS team eliminated redundancy in data files by consolidating data that previously existed in various folders, servers, and hard drives into a single source, which can be centrally maintained, eliminating multiple and possibly conflicting versions of the same dataset.

With online maps, more people can access the data. More than 50 Sempra Global employees directly use the web maps. Engineers, developers, project managers, and executive staff can log on and access what they need without requesting that data from anyone. Before, only GIS-savvy people could use and access the data," Griffin said. "Now the data is available to everyone who wants to know."

"It is vital to have the information into the hands of those who need it instantly to make better decisions," Griffin said. "Now we are giving our users the chance themselves to explore data, which has empowered them to think and collaborate in ways not available to them before. Everyone sees this as a useful tool that you can reference, that you can use all the time."



↑↑ Static maps show the Broken Bow 2 project site but may not be able to display the level of detail needed to answer a specific question.

↑ An online map of the same site can be zoomed and queried to answer questions immediately.

Crowdsourcing a University's Facilities Mapping

By Bob Nichols, Washington State University

After 40 years of rapid expansion of its more than 1,700-acre campus, Washington State University (WSU) found that its utility maps—which were primarily paper based—had become inaccessible and inaccurate. Leveraging Esri GIS technologies and Microsoft Silverlight development tools, the university created a crowdsourcing web app that enables every member of the 375-person facilities department to look at the same maps and data. More important, this data can be updated as facilities staff members work in the field.

Growing Pains

Throughout its 124-year history, WSU has experienced several large construction booms. Over the last 15 years, WSU has built or performed major renovations to nearly 40 facilities on the main campus in Pullman, Washington, causing massive changes to the utility systems. The university's utility maps became terribly out of date and led to many "surprises" in the field. To get by, crews resorted to creating and redlining their own paper maps.

In 2011, WSU Facilities Services was formed by bringing the Facilities Operations and Capital Projects departments together. New leadership and new department priorities opened the doors for further development of the department's existing GIS. At the time, GIS had been used for tracking university-owned real estate. While utility data was populated in the GIS, it had not been incorporated into the departmental workflow.

Developing a Solution

The goal was simple: create an easy-to-use mobile app so that all staff could view and query the same geospatial data as well as contribute information back into the university's GIS.

To accomplish this required upgrading ArcGIS for Server from 9.3 to 10.2.1. In addition to the many benefits of the newer architecture, upgrading was necessary so staff could perform data edits and data collection using feature services, which were available with 10.2.1.

Creating a user interface that would make for a rich and inviting user experience was a top priority. Getting people who were more comfortable with paper maps to use the mobile app was already a challenging proposition. Facilities Services wanted them to not only use the app but also use it to correct data.

Luckily, Facilities Services was already using Microsoft Silverlight and the Expression Blend IDE, so creating a unique and engaging user experience was relatively easy.

Embracing the use of touch screens for the app was important so users could make edits to utility data in the field on a tablet device. Menu items had to be easy to select and interact with while holding the tablet. The menu structure allows users to choose all menu and menu subitems using their thumbs. This not only made the app easy to use, but also allowed the maximum amount of screen real estate for the map.

The menus were designed as a stack of cards located off screen. To transition between menus, clean, fluid animations "fly" the card in and out of view as needed. Using this method had the added benefit of creating infinite scalability because the app isn't limited to a finite menu content area. If menu content is needed, a new card flies in. It flies out when the user is done with it. App functionality can be continually added without constant reworking of the entire user interface—another bonus. It also makes for an engaging and entertaining user experience.

Creating Familiarity

Good design only goes so far when enticing people to use an app. This is especially true when users' accustomed workflow must be replaced with a new one. In this case, users had kept their own paper utility maps with handwritten markups (redlines) for many years. Showing them an app containing different map data wasn't going to cut it.

To get around this, the paper maps users had been working with were scanned and georeferenced by an intern so they could be converted to a mosaic dataset. After publishing this mosaic dataset as an image service, users could view their old maps in the new app. This created instant familiarity. The added bonus was that it allowed everyone in the department to see all the maps for the first time. Previously, these maps were available only to a small group in the organization.

Starting to Correct Bad Data

Policy changes on how as-built drawings were handled and incorporated into records after a project is completed were a necessary first step for correcting current and future WSU utility data. However, this didn't address the many decades of sporadic and missed updates to utility maps.

The GIS team consists of just two full-time employees and several student interns, so there was no way they could update errors in old records while keeping up with new construction projects. The team turned to crowdsourced cartography. Facilities Services staff members know the utility systems better than anyone and could update the maps while they worked out in the field. Data could be fixed efficiently and accurately while providing everyone in the organization with access to the corrections immediately.

Corrections made in the field are called redlines. When a utilities crew member finds a feature in the field that isn't in the GIS, that feature can be added by simply opening up the Redlines menu in the app, selecting the appropriate utility system, selecting the component to add or remove, and placing the feature on the map. The user can also add attributes to the new feature.

Redlines are saved to their own feature class in ArcSDE and appear on the map as red symbols. This lets any user know that this is a redline feature that has not had its exact location verified or committed to the permanent record.

The CAD manager, using a specially designed GIS dashboard, can see when a redline feature has been recorded. He investigates the addition or deletion to determine if it exists in an old as-built drawing that was never incorporated into the GIS. If he is unable to find any record of it, he sends out a student intern with a GPS unit with centimeter accuracy to capture its exact location. Next, using AutoCAD Map 3D, he transfers the redline feature into the proper ArcSDE feature class.

It's an easy, efficient, and effective process. Using this method, 118 features in one system were located and corrected in just four days. What's more, crews now have the power to make a difference for the whole organization.

Filling in Data Voids

Crowdsourced cartography has proved extremely successful in correcting project-related changes from the past. However, the time it takes to receive as-built drawings after a major construction project is completed was still an issue. Depending on the complexity of a project, it may take years to receive the as-built drawings. This delay can lead to situations in which Facilities Services has performed remodeling to a facility before it has received the original as-built drawing.

To fill this data void required coming up with a different way for showing project-related changes to the utilities systems for a site. The latest construction set civil drawings were turned into an image service by scanning them and displaying them in the app. This let users overlay GIS data onto the civil drawings and see what changes were potentially made to utilities for that site. By showing the complete civil drawing, the user can see that it was part of the construction set and not an official as-built drawing.

Results

The app took a year to develop and has been deployed for eight months. To date, approximately 200 users have been trained, and there are more than 175 active users of the GIS. GIS is accessed by all four main campuses and used as a planning and discussion tool during meetings. By spending extra time designing an inviting and intuitive user experience and adding features like access to old paper maps, the app easily met the goal to have it adopted within the organization. There are plans to release GIS offerings to other WSU departments and continue incorporating GIS into departmental workflows across the university.

Future Development

Because Silverlight is classified as a mature technology, WSU is planning to develop a new app using ArcGIS .NET API. Using this new Esri technology should greatly enhance data collection efforts by letting users take maps and data offline. In addition, the .NET API allows developers to tap into device hardware, such as an internal GPS receiver or a laser range finder connected by Bluetooth.

For more information, contact Bob Nichols at bob.nichols@wsu.edu.

About the Author

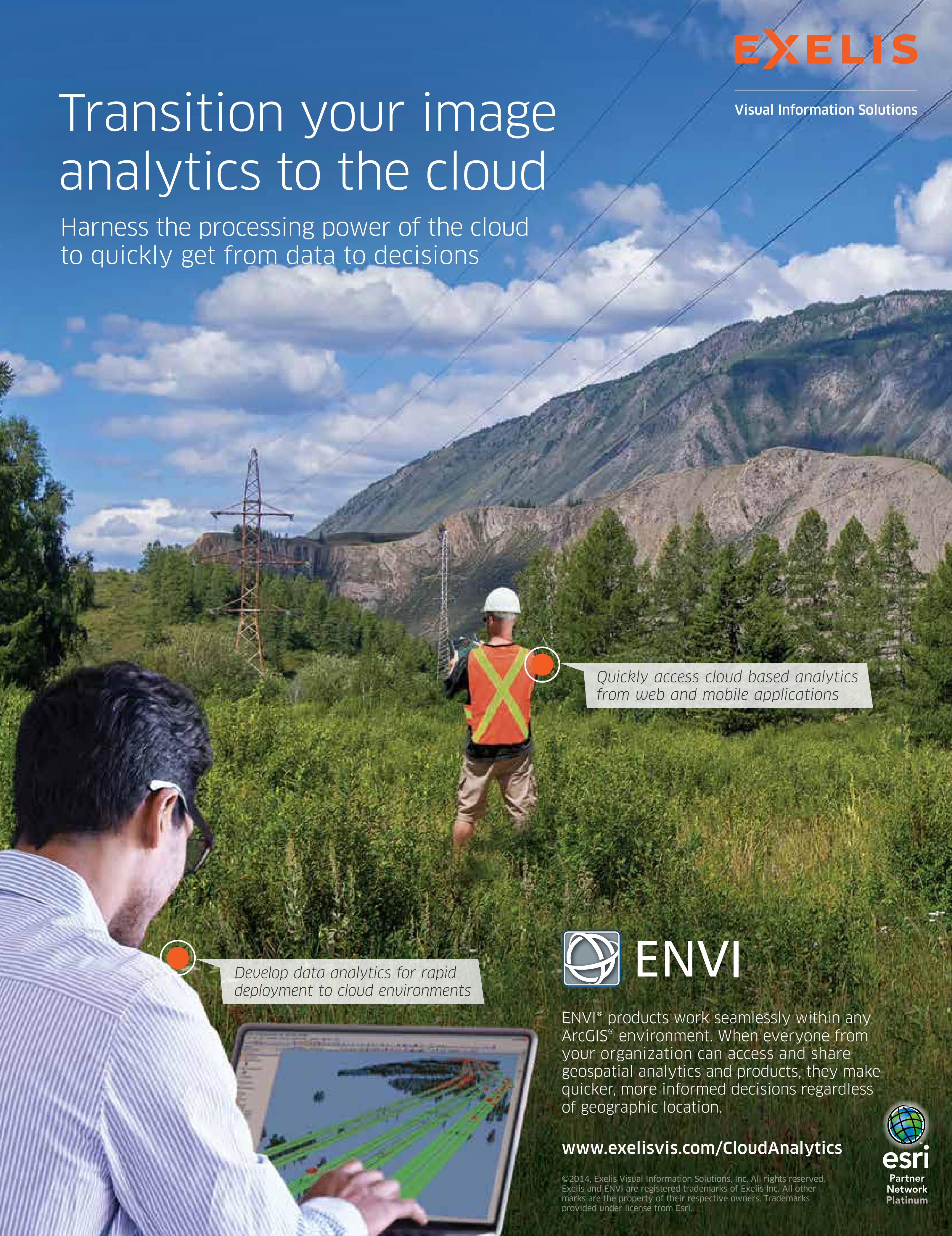
Bob Nichols is the GIS applications developer for the Facilities Services, Campus Mapping and GIS division at WSU. He is responsible for development of the university's GIS.

About WSU

Washington State University (WSU) was founded in 1890 as Washington State's Land Grant institution. It operates statewide with four campuses, five research and extension centers, four research and extension units, and one research station. WSU is home to more than 26,000 undergraduate, graduate, and professional students. The main campus is located in rural eastern Washington in the small town of Pullman. Due to the size of the main campus, WSU owns and operates its own utilities with the exception of a few natural gas and electrical lines shared with a local utility provider. This adds up to over 70 miles of streets and sidewalks, 43 miles of electrical lines, 22 miles of steam lines, 30 miles of freshwater lines, and more than 6 miles of chilled water lines making WSU—in many ways—its own municipality.

↑↑ Users can overlay current GIS data over construction civil drawings to see what changes to utilities will happen over the course of a building project.

↑ By letting crews redline utility information while out in the field, decades of missed changes to utility system maps are being quickly and easily corrected.


EXELIS
Visual Information Solutions
Transition your image analytics to the cloud
Harness the processing power of the cloud to quickly get from data to decisions
Quickly access cloud based analytics from web and mobile applications
Develop data analytics for rapid deployment to cloud environments
ENVI
ENVI® products work seamlessly within any ArcGIS® environment. When everyone from your organization can access and share geospatial analytics and products, they make quicker, more informed decisions regardless of geographic location.
www.exelisvis.com/CloudAnalytics
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Tackling Business Risk with GIS

By Jerry Biedenbender and Jordan Hamm, Sanitation District No. 1 of Northern Kentucky

Using GIS to comply with state and federal regulations led a sewer utility to develop a greatly improved maintenance program that intelligently prioritizes work on its system based on business risk.

In 2005, Sanitation District No. 1 of Northern Kentucky (SD1) entered into a consent decree with state and federal environmental regulators to address overflows in Northern Kentucky's wastewater collection system that generally occur during wet weather events and to ensure compliance with the Clean Water Act.

SD1 is a regional sewer utility that serves three of the northernmost counties in Kentucky. The settlement, negotiated among the US Environmental Protection Agency (EPA), Kentucky's Environmental and Public Protection Cabinet, and Sanitation District No. 1, calls for a 20-year plan to improve the area's waterways by addressing raw sewage overflows from the combined and separated sewer systems within SD1's service area.

As part of the consent decree, SD1 entered the capacity, management, operations, and maintenance (CMOM) program. This program states that SD1 must inspect all sewer pipes once every 10 years. Prior to entering the consent decree, SD1 operated with a relatively reactive approach. It inspected only problem pipes or pipes in areas with known issues. Naturally, as the number of inspected pipes increases, the number of known pipe-related issues increases. This additional information about the condition of the system makes for a very busy maintenance program.

What Are the Consequences?

Historically SD1's maintenance program was driven by a probability of failure (POF) score. It can be closely compared to the more commonly known Pipeline Assessment Certification Program (PACP) score. PACP is a score of the pipe's structural condition based on a visual coding assessment. When a pipe fails, the flow stops. The POF score indicates how likely it is that this will happen.

With the assessment program maturing and over 50 percent complete, there was a need for a more refined assessment of the overall risk. Over 50 percent complete meant that SD1 had more than 27,000 pipes with a POF score. Prioritizing rehabilitation schedules became time-consuming and overwhelming, especially when trying to take into account the impact of a pipe failure on the community.

The decision was made to generate a business risk exposure (BRE) score for all pipes. A BRE score calculates the nature and level of exposure that an organization is likely to confront if a specific asset or group of assets fails. To generate a BRE score, the POF score is combined with a consequence of failure (COF) score. The COF was the only missing puzzle piece. As defined by the US EPA, the COF score is the real or hypothetical results associated with the failure of an asset. In other words, the COF score establishes the level of impact each asset would have on the community if it were to fail.

Laying a Strong Foundation

A building is only as strong as the foundation it is built on. This is true with regard to work processes as detailed as determining the COF. If the data collection and calculation procedure is strong, the overall result will be solid. With this principle in mind, SD1 began the COF data process by breaking the project down into several phases: setting categories and collecting, processing, and scoring data.

The first phase involved choosing the categories that would provide the basis for the overall criticality of the pipe asset. With the aid of a local consultant, the categories chosen were cost, social/health, and environmental. Each category consisted of specific criteria. For example, diameter, depth, surface, and overflow backup were the critera assigned to the cost category. This first phase provided the driving force behind the other phases of the process.

Data Collection

In the next phase, local and state resources were used to collect all the data needed to successfully run the COF. The geospatial locations of police, school, fire, and hospital buildings were necessary to calculate the proximity of each pipe asset to each building. Having this data in place was very helpful and contributed to a strong foundation for the COF process.

Geoprocessing with ModelBuilder

With the foundation laid and data collected and stored, it was time to begin the processing phase. This phase had two main objectives: figure out the most efficient way to process the data and accomplish processing in a manner that could easily be repeated at regular intervals. ModelBuilder, a component of ArcMap in ArcGIS for Desktop, satisfied both of these goals.

Using ModelBuilder, a variety of geoprocessing tools were strung together to create complex processes that built on successive results. For example, the Near geoprocessing tool was used to collect attributes such as the distance of a pipe asset from a school, railroad, or park. With this data, a score was created based on an asset's proximity to a critical feature. The closer an asset was to a critical feature, such as a school, the higher the score it received because the consequences of pipe failure would be more significant.

↑ Analysis using only POF scoring

↑ Analysis using only COF scoring

↑ Analysis that combines POF and COF scores yielding a business risk, or BRE, score

Scoring with ModelBuilder

As mentioned previously, the COF process used three categories: cost, social/health, and environmental. These categories employed nine criteria. In this phase, attributes were associated with criteria using geoprocessing tools and ModelBuilder. Based on those attribute values, scores between 1 and 5 were assigned, with 5 representing the highest consequence of failure. For example, pipe diameter was a criteria in the cost category. Pipes that were 8 inches or less in size were given a score of 1, whereas pipes that were greater than 36 inches were given a score of 5.

Next, using the Calculate Features geoprocessing tool and ModelBuilder, each criteria was scored and weighted. The criteria of each category was then totaled and weighted to give each category a weighted score. A combination of weighted criteria scores and weighted category scores was used to calculate an overall COF score. This COF score was then added to the POF score to yield the final result, a BRE score.

Overcoming Obstacles

For any process to run well, data consistency, data integrity, and data accuracy are vital characteristics. During the COF process, SD1 met a few obstacles that had to be overcome so the entire dataset would possess these qualities.

Data Consistency

As a regional sewer utility, SD1 relies on geospatial data from three separate sources. These sources sometimes arrange data differently. The ArcGIS Data Interoperability extension was used to make the data consistent for internal users and data processes such as the COF.

Data Integrity

Two of the criteria the COF relied on were diameter and depth. While pipe assets generally contain these two attributes, a number of assets had zero values for either one or both of these fields. By creating models that used geoprocessing tools such as Select Layer by Location and Summary Statistics, this problem was overcome. The model selected each zero-value pipe, and then selected the pipes within a 100-foot buffer of the zero-value pipe to summarize the average depth or diameter of those pipes within the buffer. Next, using the Get Field Value tool, the average value was grabbed from the summary table. That average value replaced the zero value, thus giving satisfactory data for the COF criteria.

Data Accuracy

Another model gave each building in the SD1 service area an elevation value. The model ran the Spatial Join tool combining the fields from the contour layer, which held elevation values, and the building layer. However, the resultant data contained a number of buildings that lacked elevation values because the building polygon had not intersected a contour line. This was solved by modifying the existing model by adding a For iterator so the model ran a total of six times. Each time it ran, the model used the values 0-50, iterating by intervals of 10, for the Within a distance of option in the Spatial Join tool. The output yielded building elevations for the vast majority of buildings, thus satisfying this piece of the COF process.

Present and Future Uses

Combining the score data generated from the COF process with the existing POF data created a BRE score for the pipe assets. Now equipped with this score, the Asset Management team at SD1 has been using this data since June 2014 to make more informed decisions with regard to rehabilitation and maintenance of SD1 assets.

Being able to tackle a project of this magnitude using in-house staff aided by GIS technology contributed to the success of this process. The power behind a tool like ModelBuilder shows what any GIS user—with a little training, time, and backing from upper management—can accomplish.

SD1 plans to expand this process to all company assets. After all assets are inventoried, SD1 will use this same process to create a district-wide business risk assessment. This will be used to aid in decision making during SD1's budget season with the goal of identifying which departments are at a greater risk so funds can be budgeted accordingly.

For more information, contact Jerry Biedenbender at jbiedenbender@sd1.org or 859-547-1655 or Jordan Hamm at jhamm@sd1.org or 859-578-6761.

About the Authors

Jerry Biedenbender, GISP, a 2007 graduate of Northern Kentucky University, is the GIS coordinator at SD1, located in Fort Wright, Kentucky.

Jordan Hamm works as a GIS analyst for SD1. He has been employed by SD1 in the GIS department for more than 15 years.

Managing More than 9,500 Traffic Signs Using GIS

By Jim Baumann, Esri Writer

To effectively manage its more than 9,500 local traffic signs, the public works department for the city of Ames, Iowa, uses a new, custom, GIS-based sign management app called GISAssets.

Appropriate signage minimizes accidents and provides clear directions to anyone driving through the city with a population of more than 59,000. The city's signs must conform to state and federal standards, as outlined in the Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices* (MUTCD).

Ames partnered with DGTex, Inc. to create the GISAssets app, which was built on ArcGIS Runtime SDK for iOS and runs on the Apple iPad. The app, available from the Apple App Store, is used to collect data, such as traffic sign inventories and asset information, from the field and integrate that information and other remotely collected data with the department's geodatabase, which is managed using ArcGIS for Server.

Ben McConville, GIS manager in the city's public works department, has been using ArcGIS for asset management for many years. "Street signs are a challenge to accurately manage," said McConville. "You would think it is a fairly straightforward procedure; however, there are normally multiple assets at the same location."

He said that in addition to the signpost, the department must manage the three or four signs that are attached to it. "So, at that location, your database will include maintenance histories, accident reports, and retroreflectivity records for each sign as well as the post," McConville said. "In addition, there are replacement and maintenance schedules and vegetation management procedures related to the assets at that same location."

Dominic Roberge, GIS specialist for the city, worked hand in hand with traffic maintenance staff and developers at DGTex to design the application and database schema. "I spent a great deal of time identifying the needs of the crews and exactly what gaps the application needed to fill," said Roberge. "Among them were the need for bar coding and the ability to handle complex relationships. I then designed the database schema to accommodate these needs and published the web services accordingly."

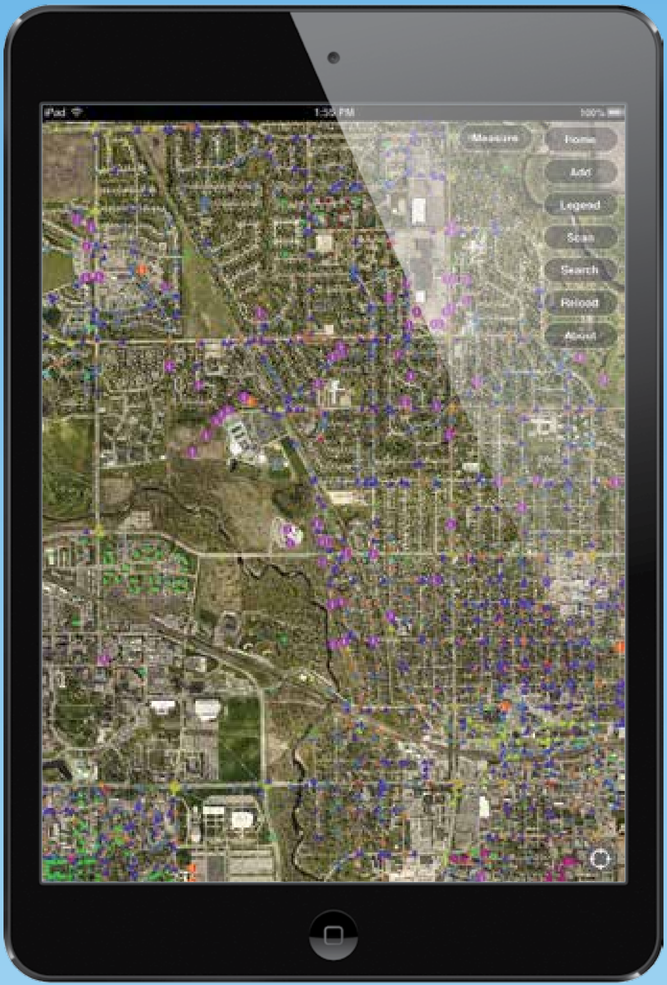
The city uses a RoadVista model 922 retroreflectometer to measure the reflectivity of each of its signs, required for the federally mandated retroreflectivity survey. In addition to measuring reflectivity, the device records a sign's GPS coordinates and reads the bar-coded label attached to it for identification purposes.

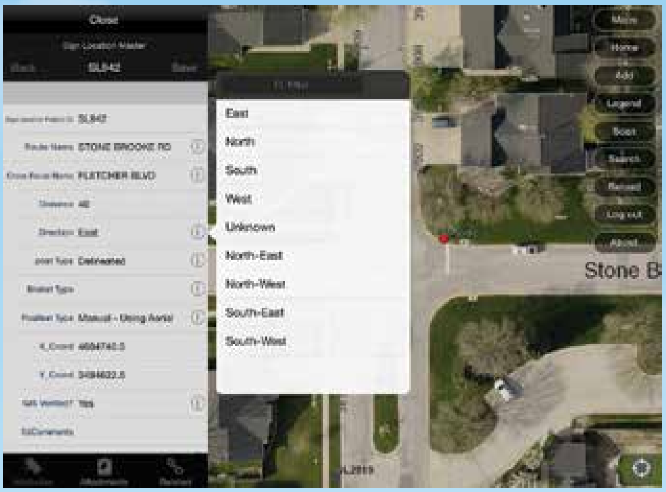
Sign Management Challenges

Signs are frequently knocked down in vehicular accidents, vandalized, or hit by snowplows. "Often the signs are simply dropped at the maintenance shop by law enforcement or maintenance crews with no explanation of where they may have come from," said Bill Latham, an Ames traffic maintenance worker. "By using bar coding, staff can easily see exactly which sign it is and where it came from, making it easy to reset."

Back in the office, the data recorded by the retroreflectometer is downloaded to the GISAssets app, which uses the sign's bar code for reference. The application then performs a join to the department's geodatabase, and the field data is automatically added to it. This helps centralize all remotely collected data with the geodatabase.

Because each sign's reflectivity data and history are





↑↑ GISAssets provides access to attachments and multiple levels of related features.

↑ GISAsset's intuitive user interface provides access to critical information at nearly all levels.

← Photos taken in the field can be attached to the geodatabase and provide information not contained in the attributes.

now part of the database, the city's traffic department can easily check to see if a specific sign is in compliance with the MUTCD. Public works staff can perform this verification process in the office or in the field, which saves both time and money.

"During city construction activities, GISAssets has proved to be extremely helpful," said Terry J. Keigley, another Ames traffic maintenance worker. "Contractors often remove entire blocks of signs prior to construction. Sign crews are now able to easily reset the signs in the exact location with no measuring. The GPS typically gets us close enough to where we can find the existing hole or stem to place the sign on."

Before using this app, the Ames public works department was faced with bulk replacement of its signs in a specified area every five years to comply with FHWA mandates. Field crews can now evaluate these assets sign by sign and then send this information to the geodatabase back in the office, where a determination is made to repair or replace a sign and a work order is issued.

Additional Functionality

The iPad provides additional functionality, such as messaging between workers and sending broadcast e-mails, that is improving the department's workflow. Field-workers can also take a photograph or video of an emergency situation, such as a water main break, and send those images to the engineering department for evaluation.

Photos can be attached to the geodatabase. "The ability to easily attach pictures is a huge benefit," said Brad Becker, traffic signal lead technician. "Pictures are a great tool to help us see what information may not be in the attributes. For example, not every MUTCD code indicates what the exact wording is on the sign. By looking at the picture, we can easily see."

"Centralizing all our public works asset data has really been a big benefit to us," said McConville. "Previously, there was a lack of integration and field connectivity, which made work tracking and inventorying difficult."

The GISAssets app has sparked interest from other departments and is increasing the use of ArcGIS in Ames, particularly because the city has an Esri enterprise license agreement (ELA). "The ELA has opened up a ton of doors for us," said McConville. "It's given us the opportunity to really explore what we can do with GIS."

The Next Phase

The Ames public works department is expanding its use of the GISAssets app by making greater use of its bar-coded reading capability. "Adding bar coding to all our public works assets makes it much easier for crews to immediately identify an asset in the field, determine its condition, and then send that information back to the geodatabase for further review," said McConville. "It will really help streamline our field crews' work and continue to keep our geodatabase up to date."

For more information on the GISAssets app, contact Ben McConville, City of Ames at 515-239-5162 or bmcconville@city.ames.ia.us.

← Community members tend a Green Belt Movement tree nursery in Tumutumu Hills, Kenya. Johnson Kosgei was the conservation organization's first GIS analyst, introducing geospatial data strategies that increased efficiencies and improved outcomes.

Photo courtesy of Marlboro Producations/www.takingrootfilm.com

FOSTERING POSITIVE ORGANIZATIONAL CHANGE

Evangelist shares his best practices for introducing GIS

By A. J. Mangum

When Johnson Kosgei was a teenager growing up in Kenya in the 1990s, a postal services company donated to his high school a decommissioned IBM mainframe. This cast-off piece of hardware was Kosgei's first exposure to a computer, and the machine's potential fascinated him, awakening an obsession with using technology to better understand the world.

He was one of the first graduates of the geomatic engineering program at Kenya's Jomo Kenyatta University of Agriculture and Technology. There he focused on remote sensing and benefited from the university's Esri-funded remote-sensing lab. Kosgei began his career as a GIS consultant for the World Agroforestry Centre. That role led him to volunteer as the first GIS analyst for the Green Belt Movement (GBM), a Nairobi-based conservation and economic development organization. He introduced GIS technology to the organization, developing strategies for its successful implementation and training field staff in mapping and GPS fundamentals. This inspired him to pursue a master's degree in GIS at the University of Redlands, where he focused on the tenets of successfully integrating geospatial technology into existing organizations.

Today, Kosgei is a GIS specialist for the energy drink company Red Bull. The first person to hold such a title at the company, Kosgei has pioneered its geospatial data initiatives and led its efforts to integrate GIS into sales, marketing, and distribution.

Kosgei's track record of successfully implementing GIS in blank slate environments—those in which the technology hasn't previously been used—has shaped his reputation as an authority on fostering positive organizational change, converting resistant skeptics into enthusiastic advocates, and enabling businesses and other organizations to fully embrace the transformative power of GIS without sacrificing preexisting operational models.

"One of the mistakes *[GIS specialists]* make is believing there's a blanket approach to organizational change," Kosgei said. "It always depends on the organization's business and political landscape. Without paying attention to what makes the organization tick and the opportunities around that, it becomes more challenging to implement change."

In organizations unfamiliar with GIS, advocacy for its adoption must center on specific, bottom-line benefits, rather than abstract explanations of the technology. Kosgei shared his strategies for effectively introducing GIS to business, nonprofit, and governmental environments.

Strategies for Introducing GIS

Kosgei asserts that advocates for GIS adoption or expansion should begin their lobbying efforts with the hard work of intelligence gathering. They should develop a solid understanding of their organization's culture through a SWOT assessment and extensive networking. *[SWOT is a methodology for evaluating the strengths, weaknesses, opportunities, and threats associated with a project or business venture.]* Spending time with would-be stakeholders will not only provide insight into their priorities and the ways in which GIS could apply to their roles but will also separate skeptics from potential technology champions.

"This information allows you to navigate the political currents rather than swim against them," Kosgei said, adding that, once audiences are identified, seeds can be sown. "Build GIS competency by citing examples and practical use cases and the associated benefits. The mind-set that's proved helpful in my endeavors is that GIS technology opens up opportunity and provides an enabling environment for end users to do what they do more effectively and efficiently."

Kosgei said that GIS advocates should be prepared to counter the notion that the discipline is purely about "putting points on a map." That perception, he said, not only diminishes the value of the field but also creates immediate barriers to justifying the costs of implementation. The presence or absence of such misconceptions is a reliable indicator of the level of GIS competency in an organization and the amount of capacity building—acquired through training, workshops, and seminars—that will be needed after implementation.

Kosgei suggested that technology proponents can equip themselves to combat such misconceptions most effectively by first gaining intimate knowledge of the organization's workflows, identifying specific steps that could be made more efficient by geospatial data analysis, and quantifying a return on an investment in GIS tools and training. In such lobbying efforts, identifying clear-cut, immediate benefits to the organization always trumps even the most passionate of conceptual or academic explanations of the technology.

"Voluminous documentation *[of GIS benefits]* easily appears cumbersome to stakeholders," he said. "One big mistake *[advocates make]* is stopping everything and focusing on a comprehensive long-term strategy. The success of a GIS initiative relies on the value it brings to an organization." That value can be addressing an existing problem, introducing elements of efficiency, reducing costs, or providing new insights to support fact-based decision making. Although a long-term vision is important, "It's paramount to focus on practical, sizable applications with clear deliverables. Tie technology application to the organization's bottom line."

Skeptics might fear that GIS adoption will require dramatic operational adjustments. Proponents can counter such concerns by crafting a GIS strategy appropriate for an organization's size, scale, and shape and by focusing conversations on Kosgei's theme of a nonthreatening, enabling environment.

↑ Johnson Kosgei, Red Bull's first GIS specialist, graduated from the University of Redlands Master of Science in Geographic Information Systems program.

Photo by William Vista provided courtesy of the University of Redlands.

"Remind skeptics that GIS seldom changes how a business operation is fundamentally run," he said. "Rather, it augments processes by providing new insights and tools to accomplish tasks at lower costs and more effectively. Of concern in the business world is the way GIS technology interplays with both existing technologies and existing structures and operations."

Kosgei noted that, "Not all problems can be solved using GIS, not all business applications need to be geoenabled, and not all workflows can be spatially enabled. But, seemingly small changes brought about by the technology can be of tremendous value. Capitalize on those changes as you continue to socialize with decision makers and technology champions."

Postimplementation, GIS managers should target areas of operation in which the technology can have immediate and significant impact. Identifying and prioritizing "low-hanging fruit" help ensure that at the end of each early undertaking, the added value of GIS can be readily demonstrated. This reassures supporters and helps erode any remaining skepticism.

"Accomplish one task at a time and start small, with short, precise, focused efforts," he said. "For example, emphasize distribution, *[employing GIS to]* assist in creating and balancing territories." In the early days after an organization's adoption of GIS, Kosgei also observed that its advocates should work to build internal capacity through training sessions and seminars that reinforce the imperatives of location analytics and empower fellow employees to integrate the technology into their own duties.

In environments in which skepticism continues to thrive, Kosgei said GIS advocates must go a step further. They must work to uncover and address the roots of such resistance. Detractors might be acting out of a fear of change, a fear of a loss of control, or simply an ongoing lack of understanding. In-house workshops can serve as forums in which action plans for successful resolutions can be forged.

A New Generation

Kosgei sees himself as part of a new generation of GIS specialists. He obtained his education in the field during an era of web GIS and web mapping, mobile GIS, cloud computing, online collaboration, and social media. Still, he remembers his own teenage awe at something as simple as an old, secondhand mainframe. In his evangelism for GIS, he works with great respect for the transformative potential of such "humble introductions" to the technology.

Before Kosgei became involved with GBM, the environmental organization did not use geoinformation technology. GBM undertakes reforestation projects, erosion-control endeavors, and environmentally friendly approaches to economic development ventures that range from beekeeping to food processing.

Kosgei introduced GIS to GBM and led the mapping of more than 3,000 hectares of deforested land so at-risk areas could be targeted and prioritized. This helped clarify the group's strategic direction. Mapped baselines of project sites offered ongoing points of comparison as work progressed, increasing accountability for GBM field personnel. In turn, projects were completed more efficiently in comparison to efforts in the organization's pre-GIS days.

Local communities that partnered with GBM were rewarded for their conservation efforts with payments for carbon-sequestration credits purchased by the World Bank Biocarbon Fund. (Such purchasers resell carbon credits to companies in carbon-emitting industries, thereby allowing those companies to lower their net emissions.)

The experience helped Kosgei see geospatial analysis as more than an information science; for him, GIS is a tool for creating positive social change. "Technology can significantly influence our integration with the environment and with each other, be it for business gain, improved governance, or the betterment of humankind," he said.

"I would like to make contributions beyond what I'm paid to do. I consider myself a technology enthusiast, and I desire to see it bring value in people's day-to-day lives. GIS capacities are opening up new opportunities to see and interact with our world, and I want to be on the forefront of that."

About the Author

A. J. Mangum is a Colorado-based writer, editor, publisher, and filmmaker.

Integrate GIS Functionality into Windows Apps with

ArcGIS Runtime SDK for .NET

By Rex Hansen, Esri ArcGIS Runtime SDK for .NET

The first commercial edition of the ArcGIS Runtime SDK for the Microsoft .NET Framework was released as version 10.2.4 in October 2014. ArcGIS Runtime SDK for .NET enables developers to build rich, high-performance GIS applications for Windows PCs, tablets, and phones. The SDK includes three APIs that support building .NET apps for Windows Desktop, Windows Store, and Windows Phone. The APIs share a common design and structure, which encourages sharing implementation logic across the Desktop, Store, and Phone platforms.

Features and functionality for the MapView discussed in this article include setting the map background, defining map interaction options, defining an initial map extent, building geometry, using graphics, working with shapefiles, and performing client-side labeling. This release of the .NET SDK also provides offline editing, security, and licensing options and an enhanced application deployment experience.

MapView

The ArcGIS Runtime SDK for .NET was designed to support the model-view-viewmodel (MVVM) workflows from the start. The relationship between the MapView and Map control exhibits this design. The MapView control is simply a container for a Map control that exposes display-related properties and interaction events.

The Map control is an object with a collection of layers and is designed to support binding scenarios where the map is maintained in a view model or model. The example in Listing 1 shows how easy it is to bind a map created in a view model to the Map property of a MapView. Note that the Map control contents are constructed within the view model and exposed via a public property, MyMap.

```
<Page.Resources>
        <local:MyViewModel x:Key="myViewModel" />
</Page.Resources>
<Grid DataContext="{StaticResource myViewModel}">
        <esri:MapView  Map="{Binding MyMap}" />
</Grid>
```

↑ Listing 1

MapView Background

To set the background for a map, use the MapView.MapBackground. By default, the map background is gray and contains a grid. To adjust this default, set the color, grid line color, grid width, and line width. Listing 2 provides an example in which the background color is set to light blue and the grid lines are made transparent.

```
<esri:MapView>
  <esri:MapView.MapBackground>
        <esri:MapBackgroundColor="LightBlue"
GridColor="Transparent" />
  </esri:MapView.MapBackground>
   . . .
```

↑ Listing 2

MapView Interaction Options

MapView has InteractionOptions to control interaction with a map using a variety of inputs. This includes enabling and disabling all interaction or just a subset of pan, rotation, and zoom options. For example, the XAML in Listing 3 demonstrates how a set of pan options are enabled, but the user cannot rotate or zoom in on a map in the MapView.

```
<esri:MapView.InteractionOptions>
  <esri:InteractionOptions IsEnabled="True">
        <esri:InteractionOptions.PanOptions>
                  <esri:PanOptions
                            IsEnabled="True"
                            IsDragEnabled="True"
                            IsFlickEnabled="True"
                            IsKeyboardEnabled="True">
                  </esri:PanOptions>
        </esri:InteractionOptions.PanOptions>
    <esri:InteractionOptions.RotationOptions>
      <esri:RotationOptions IsEnabled="False" />
    </esri:InteractionOptions.RotationOptions>
    <esri:InteractionOptions.ZoomOptions>
      <esri:ZoomOptions IsEnabled="False" />
    </esri:InteractionOptions.ZoomOptions>
  </esri:InteractionOptions>
</esri:MapView.InteractionOptions>
```

↑ Listing 3

Setting Initial Map Extent

Use Map.InitialViewpoint to set the startup extent to an envelope or a location and scale. The property can be set in XAML (Desktop only) or in code as shown in Listing 4.

```
map.InitialViewpoint = new Viewpoint (new Envelope _
    SpatialReferences.Wgs84));

map.InitialViewpoint = new Viewpoint (new MapPoint _
    (-105, 50, SpatialReferences.Wgs84), 1000000);
```

↑ Listing 4

Note that the initial viewpoint can be in a different spatial reference than the map. For example, you can define a startup extent in WGS84 while the map spatial reference is set to Web Mercator. The initial viewpoint will be projected to the map's spatial reference on the fly.

Creating Geometry

You can use a constructor or a builder to create geometry. In most cases, the constructor is the most efficient and reliable technique. As shown in Listing 5, you can start with a point collection when creating a new polygon.

```
PointCollection coords = new PointCollection();
coords.Add(new MapPoint(center.X - halfLen, center.Y + _
    halfLen));
coords.Add(new MapPoint(center.X + halfLen, center.Y + _
    halfLen));
coords.Add(new MapPoint(center.X + halfLen, center.Y - _
    halfLen));coords.Add(new MapPoint(center.X - halfLen, _
    center.Y - halfLen));
coords.Add(new MapPoint(center.X - halfLen, center.Y + _
    halfLen));

Polygon polygon = new Polygon(coords, _
    SpatialReferences.Wgs84);
```

↑ Listing 5

↑ Change the default background using MapView.MapBackground.

However, if geometry needs to change, use a builder. The code in Listing 6 changes the coordinate of the first point in the polygon. Use this example as a guide. Whether using a constructor or a builder, be sure to define the spatial reference when creating geometry as shown.

```
PolygonBuilder builder = new PolygonBuilder(polygon);
builder.Parts[0][0] = new LineSegment(new MapPoint(x1, y1), _
    builder.Parts[0][0].EndPoint);
polygon = builder.ToGeometry();
```

↑ Listing 6

Graphics Overlays

Graphics overlays enable the display of transient spatial data, such as query results or buffer polygons, as graphics on top of a map (but beneath map overlays). Graphics overlays can persist apart from a map, and graphics in an overlay will be reprojected on the fly to accommodate changes to the underlying map's spatial reference.

To render a large number of graphics, set the rendering mode to static. When the rendering mode is static, graphics will not refresh until map navigation has stopped, but map responsiveness is retained. For a more fluid graphic rendering experience during navigation, set the rendering mode to dynamic.

Because graphics overlays are not in the map, graphics in overlays will not appear in a map's legend or be displayed when the map is printed. Listing 7 shows a GraphicsOverlay in XAML with renderer, selection color, rendering mode, and label properties defined. Graphics must be added to the graphics overlay in code.

```
<esri:MapView>
  <esri:MapView.GraphicsOverlays>
    <esri:GraphicsOverlay Renderer="{StaticResource
myRenderer}"
            RenderingMode="Static"
SelectionColor="Yellow"
            >
      <esri:GraphicsOverlay.Labeling>
        <esri:LabelProperties>
          <esri:AttributeLabelClass
TextExpression="[NAME]">
            <esri:AttributeLabelClass.Symbol>
              <esri:TextSymbol Color="Black" />
            </esri:AttributeLabelClass.Symbol>
          </esri:AttributeLabelClass>
        </esri:LabelProperties>
      </esri:GraphicsOverlay.Labeling>
    </esri:GraphicsOverlay>
  </esri:MapView.GraphicsOverlays>
  <esri:Map>
    <esri:ArcGISTiledMapServiceLayer ServiceUri="http://
services.arcgisonline.com/arcgis/rest/services/
```

```
World_Topo_Map/MapServer" />
  </esri:Map>
</esri:MapView>
```

↑ Listing 7

Working with Shapefiles

The .NET SDK supports direct read of shapefiles for display in a map as a feature layer. Listing 8 shows how to add a shapefile to a map in code (adding shapefiles in XAML is not supported). A default renderer is provided. Set the renderer on the feature layer to change symbology.

```
string filename = @"C:\data\world-continents.shp";
Esri.ArcGISRuntime.Data.ShapefileTable table = _
    await Esri.ArcGISRuntime.Data.ShapefileTable. _
    OpenAsync(filename);
FeatureLayer layer = new FeatureLayer(table);
mv.Map.Layers.Add(layer);
```

↑ Listing 8

Shapefiles do not support editing. Calls to add/update/delete operations will throw a System.NotSupportedException. Also, shapefiles do not support reprojection on the fly. The spatial reference of the map and the shapefile must match for features in the shapefile to be visible.

To reproject a shapefile manually, wait until the spatial reference of the map is set, iterate through features in the shapefile, reproject to the map spatial reference, and add the shapefile features as graphics to a graphics layer or overlay. The code in Listing 9 shows simple conditional logic to determine if shapefile contents need to be displayed as graphics or features. If using a graphics overlay, a renderer must be defined.

```
Esri.ArcGISRuntime.Data.ShapefileTable table = _
    await Esri.ArcGISRuntime.Data.ShapefileTable. _
    OpenAsync(filename);

if (table.SpatialReference != mv.SpatialReference)
{
  var items = await table.QueryAsync(new Esri. _
    ArcGISRuntime.Data.QueryFilter() { MaximumRows = _
    1000});

  GraphicsOverlay overlay = new GraphicsOverlay()
  {
    GraphicsSource = items.Select(f => new Graphic _
        (f.Geometry, f.Attributes)),
    RenderingMode = GraphicsRenderingMode.Static
  };

  // Define renderer for graphics overlay
  overlay.Renderer = myRenderer;
  mv.GraphicsOverlays.Add(overlay);
}
else
{
  FeatureLayer layer = new FeatureLayer(table);
  mv.Map.Layers.Add(layer);
}
```

↑ Listing 9

It is important to note that QueryAsync will load the entire shapefile into memory. The code example in Listing 9 also shows how to limit the number of features returned using the MaximumRows property. You can use this technique to control the number of features, and thus memory, used in your application.

Client-Side Labeling

Client-side labeling supports feature layers and graphics overlays. If a feature layer references a layer in an ArcGIS service (either map or feature) that defines label info, it will be honored. The API supports defining label properties to manage duplicates, text wrapping, scale limits, placement, position, and the text symbol to use for display—all on the client.

In addition, labeling can be enabled or disabled completely on the MapView. In the example in Listing 10, label properties are defined on a feature layer that contains parcel polygons. Label text uses the attribute value in the "APN" field and places the label horizontally in the center of the polygon but will reposition the label for a best fit. If unable to place, then the label will be removed.

```
<esri:MapView>
  <esri:MapView.Labeling>
    <esri:ViewLabelProperties IsEnabled="True" />
  </esri:MapView.Labeling>
  <esri:Map>
    <esri:ArcGISTiledMapServiceLayer
ServiceUri="http://services.arcgisonline.com/arcgis/rest/
services/World_Topo_Map/MapServer" />
    <esri:FeatureLayer>
      <esri:ServiceFeatureTable
ServiceUri="http://serverapps102.esri.com/arcgis/rest/ser-
vices/AnaheimParcelsSmallLabels/MapServer/0" />
      <esri:FeatureLayer.Labeling>
        <esri:LabelProperties IsEnabled="True">
          <esri:AttributeLabelClass TextExpression="[APN]"
                 LabelPlacement="PolygonAlwaysHorizontal"
                 LabelPosition="RepositionOrRemove">
          <esri:AttributeLabelClass.Symbol>
               <esri:TextSymbol Color="Black"
                  BackgroundColor="White" />
            </esri:AttributeLabelClass.Symbol>
          </esri:AttributeLabelClass>
        </esri:LabelProperties>
```

```
      </esri:FeatureLayer.Labeling>
    </esri:FeatureLayer>
  </esri:Map>
</esri:MapView>
```

↑ Listing 10

Offline Editing

Use sync-enabled feature services hosted by ArcGIS for Server (version 10.2.2 or higher) and ArcGIS Online to generate local geodatabases with editable feature tables. Local geodatabases can be generated on the fly at runtime or provisioned beforehand and made available on a device. The local geodatabase contains feature tables that can be displayed on a map and features that can be added, updated, and deleted. To apply local edits to a feature table in a geodatabase hosted by a remote feature service, merely synchronize local changes when a connection to the remote service is available. The code example in Listing 11 shows a simplified workflow for creating a local geodatabase from a sync-enabled feature service and then synchronizing changes with the service.

```
// Create a new task that will be used to generate a
local geodatabase from a sync enabled feature service.
GeodatabaseSyncTask syncTask = new
GeodatabaseSyncTask(new Uri("http://sampleserver6.
arcgisonline.com/arcgis/rest/services/Sync/SaveTheBaySync/
MapServer"));
// Generate the local geodatabase. Input variables in-
clude generation parameters such as sync model and layer
queries,
// time span to check progress on the asynchronous re-
quest, and details on progress.
// When complete, an action handles the result and re-
turns details on where the geodatabase is available for
download.
GenerateGeodatabaseResult result = await syncTask.Generat
eGeodatabaseAsync(options, completionAction,
TimeSpan.FromSeconds(3), generationProgress,
 CancellationToken.None);
// Sync changes in the local geodatabase to the feature
service. Input variables include the local geodatabase,
time span
// to check progress on the asynchronous request, and
details on progress. When the changes (deltas) in the
local geodatabase
// are up uploaded, and optional action can capture the
result to determine success or failure. When sync is
complete,
// an action handles the result and returns details on
the success of failure of the operation.
await syncTask.SyncGeodatabaseAsync(gdbTable.Geodatabase,
completionAction, deltaUploadAction,
          TimeSpan.FromSeconds(3), syncProgress,
          CancellationToken.None);
```

↑ Listing 11

↑ Client-side labeling supports feature layers and graphics overlays.

Keep in mind that the edits that are last committed (synced) to the service will overwrite previously committed edits, even if committed edits were made at a later time.

Security Options

Accessing secure resources is easy and flexible. Here is a list of the key characteristics of IdentityManager and its related components. IdentityManager is active by default.

IdentityManager's challenge delegate has been replaced with a challenge interface, IChallengeHandler. The API also includes a ChallengeHandler class that implements IChallengeHandler and the constructor can be passed a method that matches the interface definition required to handle a challenge, shown in Listing 12.

```
IdentityManager.Current.ChallengeHandler = _
    new ChallengeHandler(CreateCredentialAsync);
. . .
public async Task<Credential> CreateCredentialAsync _
    (CredentialRequestInfo info)
{
  // get or create a credential
  return credential;
}
```

↑ Listing 12

The Windows Store platform includes Credential Picker, a standard UI for entering credentials. As a result, the default challenge handler (named DefaultChallengeHandler), which is included with ArcGIS Runtime SDK for .NET, is only supported for use with the Windows Store API. The Windows Desktop and Phone platforms do not have a standard UI for entering credentials at this time. The ArcGIS Runtime Toolkit for .NET contains examples of dialogs for entering credentials on both platforms that are available on GitHub (github.com/Esri/arcgis-toolkit-dotnet). See the SignInChallengeHandler class for more details. Customizing the UI for the SignInChallengeHandler requires modifying source code in the toolkit.

The DefaultChallengeHandler (Windows Store only) and SignInChallengeHandler for Windows Phone support use of a credential locker to store and retrieve credential details. The example in Listing 13 will cast the current challenge handler to DefaultChallengeHandler, enable saving credentials in the credential locker, and include an option in the UI for the user to opt into saving credentials and enable it by default. Since Desktop does not provide a credential locker out of the box, implementation for a credential manager (Desktop only) is included with the ArcGIS Runtime Toolkit for .NET on GitHub.

```
DefaultChallengeHandler dch = IdentityManager.Current.
ChallengeHandler as DefaultChallengeHandler;
dch.AllowSaveCredentials = true;
dch.CredentialSaveOption = Windows.Security.Credentials._
    UI.CredentialSaveOption.Selected;
```

↑ Listing 13

IdentityManager supports accessing resources on systems secured using ArcGIS tokens, OAuth, network authentication (e.g., Integrated Windows Authentication [IWA]), and client certificates. This includes secure resources hosted by ArcGIS for Server, Portal for ArcGIS, and ArcGIS Online. A set of classes is derived from Esri.ArcGISRuntime.Security. Credential to reference different types of security protocols. These include ArcGISTokenCredential, OAuthTokenCredential, ArcGISNetworkCredential, and CertificateCredential. During a challenge, use CredentialRequestInfo.AuthenicationType to determine the type of credential to create or return.

IdentityManager supports a global OAuth authorize component via the IdentityManager.Current.OAuthAuthorizeHandler property. The component must implement IOAuthAuthorizeHandler and contains logic for hosting the sign-in page and handling authorization results. Windows Store includes OAuth implementation with the DefaultChallengeHandler. The ArcGIS Runtime Toolkit for .NET contains sample handler implementations for entering credentials on both Phone and Desktop. See these samples on GitHub.

Licensing

A set of classes under Esri.ArcGISRuntime support the SDK licensing structure. By default, the SDK runs in developer mode. Running in developer mode results in a watermark on the map (text indicating the SDK is being used for development); debug messages when standard license functionality is used; and a message box when local server starts (Desktop only).

To run an app with a basic license, get a client ID from the ArcGIS for Developers site. Standard licenses are available for purchase in deployment packs. See the licensing documentation on the ArcGIS for Developers site for more details.

The code in Listing 14 shows the licensing code workflow executed on application startup. Note that once an application session is licensed, it cannot be unlicensed.

```
// Required for Basic and Standard license
ArcGISRuntimeEnvironment.ClientId = "<client id>";

// Standard license string from a deployment pack
ArcGISRuntimeEnvironment.License.SetLicense _
    ("<standard license string>");

// -OR-
// Standard license info when logged in as a named user
account to an ArcGIS Online organization or Portal for
ArcGIS
ArcGISRuntimeEnvironment.License.SetLicense _
    (portal.ArcGISPortalInfo.LicenseInfo);

// Initialize runtime with license details provided.
ArcGISRuntimeEnvironment.Initialize();
```

↑ Listing 14

Deployment Experience

Preparing an application for deployment is integrated with Visual Studio 2013 and 2012 editions (Express editions are not supported). To create a deployment, merely right-click a project in Solution Explorer and select Add ArcGIS Runtime Deployment Manifest.

This will create a Deployment.arcgisruntimemanifest file with a UI to enable or disable the inclusion of resources and components required for use by the application. The resources and components differ depending on the API. When you open the file or build the project, you will be prompted to include imports in your project file to support deployment and reload your project.

When the project is built, resources for deployment will be copied to the output folder for the project. The contents of the output folder can be distributed as a WPF application or used to build an app package for Store or Phone.

Next Steps

To learn more, go to the ArcGIS Runtime SDK for .NET section of the ArcGIS for Developers website (developers.arcgis.com/net), where you can download the product and browse system requirements, guide documentation, and API reference. Source code for an extensive toolkit, instructive samples, and demo applications are available on GitHub (github.com/Esri/arcgis-toolkit-dotnet) to enhance your development experience. For those developers who want to get started quickly with Visual Studio, Esri provides NuGet packages for both the core product and toolkit. Details about the NuGet packages and other tools and features can be found on the ArcGIS for Developers website.

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esri.com/hardware

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What Does It Take to Build a Smart Community?

By Chris Thomas, Esri Government Industry Manager

The term *smart city* has been gaining quite a bit of attention lately. Known by many names—livable community, sustainable city, resilient city, and even smart nation or subsets like safe city or healthy community—they share similar goals. The objective is to build a government that is more responsive, productive, efficient, transparent, and more engaged with its citizens.

At Esri, we have opted to embrace two terms: *smart communities* and *resilient communities*. Building smart communities reflects national, state, regional, and local governments' desire to improve quality of life. Building resilient communities relates to assisting governments in preparing for and recovering from man-made and natural disasters such as hurricanes, floods, earthquakes, economic collapse, or climate change.

There are a lot of smart approaches out there claiming to help build a next-generation smart community. However, most approaches only support large metropolitan areas or are focused on a single problem. After years of working in partnership with thousands of governments around the world and asking how we can really help, a clear path has emerged.

This approach will support governments regardless of size or geography. It delivers solutions that cover more disciplines across a government as a means of strengthening all government operations. Think of government as a platform. At its core, building smart communities involves working side by side with governments and professional trade associations to truly understand government needs.

There are four steps for creating a successful strategy to support smart communities.

1 Start with a world-class GIS platform.

The primary reason governments the world over have embraced GIS is that location is the most common denominator looked at when addressing a problem. The solution needs to serve GIS professionals, knowledge workers who simply use GIS, field-workers, decision makers, and citizens. It also needs to support the five major government workflows: collecting data, analyzing and performing what-if scenarios against information, improving operational awareness,improving field operations, and enabling civic engagement.

2 Develop a location strategy that allows governments to prioritize the GIS applications they need.

This needs assessment indicates a government's readiness to incorporate new solutions and how quickly it wants to make those changes. A government can begin by analyzing issues for the entire organization, department by department, or tackle a single department, such as law enforcement or health, to meet goals more limited in scope such as smart infrastructure, smart buildings, healthy communities, or safe cities.

3 Deliver real solutions that serve government priorities.

Governments know that their biggest challenges are often improving infrastructure, efficiency, productivity, and local economic conditions as well delivering green solutions. They hear regularly from or poll businesses and citizens on their priorities. These governments may not always have quick answers for solving these issues.

We have found that working side by side with governments and asking what apps they wish technology companies would build results in the development and delivery of apps that successfully meet real needs. These apps are honed by working directly with governments on design and testing. Once completed and tested, the solutions are given back to governments at no charge. These apps can be deployed immediately and tailored over time.

4 Develop strong relationships with business partners.

Partners can deliver sophisticated solutions for permitting, crime analysis, asset management, and climate analysis, for example, that are built on top of a strong GIS platform. They can extend customized solutions that scale with a state, municipal, or regional government over time.

To see the results of this approach, explore these smart community offerings at esri.com/smartcommunities. Begin building a smart community today.

No User Left BEHIND

By Curtis Hinton, Geographic Technologies Group, and John Martineau,
City of Rio Rancho, New Mexico

A city in New Mexico has transformed its GIS into an enterprise implementation in a relatively short time, aided by enterprise licensing. Located just north of Albuquerque, Rio Rancho has a population of 92,000. Like many other cities, Rio Rancho's GIS had developed in departmental silos, with Public Works and Development Services leading the way. After a decade of uncoordinated use, the city understood that GIS was becoming more instrumental to service delivery. Therefore, the city embarked on a strategic planning process with the goal of advancing and coordinating GIS enterprise-wide.

Late in 2012, the city promoted John Martineau to the role of GIS manager. At the outset, Martineau determined that he wouldn't be satisfied unless the GIS was doing everything that it could to advance service delivery in every department. He understood that GIS was not a standalone technology. His goal was to have GIS become the portal into all city data—spatial and nonspatial. The city partnered with Esri Gold Tier Partner Geographic Technologies Group (GTG) to achieve this goal.

Early in the project, it became apparent that the city's software needs had outstripped its licensing. Users were being educated about GIS, and the demand for access to GIS data and software was increasing rapidly. Concurrently, the GIS team was investigating ArcGIS for Local Government and ArcGIS Online as a means of disseminating information and functionality to the organization and the public.

An analysis of the financial commitment necessary to deliver the planned solutions prompted the city to enter into an enterprise license agreement (ELA) with Esri. Once the GIS team was no longer constricted by lack of software licensing, the expansion of GIS began in earnest.

Martineau insisted that enabling users

with traditional GIS data was insufficient. His vision was to use GIS as the window into all of the city's technologies and data.

To that end, the city's GIS team worked with GTG to geoenable every dataset imaginable. Existing IT datasets were scrubbed and geoenabled. This included data from SunGard HTE (for licensing, permitting, utility accounts, 911, and police records), MicroPaver (for pavement management), Maintenance Connections (for work orders), RescueBridge (for fire records), and GraniteXP (for pipeline inspections).

In addition, the city's 1,800 scanned documents—engineering drawings, studies, reports, project files, and plans—were linked to their geographic location. Back end middleware was deployed to synchronize these systems continually so that data is immediately available within the GIS. All this data, coupled with more than 100 GIS layers, provides a wealth of information. Existing data was ported into the Esri Local Government Information Model (LGIM) so Esri maps and apps could be leveraged.

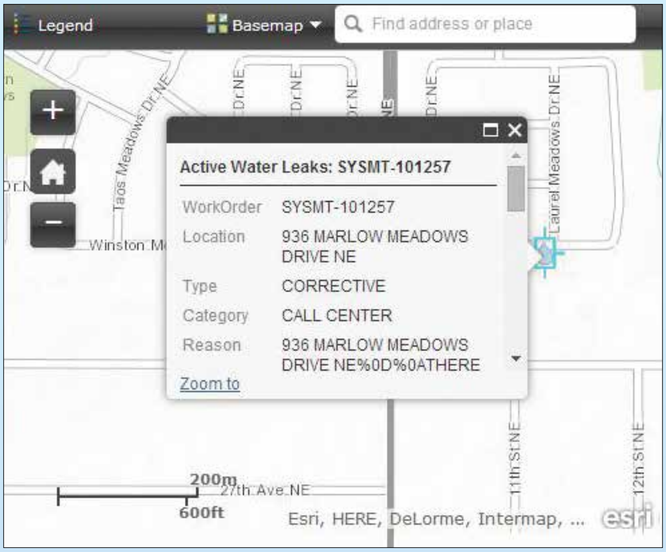
↑ Police Department Public Safety Analyst, an ArcGIS for Server-based app

The challenge was how best to enable users to consume and analyze all of this information. The city recognized that application deployment is where many organizations fail to realize the true power of GIS. After much planning, the city decided to implement a diverse collection of ArcGIS Online, ArcGIS, and third-party Esri-based apps. These apps were selected to meet the needs of three groups: internal users, city workers in the field, and the public.

Internally, a mix of applications was chosen. ArcGIS Viewer for Flex was deployed through eight targeted portals instead of deploying a single one-size-fits-all app that would not be the right fit for all Rio Rancho users. These portals were configured to meet the specific needs of user groups by configuring MapTips, data layers, and searches and linking to non-spatial IT systems.

Portals were deployed for the city clerk, city manager, code enforcement, development services, financial services, parks and recreation, public works, engineering, and public works utilities. This meant that departments no longer needed to consult various datasets to access the information needed. The result: decision making has been streamlined, time is being saved, and city staff members are more informed.

City of Rio Rancho staff members indicated they not only needed to have access to pertinent GIS data layers in the office but also access to this information in the field. This need was met by deploying mobile GIS maps to field crews. The city decided to use ArcGIS Online maps and applications to make this data available in the field. Staff members no longer print hard-copy maps or have to remember information they viewed in the office. Now they can access that data in the field.



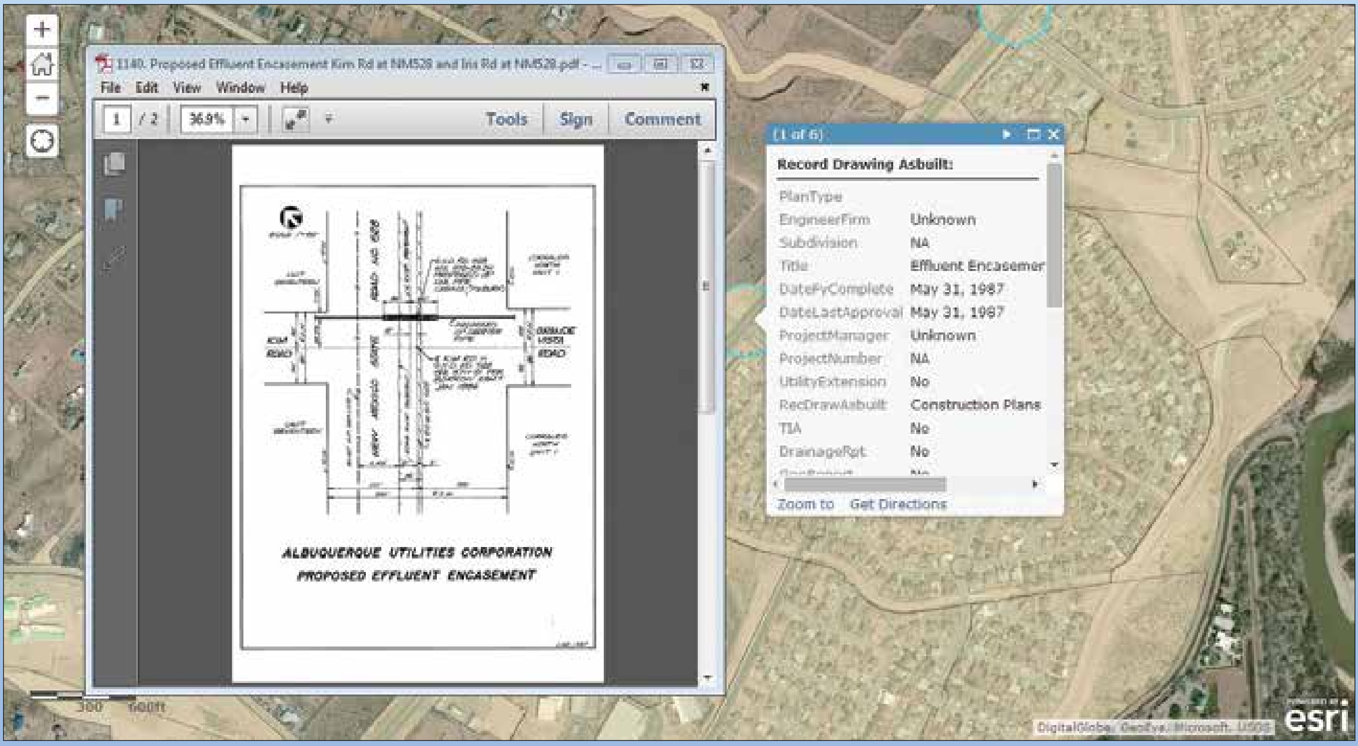
← Public-facing ArcGIS Online portal for viewing active water leaks

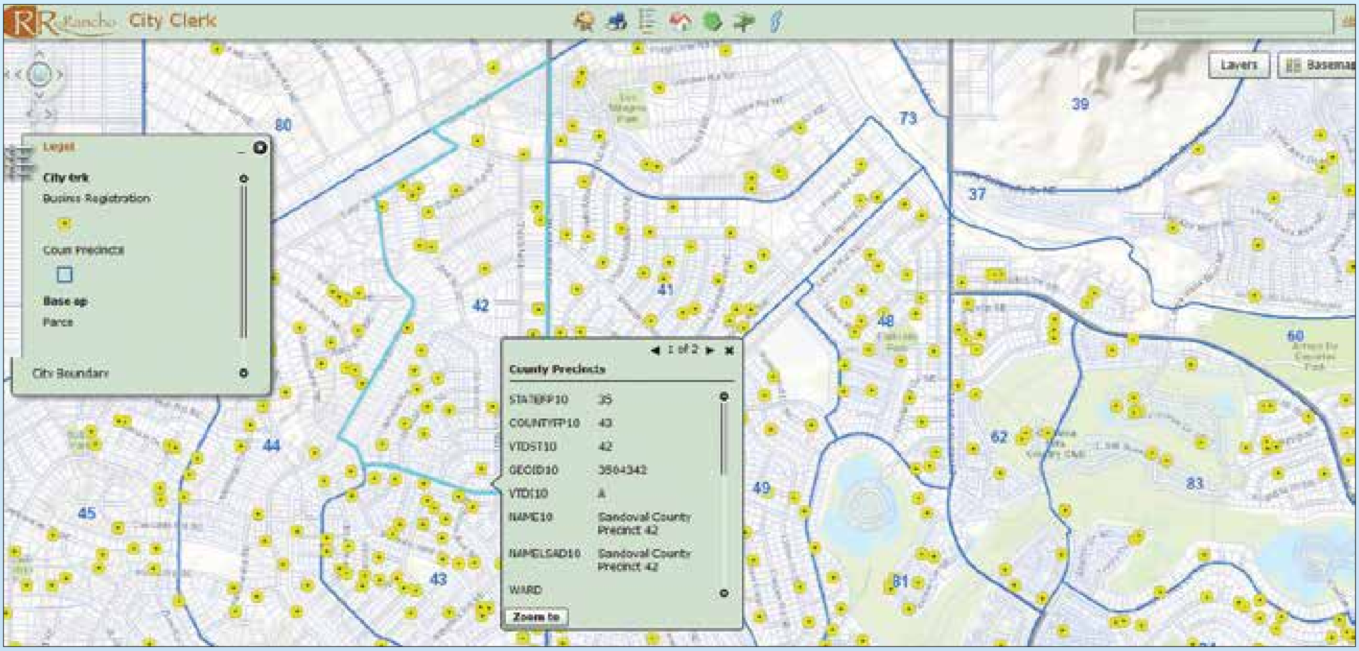
↓ ArcGIS Online Field Viewer for Line Locators lets field-workers view the location of as-builts throughout the city and retrieve PDFs for specific as-builts.

→ ArcGIS Viewer for Flex portal for the city clerk

The city deployed four mobile maps as part of this initiative. The mobile map for building inspectors contains two vital layers of GIS data for inspectors—parcel data and building permits. The engineering mobile application allows the engineering staff to view parcel data as well as record as-built drawings. Not only can staff view the area for each as-built, but they can bring up a PDF of the as-built while in the field to get more information.

The third application is for line locating crews. This application, similar to the application for engineering staff, allows staff to view the location of as-builts throughout the city and to retrieve the PDF of that particular as-built. The fourth mobile application allows utility staff to view information from the computerized maintenance management system (CMMS) as well as sewer, water, and stormwater gravity main data.





Public safety had needed to use specialized third-party products. GTG's Looking Glass Suite was selected for use in the 911 center, and police and fire departments. The 911 center had struggled for years with software that could not use live data with Esri GIS software.

Looking Glass Dispatch enabled dispatchers to track all active incidents, link building preplans and CCTV feeds, view live traffic data, and access any GIS data layer. The fire and police departments were enabled with Vantage Points Public Safety Analyst (PSA). PSA allows staff to view all incidents, do hot spot analysis and predictive analysis, and access executive dashboards that display live data.

Public safety wanted to use GIS in the field. To that end, the department deployed Vantage Points Mobile for their mobile data terminals (MDTs) and Vantage Points SMART for use on tablets and smartphones. Field staff can now view live GIS data, incident data, and the geolocation of vehicles and smart devices.

It was important for the city of Rio Rancho to provide GIS data and information to citizens through an easy-to-use GIS portal. The city deployed three GIS portals for citizens' use: one showing water leaks, another for viewing parcel information, and a parks and recreation area locator. Each app was built using the ArcGIS Online apps the city could access with its ArcGIS Online organizational subscription.

The water leak map lets citizens view the location and other information about water leaks in the city. This data is derived directly from the water database using SQL statements. With the parcel map, citizens can view information about real property located in the city. Finally, citizens can use the parks and recreation finder to search for parks and amenities near their address, find out about city parks, and get routing information to parks.

The goal of most municipal GIS implementations is enterprise-wide adoption. Rio Rancho has achieved enterprise-wide success in a short time by focusing on user needs, identifying practical solutions, and leveraging the power of the Esri toolset. Plans are under way to continue expanding Rio Rancho's hugely successful effort with dataset development and implementing a number of other internal and external portals.

For more information, contact Curtis Hinton, president of GTG, at curt@geotg.com or 919-344-2169, or John Martineau, GIS manager for the City of Rio Rancho, New Mexico, at jmartineau@ci.rio-rancho.nm.us or 505-891-5054.

By Carla Wheeler and Jim Baumann, Esri Writers

Small Town, BIG Dreams

When residents of South Windsor, Connecticut, want to report a damaged stop sign or a missed trash pickup, they report the problem using the town's new iOS mobile app that was developed by Esri.

If public works employees fix a pothole, they can use the same app on their town-issued iPhone or iPad to inform their supervisor that the work was completed. The Town of South Windsor Maps Viewer mobile app—also available online via the Citizen Service Request dashboard—is just one of the Esri ArcGIS-powered apps South Windsor uses since it obtained an Esri Small Municipal and County Government Enterprise License Agreement (ELA).

The ELA includes unlimited access to many components in the ArcGIS platform, including ArcGIS for Desktop, ArcGIS for Server, ArcGIS Online, and developer tools to build desktop and mobile apps.

"The real win for us, a community of 26,000, is everything we can dream, we have the tools to build," said Scott E. Roberts, the town's chief information officer and director of information technology.

And lately, South Windsor is dreaming big. The town is modernizing and migrating all its dashboards—Citizen Service Request, Emergency Operations, Snowplowing, and Leaf Collection—from ArcGIS Viewer for Flex to ArcGIS Online apps.

"ArcGIS Online provides us with the ability to collaborate with our staff in remote locations, interact in the field, and close the loop by receiving input from our citizens," Roberts said. "Without ArcGIS Online, our GIS would remain in the hands of a few people within our buildings. This opens up real possibilities for improving processes now that it's in the hands of more of our staff."

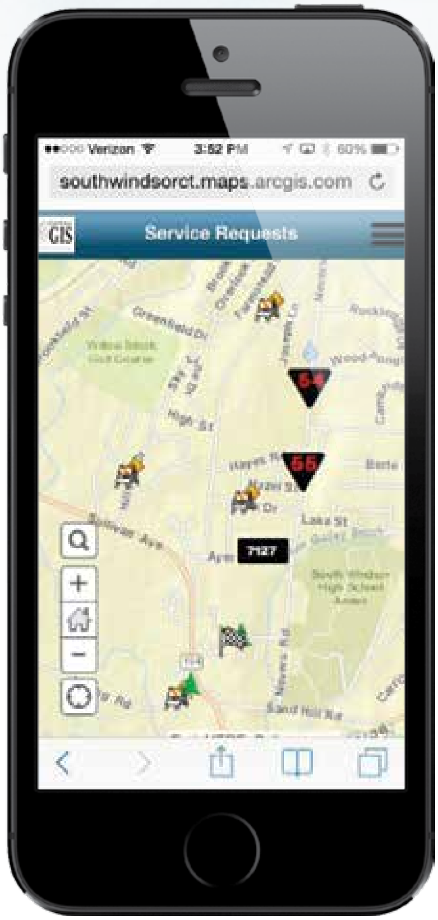
A Community That Cares

South Windsor residents have a long history of collaborating and sharing information for the common good. In the 1630s, the Podunk Indians and English settlers lived peacefully in what is today South Windsor, a town north of Hartford, on the Connecticut River. They dealt with issues such as diseases, land purchases, and conflicts with other Indian tribes. That spirit of cooperation continues today, though the problems the citizens of South Windsor tackle now are less harrowing.

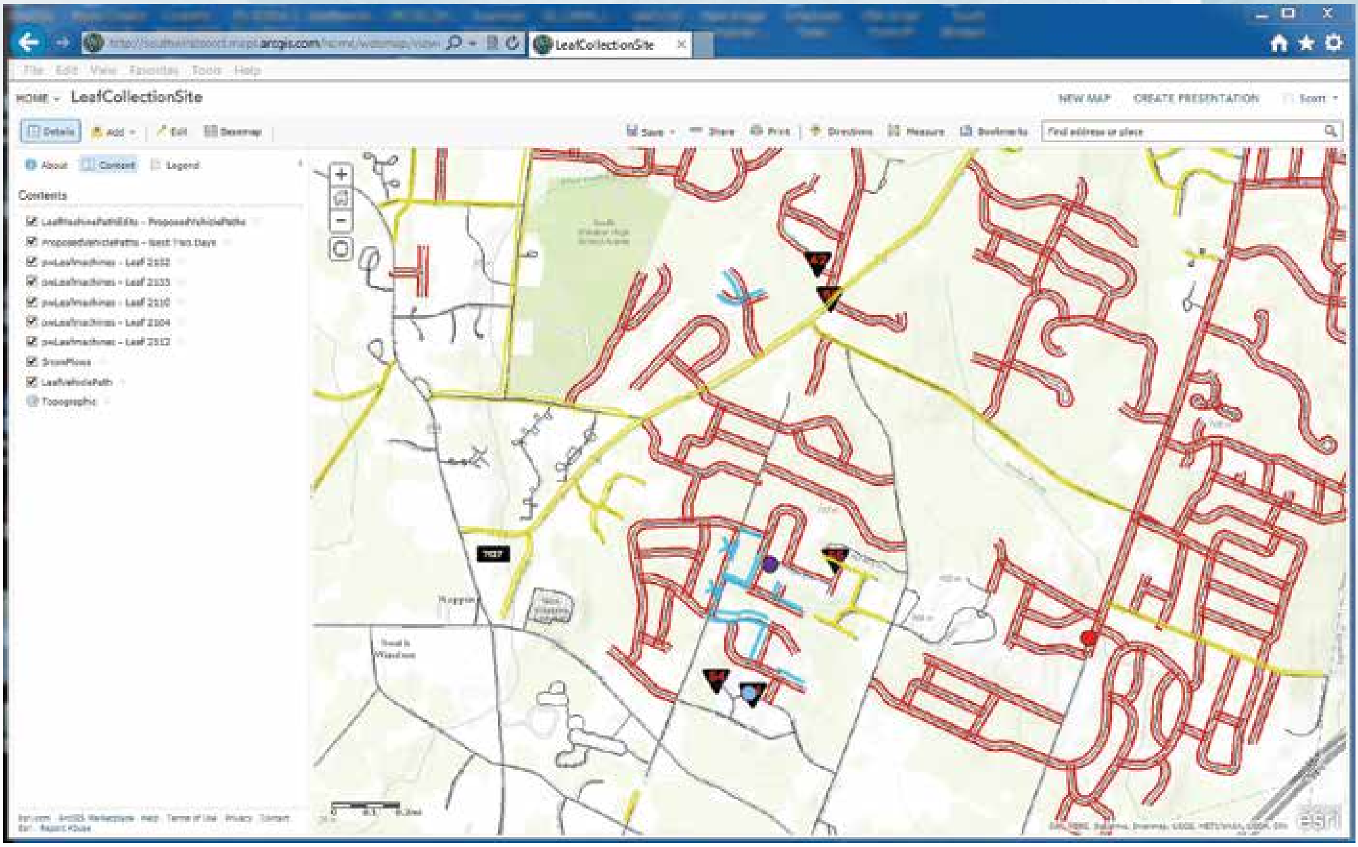
Handling Citizen Requests

The Citizen Service Request dashboard, available at the town's website, was developed by the South Windsor Public Works Department two years ago to make it easy for people to report community problems such as missed trash pickup, potholes, defective streetlights, mailbox damage, fallen trees, and illegal dumping.

A developer from Esri Professional Services created the Town of South Windsor Maps Viewer, an iOS app that is available at the Apple App Store, so citizens could make service requests using an iPhone, iPad, or iPod touch. Now residents can either use the iOS app or the online dashboard to report an issue. The dashboard was built and deployed



↑ Esri Professional Services created the Town of South Windsor Maps Viewer app for iOS devices. Service requests appear on the app's map.



↑ The streets in red show where leaves have been collected, while the streets in yellow show where leaves will be collected over the next two days. Blue markings show the map updating as leaf collection vehicles move through the neighborhoods gathering leaves.

using Esri's ArcGIS for Server.

The iOS app works by using the GPS capabilities on a mobile device so a citizen or staff member can capture the location of the issue or problem and use the simple service request form to provide a description of the issue. After entering the type of problem, name, phone number, and e-mail, the report can be submitted via the app or dashboard. The requester will continue receiving updates about the status of the request until the issue is resolved.

"When a request from the public comes in, it is automatically processed and routed to the appropriate department for response and, if appropriate, a work order is issued," said Dawn Mulholland, GIS analyst, Town of South Windsor. "At the same time, a receipt is sent back to the sender indicating that we have received the request and are processing it."

Roberts uses this scenario as an example. While you are driving to work, you notice a stop sign near your house is missing. You pull your car over safely to the side of the road and use the Town of South Windsor Maps Viewer app to notify the town officials about the missing sign.

"By the time you get to work, you could have theoretically received a 'thank you for your request' e-mail," Roberts said, adding that, after lunch, another e-mail could arrive saying that the work has been completed. "When you drive home, you could see a brand-new sign up."

The reporting system is automated. A Python script runs every 15 minutes, searching for new requests coming into the dashboard system from citizens or town employees. When one arrives, it appears as an icon on the dashboard. An e-mail with a work order is automatically generated and sent to the appropriate department to vet. If it is approved, it is assigned to a crew. Once the job has been completed, the icon disappears from the dashboard and a final e-mail is sent to the requester, saying the service request was fulfilled.

City administrators like this automated system because it increases accountability by staff, provides them with metrics, and speeds workflow, according to Roberts. Town staff also use the Citizen Service Request dashboard to keep residents informed about projects such as road reconstruction, drainage work, and sewer manhole cover inspections.

Managing Operations with Maps

The town also uses dashboards to manage snowplowing, leaf collection, and emergency operations. The dashboards were built two years ago using ArcGIS Viewer for Flex but are being moved to ArcGIS Online.

The Leaf Collection dashboard already has aleady made the switch to ArcGIS Online. It color-codes streets: those marked in red indicate where leaf collection has been completed, while those in yellow show where leaves will be collected over the next two days. Another Python script, running at night, keeps the dashboard map up to date so streets initially marked in yellow will be changed to red after the leaves are picked up.

The dashboards are configured to handle public works service requests. At a moment's notice, they can be switched over to handle emergency operations such as dealing with fallen trees, downed electrical lines, and road closures. Emergency Operations Center commanders can monitor real-time situations and quickly coordinate responses using the town's Emergency Operations dashboard as information comes in from first responders in the field.

The town also uses Collector for ArcGIS, Esri's app for smartphones and tablets, to collect data in the field and overlay it on maps accessed from ArcGIS Online. This ability to combine data from these sources instantly is valuable when responding to citizens' requests for service as well as when performing maintenance tasks or dealing with emergency situations.

> "The real win for us, a community of 26,000, is everything we can dream, we have the tools to build."

Staff make PDF maps of the dashboard and post them online to remind residents that crews will be by soon to gather leaves. "We're telling them to get *[their leaves]* to the curb," Roberts said.

The town also invested in automatic vehicle location (AVL) devices. The AVLs, installed in the trucks used by town employees and contract workers, monitor both the location and speed of the leaf collection and snowplows.

"With our snowplowing and leaf collection dashboards, we can track both sides of the road with the AVL," Roberts said. "This not only allows us to keep track of the drivers to make sure they are working on the assigned routes, but it also provides us with insight into the operational progress of various programs. Additionally, the information is archived and available to managers to review in questionable circumstances. For instance, we know when a street was plowed and how fast the driver was going."

Sharing the GIS Wealth

Because of the success South Windsor has had using GIS, the town decided to share its apps with neighboring communities because sharing information with them would benefit South Windsor as well as its neighbors.

"For example, there is no direct highway access into South Windsor, and during an emergency, knowing which roads are passable through neighboring communities is essential to emergency crews and our residents."

South Windsor created a one-page letter of agreement (LOA) to formalize sharing its applications with other municipalities. Any apps the town develops will be shared with other towns that are interested in implementing a similar program. Those towns will still need to purchase the Esri licenses and the third-party packages that South Windsor has integrated, but the apps are free. "The only stipulation is that if you make any enhancements or changes to the applications, you share those changes with us so that they continue to improve," said Roberts.

Newtown, south of Hartford, signed the LOA with South Windsor. "Though I changed a few things in the code for our specific workflow and processes, *[the apps]* were pretty straightforward to implement," said Steven Birney, Newtown's GIS software specialist. "There are variables built into the application that allow you to easily make necessary changes."

Matthew Galligan, South Windsor town manager, was quick to spread the word about the capabilities of the smartphone app and LOA at the recent Connecticut Conference of Municipalities. "At the moment, we have more than 10 LOAs with neighboring towns pending, and the interest in implementing the application continues to increase," said Galligan. "Even the Capitol Region Council of Government has shown interest in the application because it can be adapted for use by larger agencies as well as smaller municipalities. Basically, it puts us all on the same page."

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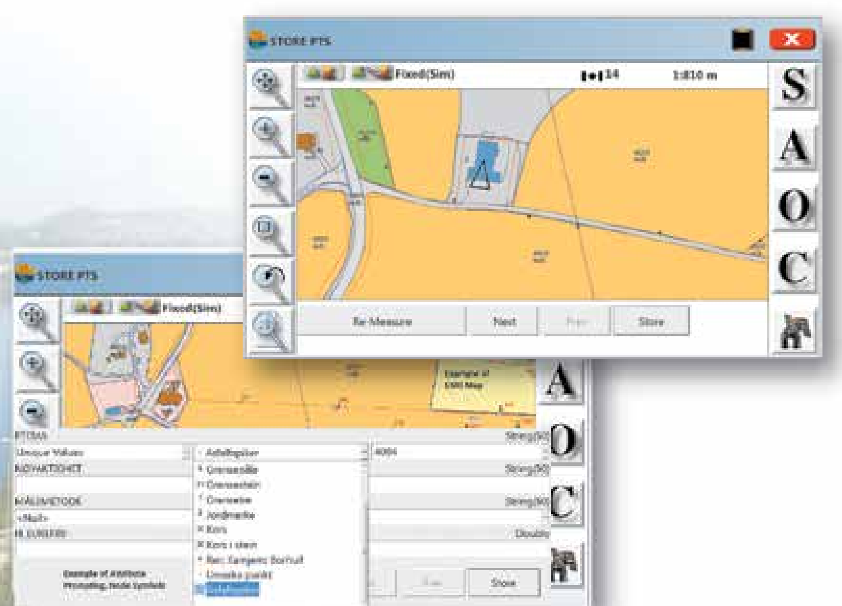

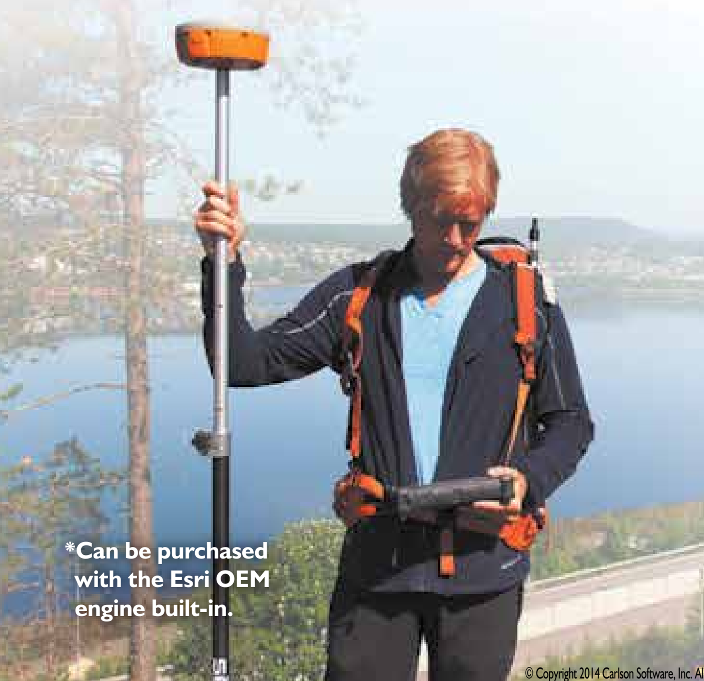

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Organizing the Table of Contents

By Mike Price, Entrada/San Juan, Inc.

↑ Mike Price

In the Fall 2014 issue of *ArcUser* magazine, I presented best practices for data acquisition and management and project setup. In this issue, I present tips and tricks related to creating a more useful table of contents (TOC). These practices were developed through many years of production mapping in earth sciences, public safety, and other disciplines.

Rather than a tutorial, this article shares shortcuts and insights and does not require a training dataset. Illustrations were made using examples from a wall map developed for the Kent Regional Fire Authority (KRFA), Kent, Washington. The data has been simplified and standardized for public display and future training purposes. Much of this data will be used in the Esri Fire GIS University program, which will be rolled out in Redlands, California, in late January 2015. This article focuses on better ways for organizing the TOC in ArcMap. The tips range from ones for starting new projects to ones for improving map output. I hope these tips provide valuable suggestions and insights that will help you standardize workflows, incorporate best practices, and promote the creativity that leads to the making of meaningful maps.

Data Frame Fundamentals

When you open a new ArcMap document, by default the program creates an empty data-frame named Layers.

Immediately rename the data frame to something more meaningful. If you are in production mode, consider renaming the data frame to specify the coordinate system. It will serve as an excellent reminder while you build your map.

The first data loaded in the data frame that has projection information will define the coordinate system for the data frame. When adding the first data layer, verify that it is projected and correctly defined in the coordinate system that you want to use.

Open data frame properties and confirm the coordinate system is correct before continuing.

Data Layers: What's in a Name?

ArcMap uses the actual name of the source data unless an alias has been defined. It will use that name in the map legend, in the Layer file, and in an exported PDF file that has been created with layers.

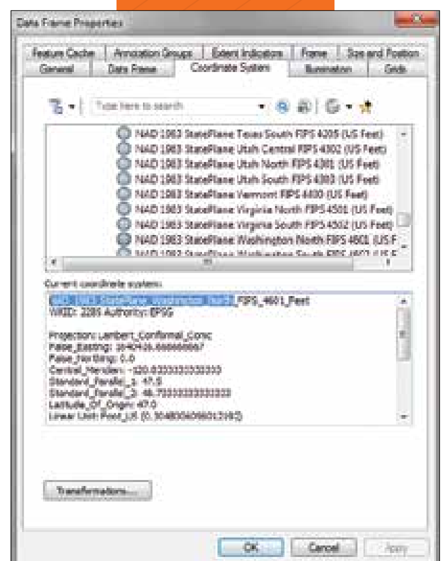
Immediately provide a layer name that uses descriptive, friendly terms. You may have noticed that I typically don't recommend using spaces and other nonalphanumeric characters in file names. However, customized data names in the TOC is an instance in which I bend this rule (even for Layer files).

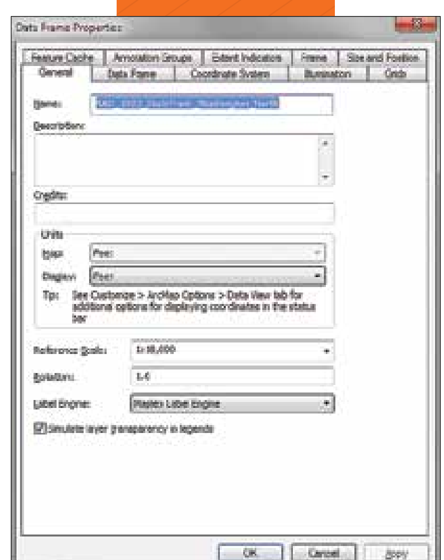
However, avoid unusual ASCII punctuation characters. Forward and backward slashes, algebraic operators, the "at" (@) symbol, the ampersand (&), and many other characters do not behave well in legend fonts, Layer file names, and other uses. Even though space and character string length is often important, don't hesitate to spell out or use standard alphanumeric abbreviations. Following proper TOC naming protocols gives users a head start understanding the information the map is conveying.

Layouts, Bookmarks, and Scale

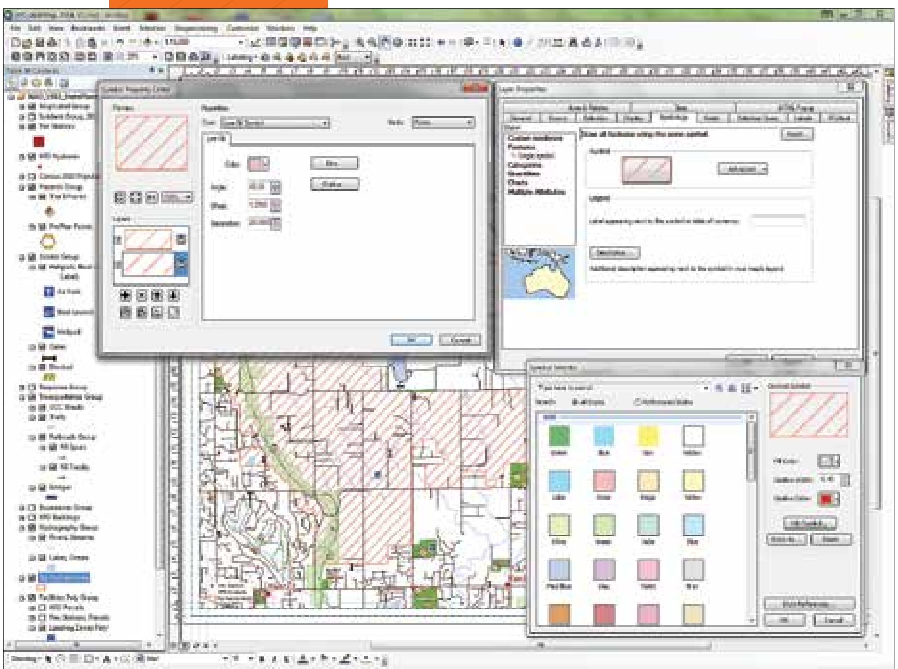
Once you've added data to the TOC and defined the primary areas of interest in the map, consider creating scaled bookmarks to allow quick and consistent access to important map locations.

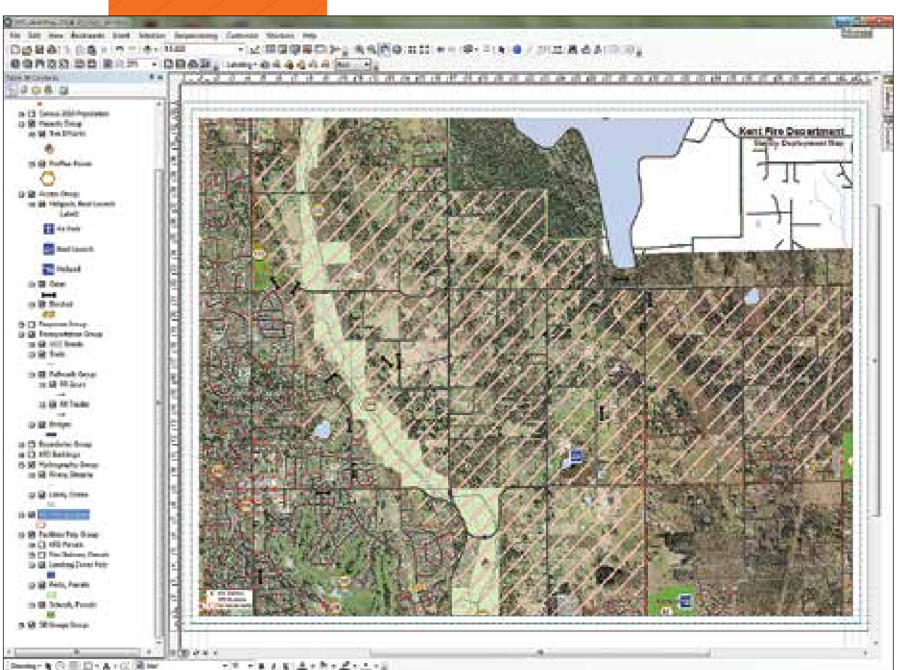
When I start a new map, I work primarily in Data View, but before long, I start imagining how the map might look as a printed or





↑ After verifying the coordinate system, consider renaming the data frame as its coordinate system. Simply copy the name from the Coordinate System tab, click the General tab, and paste the coordinate system name in the Name text box.





↑↑ To retain unique layers in a PDF output, consider using colorful patterned fills instead of transparent layers. Here a diagonal hatch pattern fill is being created in the Symbol Property Editor.

↑ A pattern fill may be placed over imagery and large polygons without applying transparency. When the map is exported with a pattern fill, a PDF export will show the pattern fill as its own layer instead of merging it with all underlying vectors as it would with a transparent layer.

graphic export or in a layout. Since ArcMap allows only one layout per ArcMap document, I choose the preferred output media and size for each map, and I create an appropriate layout. When I need to create output in multiple formats, I clone a finished map and create new layouts by naming each copy of the map document so I can quickly identify its content and format.

Once I have established a specific layout, I define scale-dependent bookmarks that quickly return to important areas. These bookmarks are in Layout View and include the proportional scale in the bookmark's name. Bookmarks are another area where I bend the naming rules by using spaces, upper- and lowercase text, and even a few odd characters such as colons (e.g., Station 74 Detail 1:10,000).

Points, Lines, Polygons, and Rasters Too

I'm often surprised by people who organize data in the TOC without considering the effect of data stacking on display. Data layers in the TOC draw from bottom to top, so there is potential to hide point and polylines under polygons and rasters. Watch data organization in the TOC carefully. Keep rasters and imagery near the bottom of the TOC, below all vector data. When arranging vector data, try to keep point layers at the top, above all polyline layers. Position polygon layers at or near the bottom, below points and polylines but above rasters.

If you need to place a polygon boundary at or near the top of the TOC, consider rendering it as an outline without any fill. You can also apply partial transparency to one or more polygon or polyline layers. Experiment carefully with transparency to obtain the desired result. Partially transparent layers in a map are automatically displayed as a lighter color that simulates transparency. A word of caution, however: If you export the map as a layered PDF product, ArcMap will render the transparent layer and layers located below it in the TOC as a single base layer named Image. To retain unique layers in a PDF output, consider using colorful patterned fills instead. Experiment with map output until you obtain desired results.

Overloaded TOCs and Layer Groups

The tendency to load too much data into a single TOC is a common problem for students and professionals alike. If all the data layers added to a map are not visible in the TOC display, the map can be confusing. There are several ways to avoid overstuffing a TOC.

The first option is to create a second data frame with its own TOC for specific tasks such as editing, image georeferencing, or geoprocessing. It's much easier to navigate menus and pick lists when the TOC is not overburdened. This is especially important when editing. Include only the data necessary to perform editing tasks. This reduces the possibility of damaging, compromising, or even accidentally selecting data that should not be modified.

One way to streamline a TOC is to selectively organize related data into a Group Layer. By using a Group Layer to organize related data layers, those layers can be quickly accessed, repositioned in the TOC, turned on and off, and even removed as a single entity. The layers in a Group Layer draw in the same order in which they are positioned in the Group Layer, so consider the type of data in each layer and how it will be displayed. Groups containing mixed points, polylines, and polygons can be problematic. I often use Group Layers to organize tiled raster images such as orthophotography.

Be careful when repositioning data in the TOC. It's quite easy to accidentally drop a data layer into the incorrect Group Layer and then lose track of its location. When repositioning a single layer immediately below an expanded Group Layer, collapse the Group Layer before moving the data. After defining a Group Layer, consider saving the entire Group Layer as a single Layer file so it can be quickly loaded into another map or data frame.

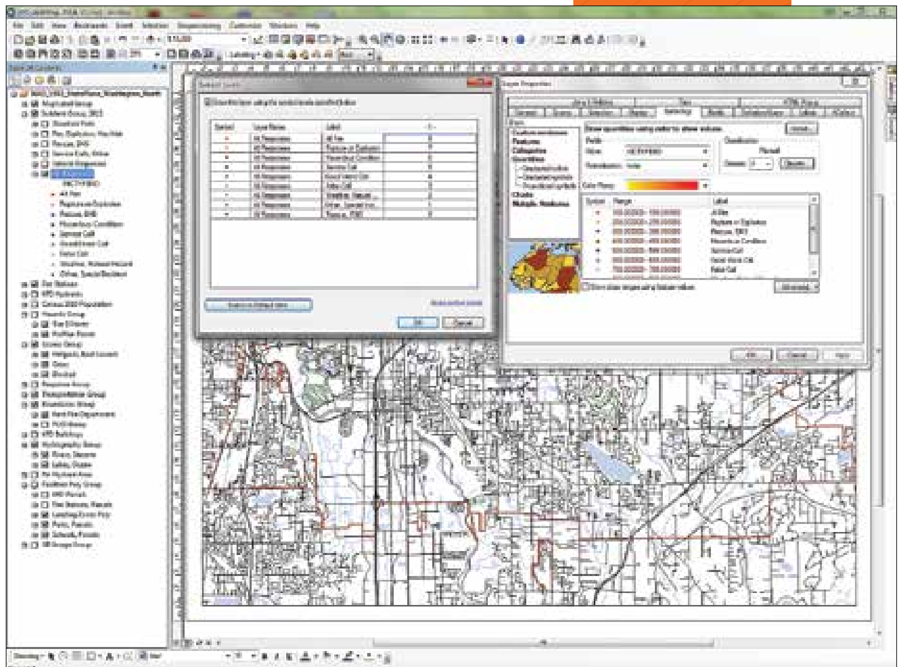
Definition Queries or Symbol Levels or Both?

Sometimes it is important to filter thematic data so information can be displayed in a preferred order within a layer. For example, in a fire service map, incident data is usually coded by response type that includes not only fires but also incidents such as explosions/ruptures, hazardous substances, rescue/emergency medical service (EMS), service calls, and false alarms.

In a year, approximately three-quarters of the calls at many agencies are directly related to rescue/EMS. Many of the remaining response calls are service calls and public assistance calls. Calls to respond to fires, explosions, and HazMat incidents make up a small percentage of the total number of calls.

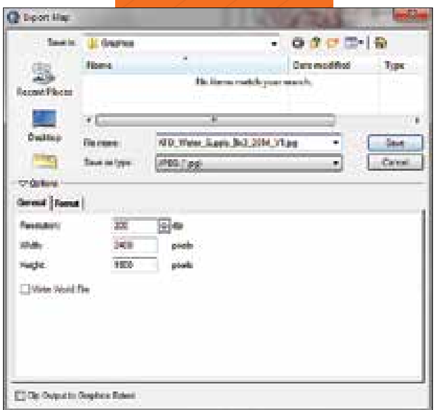
Incidents are often mapped for a 12-month period. During that period, an agency may have responded to 10,000 incidents. When rescue/EMS responses are mapped, they tend to overwhelm all other calls. To show the relationship of fire-related incidents to all calls, it is important to filter and/or stack fire calls so they are displayed on top of medical and service calls. Two methods can be used to separate the fire calls from the larger group, or at least make them more visible.

The traditional approach to refining point data is to create subsets of focus points and display them above other points in the group. In the fire example, all fire, explosion, and HazMat points are filtered using a definition query that employs a standard numeric code to display these points preferentially. Service and other calls are also



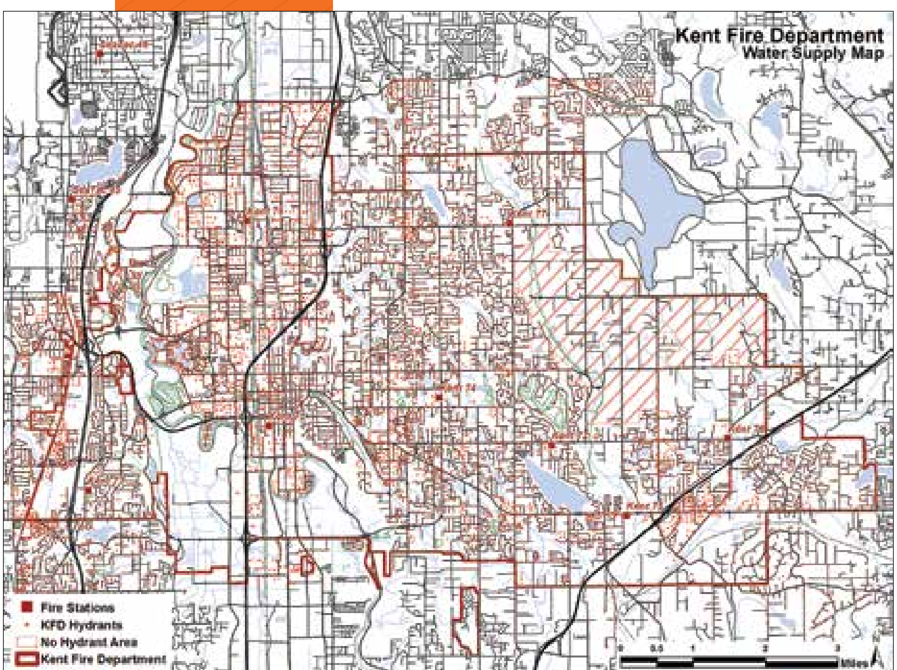
↑↑ When All Incidents display, Symbol Levels cause the points to draw from bottom to top with numerous rescue and EMS calls posting below all other calls. All fire responses are drawn at the top.

↑ To create a 4 x 3 aspect ratio Layout for PowerPoint and other reports, save the project with a new name that includes 4 x 3. Resize the data frame to 12 x 9 inches, shrink the map to fit the full frame, and adjust fonts and symbols.



segregated numerically below fire calls but above rescue/EMS calls. The subsets are typically grouped in this order. Inside the Incidents Group, subsets will draw in order and response types may be displayed and modeled individually.

To show all incidents with fire responses on top, use symbol levels to reorganize the display order in a thematic legend so important points plot on top regardless of their position in the point list. Before symbol levels were available, records were sorted in an *x,y* table to emphasize primary points, then the points were posted in the sorted order. Symbol levels have simplified this process considerably. For more information on symbol levels, read and work the tutorial "Displaying points: Using symbol levels to optimize point display" in the Summer 2012 issue of *ArcUser.*



↑↑ Export the resized map as a JPEG file or PDF. Turn on only layers that you want to see in individual graphics and name the exported file to include 4 x 3.

↑ This graphic displays Water Supply features, including fire hydrants, the No Hydrant Area, and surface hydrography. Fire fighters use this map to locate hydrants and static water sources and to plan water transport in areas without hydrants.

PDF, PPT, and Document Tricks

Many of the best practices concepts presented in this article aid in the creation of high-quality digital output. However, many maps are not designed for immediate paper printing. Instead, they are embedded in or attached to a digital product, such as a Microsoft PowerPoint file, for review, presentation, and digital dissemination.

The ArcGIS PDF export utility provides a high resolution, low cost way to disseminate maps, graphics, and text. Through careful organization of points, lines, polygons, rasters, and text labels, you can produce very powerful, intelligent, portable products using only core Esri ArcGIS software.

Often, clients ask me to prepare a map with a 4 x 3 aspect ratio without margins for use in a report or PowerPoint presentation. Save your project with a new name that includes "4 x 3." Use Page Setup to resize the data frame to 12 x 9 inches and shrink the map to fit the full frame. Create new guidelines and adjust the font size and position of all text and cartographic objects. Modify the Reference Scale to avoid resizing point symbols and attribute-based labels. Use scale-defined bookmarks to pinpoint areas of interest on the map for multiple exports.

I typically export map graphics as JPEGs, although some clients prefer layered PDF files. The names of these graphic files include the subject, extent, and scale. The JPEG files are static, but the layered PDF files allow the end user to carefully adjust labels and layer visibility before capturing a snapshot to export to PowerPoint. The important export concepts include creating the 4 x 3 landscape layout and using predefined Bookmarks that return you to exactly the same map extent and scale for future graphic export.

Summary

GIS best practices are a moving target. I continually develop new and better ways to perform mapping and analysis tasks efficiently and accurately and make a better map. Try them out and incorporate them into your workflows as you see fit.

Acknowledgments

Thanks again to the Kent Fire Department for continually challenging me to develop new and innovative ways to create and deploy maps and spatial data. Thanks to all my other data development, mapping, and modeling friends, associates, and students. Without your continued input, ideas, and critique, I could not develop, document, and teach these concepts.

← Photo is courtesy of University of Idaho Photographic Services

Updating Your Metadata Just Got a Little Easier

By Bruce Godfrey (GISP), Jeremy Kenyon, and Alex Kyrios, University of Idaho Library and Dan Spinosa, Innovate! Inc.

Maintaining metadata for many ArcGIS items can be a daunting task. The University of Idaho Library developed an ArcGIS Add-In that makes this task much simpler.

The out-of-the-box graphical user interface metadata tools in ArcCatalog 10.x are designed primarily to allow users to interact with metadata one item at a time. Although ArcCatalog offers a limited number of tools for performing metadata operations on multiple items, there is a need for more efficient and effective tools.

The ability to efficiently modify the content of multiple items iteratively is not just desirable, it is necessary. Editing metadata for many ArcGIS items can be accomplished using other approaches such as XSLT and Python. However, a method that requires scripting is not always user-friendly. A tool with a graphical user interface is, in many cases, simpler and more efficient.

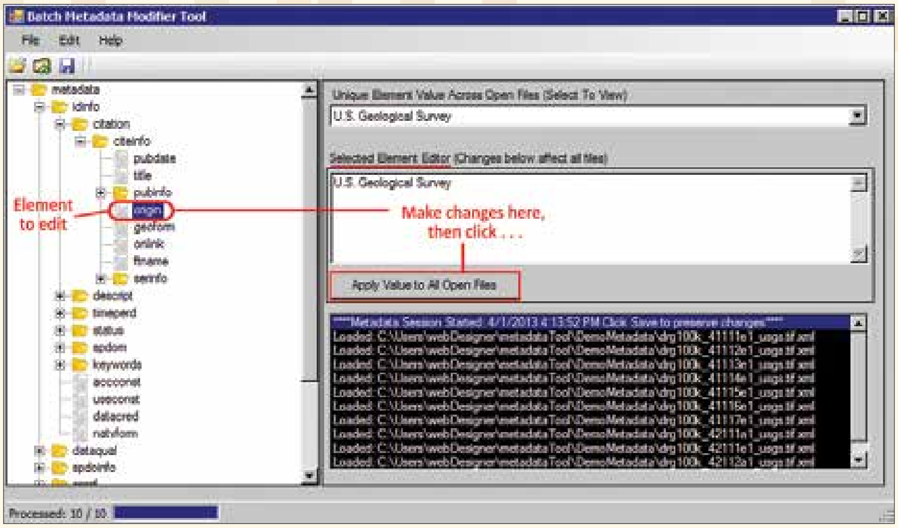
The Batch Metadata Modifier Toolbar is a step in that direction. The toolbar, which is available as an ArcGIS Add-In, currently contains two tools, Batch Metadata Modifier Tool and the Batch Metadata Thumbnail Creator Tool.

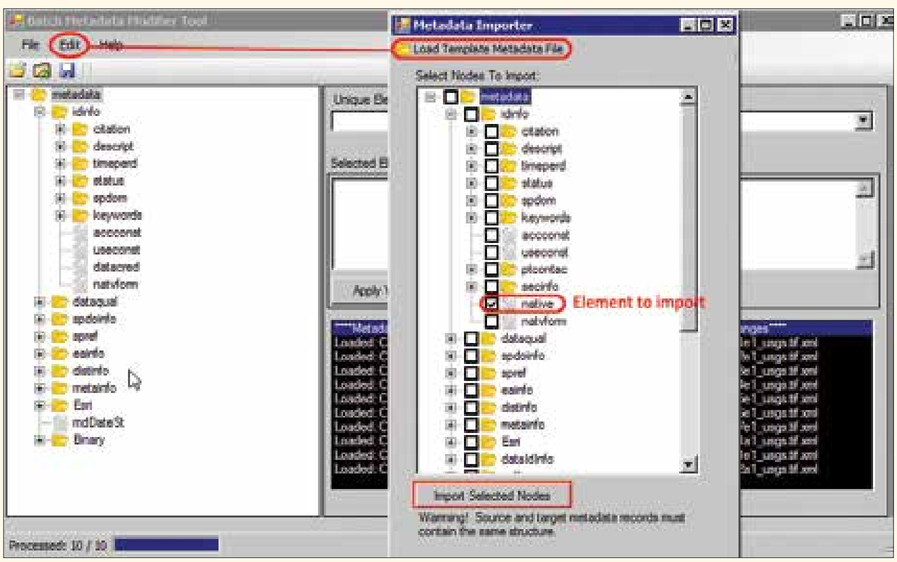
The Batch Metadata Modifier Tool, which is also available as a stand-alone Windows executable application, allows users to iteratively update metadata on multiple items. The Batch Metadata Thumbnail Creator Tool enables the batch-creation of the graphic that appears with an item's metadata to illustrate the item.

Iteration capabilities are imperative when the task at hand involves applying identical updates to large batches of files. The Batch Metadata Modifier Tool is simple to use and eliminates the need to perform protracted, mundane repetitions of identical operations on multiple files individually. A user can open a single file or group of files via the ArcCatalog Contents Tab to modify existing elements, find and replace element content, delete a metadata element, or import metadata elements from external templates.

The metadata structure for a file or many files is presented as a hierarchical tree in the left-hand window. The user can navigate through the tree and examine the values of each element, which are listed in the Unique Element Value Across Open Files drop-down menu on the left. The user can edit the value in the window below it, and then, if desired, replicate those changes across all similar elements in all open files. The Batch Thumbnail Creator Tool is similarly simple to use. A user can open a single file or group of files via the ArcCatalog Contents Tab to generate thumbnails.

This tool has a lengthy history because since its inception, INSIDE Idaho has





↑↑ In the Unique Element Value Across Open Files drop-down menu, the user can edit the value in the window below it and replicate those changes across all similar elements in all open files.

↑ A user can open a single file or group of files to import metadata elements from external templates.

operated under the principle that metadata is necessary not only for discovery but also for use and understanding. INSIDE Idaho, the State of Idaho Geospatial Data Clearinghouse operated by the University of Idaho Library, maintains approximately 60,000 metadata records based on three standardized formats: the Content Standard for Digital Geospatial Metadata (CSDGM), the ISO 191** series, and the ArcGIS 1.0 format. Staff also help researchers generate standardized documentation for data products submitted to the INSIDE Idaho repository.

INSIDE Idaho originally developed a similar tool in 2004 for the ArcGIS 9.x for Desktop platform. The tool was used extensively by INSIDE Idaho staff to maintain documentation for items in its repository.

The 10.x platform required the creation of a new tool. The resultant multithreaded application, developed in C# using the ArcObjects SDK for .NET, was created by students at the University of Idaho in conjunction with Esri partner Innovate! Inc. Innovate has extensive experience developing metadata applications, including the EPA Metadata Editor. *[See "The EPA Metadata Editor" in the July–September 2007 issue of ArcUser.]* Initial development of the new tool began in 2011, but due to a lack of funding, the tool was not ready for initial release until 2013.

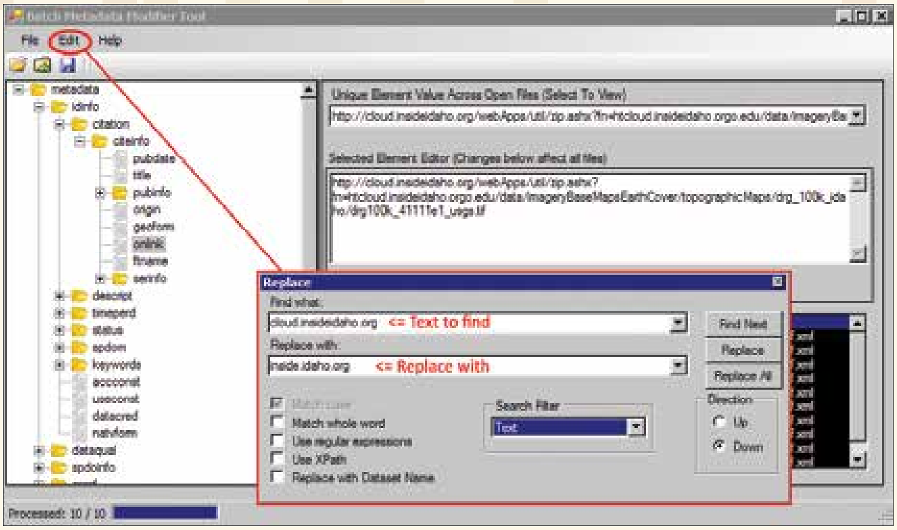
The Batch Metadata Modifier Tool supports scientific research data services. For example, University of Idaho staff support the United States Geological Survey's National Climate Change and Wildlife Science Center. The metadata records delivered for this project often need small adjustments such as the addition of keywords, improvements to the projection information, or refinements to titles and contact information.

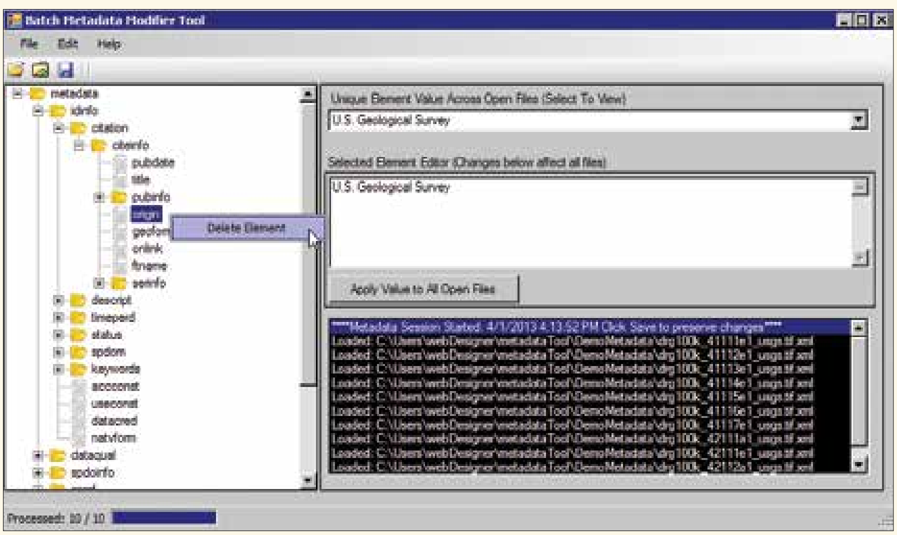
It is not uncommon for climate-related data and metadata files to be produced under a series of different climate projections and scenarios, thus requiring multiple similar files. Depending on the research, there may be several dozen or several thousand files. When a change is needed, it must often be propagated across all the files. With the Batch Metadata Modifier Tool, the University of Idaho staff can accomplish this task with ease.

While this tool is very useful in its present state, it could benefit from further enhancements. The tool currently does not load the schemas for metadata it modifies. Such an adjustment could be valuable for users, since the schema could then be queried to understand the document's structure.

Additionally, the ability to select objects that exist in multiple locations would be helpful. It would be useful to recursively walk directories and geodatabase feature datasets within ArcCatalog to more efficiently update large collections of items that exist in different locations on the file system or in a geodatabase. This was possible in 9.x utilizing searching and shortcuts, but that functionality was removed in the 10.x platform.

This tool is primarily designed to be used by those familiar with metadata, metadata standards, and metadata schemas, particularly those with experience modifying





↑↑ The Batch Metadata Modifier Tool can also find and replace element content.

↑ This tool is primarily designed for use by people familiar with metadata, metadata standards, and metadata schemas.

standardized metadata. Users of this tool must fully understand the files they are modifying and are encouraged to make copies of their documentation prior to performing batch modifications.

The Batch Metadata Modifier Toolbar represents a significant step forward in efficiently managing multiple metadata records. The authors welcome collaboration on further development of this tool.

For more information, contact Bruce Godfrey, GIS Librarian, University of Idaho at bgodfrey@uidaho.edu.

About the Authors

Bruce Godfrey, Jeremy Kenyon, and Alex Kyrios are faculty members at the University of Idaho Library. Godfrey is a GIS librarian, Kenyon is a research librarian, and Kyrios is a metadata and catalog librarian. All are involved in the creation, maintenance, and curation of standardized documentation for geospatial resources.

Dan Spinosa, geospatial developer at Innovate! Inc., has more than 12 years of project management experience supporting programs at the local and national government levels as well as programs within academia. He has been one of the lead developers for supporting desktop and web-based metadata solutions utilized by the University of Idaho and EPA Environmental Dataset Gateway.

Get the Batch Metadata Modifier Tool

Go to the INSIDE Idaho website to download this free add-in for ArcGIS.

- This tool is designed for people who are familiar with XML metadata structures and schemas.
- It can be run as an ArcGIS Add-In or as a stand-alone Windows executable file. It runs on PC only and is not supported on Mac.
- The ArcGIS Add-In requires ArcGIS 10.2 for Desktop.
- Metadata formats accepted: FGDC CSDGM, ArcGIS 1.0, ArcGIS ISO, and ISO 19115.

Create a Python Tool That Summarizes

ArcMap Layer Properties

By Colin Lindeman, Pacific Disaster Center

What You Will Need

- ArcGIS 10.2 for Desktop
- An Internet connection
- A text editor
- Microsoft Excel (optional)
- Sample dataset and resources downloaded from the *ArcUser* website

This article shows how to create Python script that runs as a tool in ArcToolbox. This tool automatically batch processes ArcMap documents, gathers information about the layers in those documents, and outputs that information as a comma-separated values (CSV) file that can be viewed as a table in Microsoft Excel or another program that can open CSV files.

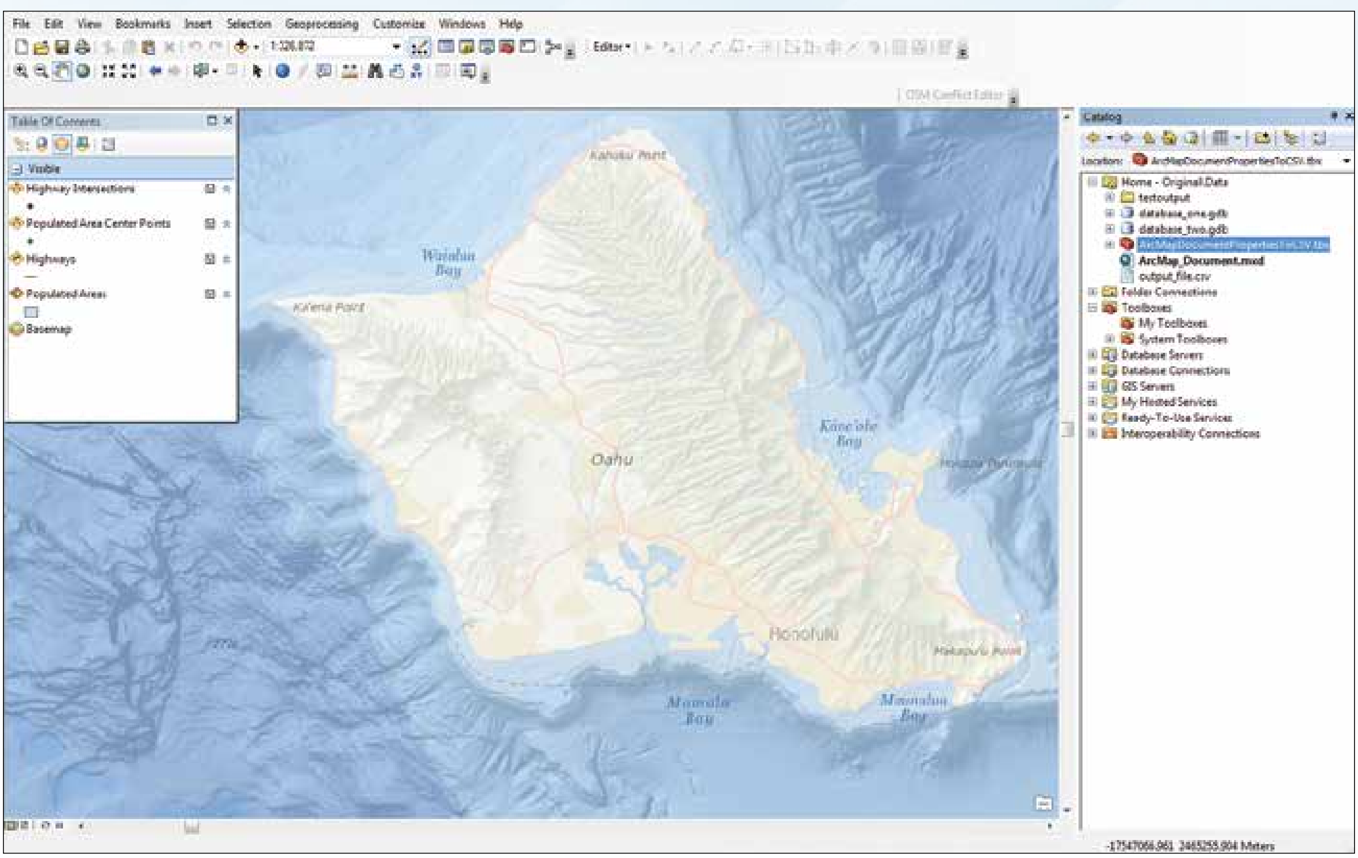
To work this exercise, you should be familiar with authoring Python scripts that use the ArcPy module, using ArcGIS for Desktop (especially ArcToolbox), and know how to add tools from a script file. This exercise uses several Python packages: ArcPy (the ArcGIS site package), os (miscellaneous operating system interfaces), fnmatch (UNIX file name pattern matching), and csv (CSV file reading and writing).

The Challenge

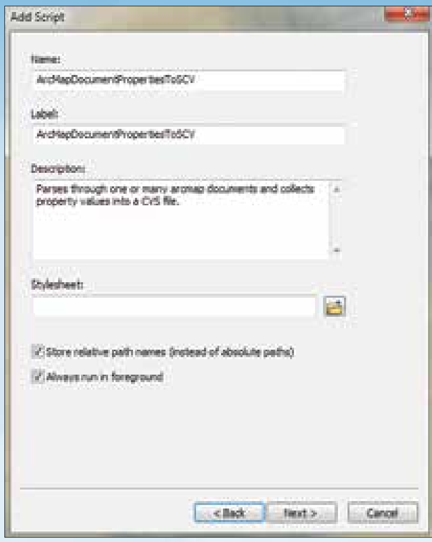
The goal of this exercise is to create a tool that automatically inventories the map layers in a single ArcMap document or several ArcMap documents contained in a folder and generates a CSV file listing the properties of those layers.

The Goal

To accomplish the challenge, you will develop a Python script that is run as a Python toolbox in ArcMap or ArcCatalog. This script will have user inputs for a directory or an individual ArcMap document (MXD) to parse and generate output as a CSV file. The CSV file can be opened in Microsoft Excel or another program that can read CSV files and be viewed as a table. By creating this tool in a Python toolbox, any ArcGIS user can use ArcPy functionality without knowing Python.



↑ Create a toolbox for the Python script.



↑ Fill out the parameters for the script tool.

The Solution

Although this example will work with one ArcMap document, the Python script will be able to process all ArcMap documents in a directory and any subdirectories it contains.

Create a new Python script using a Python editor or by simply creating a new text file (.txt) and changing the file extension to .py. *[Note: If file extensions are not displayed in Windows, uncheck the Hide extensions for known file types in Folder Options located on Control Panel in the Windows operating system.]*

There are a variety of methods for developing this script. Listing 1 provides one example. It imports modules, defines the ArcMap documents that will be processed, defines their paths, parses the documents, and writes the information to a user-defined CSV file.

(This first section imports the modules.)

```
#Import modules...

import arcpy, os, fnmatch, csv
```

(The next section defines the user input variables.)

```
#User input variables...

mxddirectory = arcpy.GetParameterAsText(0)

mxd_single = arcpy.GetParameterAsText(1)

outputcsvlocation = arcpy.GetParameterAsText(2)
```

(This section defines the ArcMap documents to parse.)

```
#Create an empty list of ArcMap documents to process...

mxd_list=[]

#If a user defined a single mxd, add its path to the list...

if len(mxd_single) > 0:

  mxd_list.append(mxd_single)

#Otherwise walk through the input directory, adding paths for
each .mxd file found to the list...

else:

  for dirpath in os.walk(mxddirectory): #os.walk returns \
    (dirpath, dirnames, filenames)

    for filename in filenames[2]:

      if fnmatch.fnmatch(filename, "*.mxd"):

        mxd_list.append(os.path.join(dirpath[0], filename))
```

(This section parses the documents and writes the information to a user-defined CSV file.)

```
#Iterate the list of mxd paths and gather property values then
write to csv file...

if len(mxd_list) > 0:

  #Create the csv file...

  outputcsv = open(outputcsvlocation,"wb")

  writer = csv.writer(outputcsv, dialect = 'excel')
```

```
#Write a header row to the csv file...
writer.writerow([“mxdpath”, “layername”, “layerdescription”, “layersource”])
#Iterate through the list of ArcMap Documents...
for mxdpath in mxd_list:
  mxdname = os.path.split(mxdpath)[1]
  try:
    mxd = arcpy.mapping.MapDocument(mxdpath)
    #Iterate through the ArcMap Document layers...
    for layer in arcpy.mapping.ListLayers(mxd):
      layerattributes = [mxdpath, layer.longName, \
      layer.description, layer.dataSource]
      #Write the attributes to the csv file...
      writer.writerow(layerattributes)
  except:
    arcpy.AddMessage(“EXCEPTION: {0}”.format(mxdpath))
  del mxd
#close the csv file to save it...
outputcsv.close()
#If no ArcMap Documents are in the list, then notify via an
error message...
else:
  arcpy.AddError(“No ArcMap Documents found. Please check your input \
    variables.”)
```

↑ Listing 1

Adding the Script to a Toolbox

Open ArcMap, then open Catalog. In Catalog, navigate to the folder where you want to keep the new toolbox for the script and right-click it. Choose New > Toolbox. Rename the toolbox.

Right-click New toolbox and choose Add > Script. In the Add Script dialog box, enter name (ArcMapDocumentPropertiesToCSV), label (ArcMapDocumentPropertiesToCSV), and description (Parses through one or many ArcMap documents and collects property values into a CSV file) for the script. Check the box next to Enable the Store relative path names to eliminate the need to update the toolbox on the script's source path. Click Next.

Use the Browse button to select the script file. Leave Show command window when

↖ On the Parameters tab of the Add Script dialog box, select mxd_directory and fill out the Parameter Properties grid as shown in Table 2.

← On the Parameters tab of the Add Script dialog box, select mxd_single and fill out the same Parameter Properties in the grid as in the previous step as shown in Table 2.

↙ On the Parameters tab of the Add Script dialog box, select output_cvs_location and fill out the Parameter Properties in the grid as shown in Table 3.

executing script box unchecked because the script itself includes the ability to display messages in the Geoprocessing window. Check Run Python script in process to allow it to run faster.

In the next pane, add the user input variables.

In the upper grid, fill in the values in Table 1.

Display Name	Data Type
mxd_directory	Folder
mxd_single	ArcMap Document
output_csv_location	File

↑ Table 1: Inputs for upper grid

Property	Value
Type	Optional
Direction	Input
MultiValue	No
Filter	None

↑ Table 2: Select mxd_directory and add these parameter properties. Select mxd_single and add the same parameters.

Property	Value
Type	Required
Direction	Output
MultiValue	No
Filter	File

↑ Table 3: Select output_csv_location and add these parameters.

Running the Tool

Double-click the script tool to invoke it. In the dialog box, click the first Browse button to select a folder directory (mxd_directory) or the second Browse button to select a single ArcMap document.

If parameters are entered for both, the single ArcMap document will be parsed and not the ArcMap documents in the folder directory specified. If no input is given, then an error will occur. Select an output file and directory. It is best to use the wizard for each user input variable.

This script can be expanded to include reading other properties for the MXD and its layers. It can also be used to set the values for certain properties. For example, dates, URLs, and organization names could be updated.

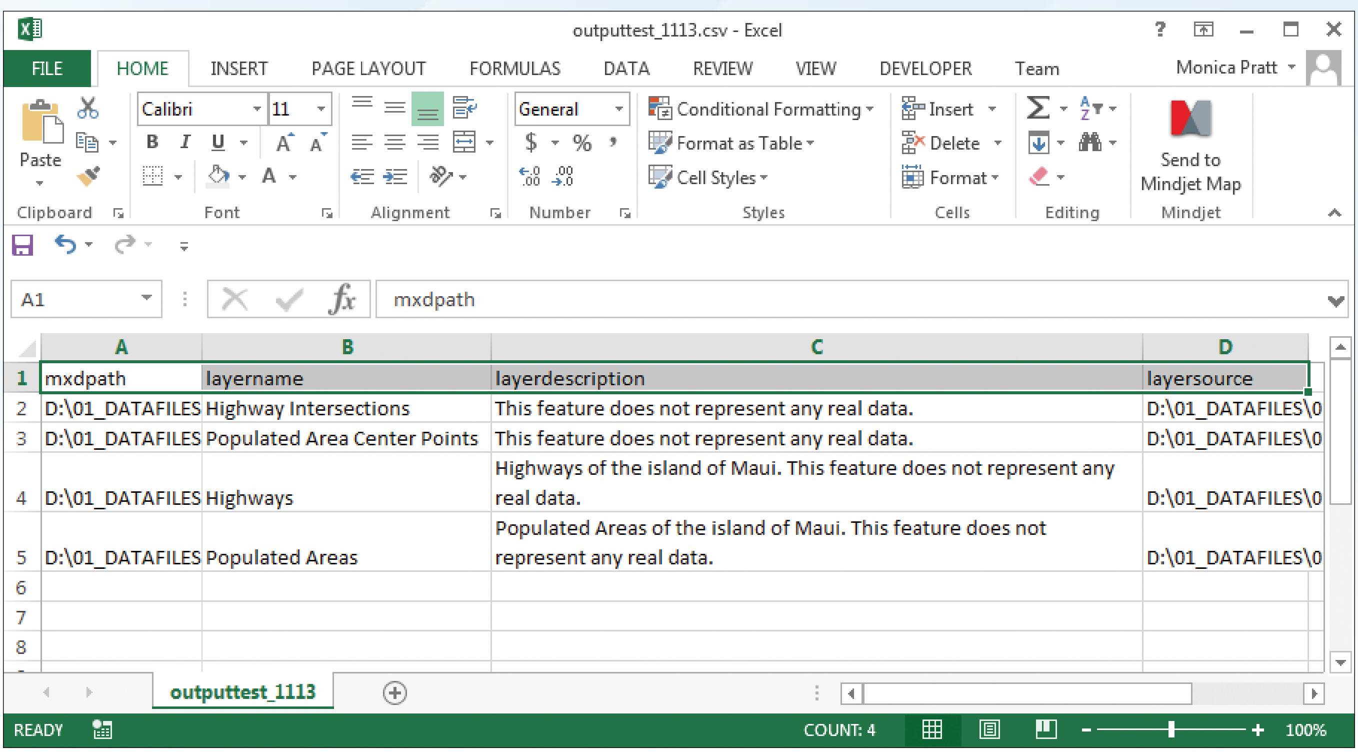
Summary and Conclusion

Python's csv module and ArcPy have made it an easier task to gather information about ArcMap documents and the layers they contain and summarize that information in a format that can be viewed as a standard spreadsheet. Authoring the Python script so it can be used as a script in an Esri toolbox means processing can be used repeatedly by others who may not know how to code in Python or ArcPy.

For more information, contact Colin Lindeman at clindeman@pdc.org.

About the Author

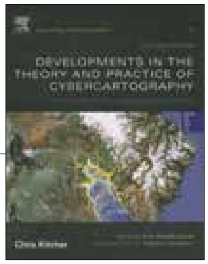
Colin Lindeman is a senior geospatial data systems analyst at the Pacific Disaster Center. Lindeman has been developing Python scripts for a variety of uses from geoprocessing tasks for use in ArcGIS for Server to batch processing and data conditioning.



	A	B	C	D
1	mxdpath	layername	layerdescription	layersource
2	D:\01_DATAFILES	Highway Intersections	This feature does not represent any real data.	D:\01_DATAFILES\0
3	D:\01_DATAFILES	Populated Area Center Points	This feature does not represent any real data.	D:\01_DATAFILES\0
4	D:\01_DATAFILES	Highways	Highways of the island of Maui. This feature does not represent any real data.	D:\01_DATAFILES\0
5	D:\01_DATAFILES	Populated Areas	Populated Areas of the island of Maui. This feature does not represent any real data.	D:\01_DATAFILES\0
6				
7				
8				

↑ The CSV file generated by the tool lists map layers and can be viewed in Microsoft Excel.

GIS Bookshelf

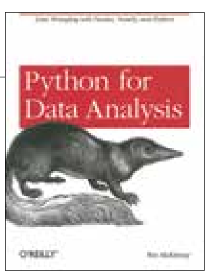


Developments in the Theory and Practice of Cybercartography, Volume 5, Second Edition: Applications and Indigenous Mapping (Modern Cartography Series)

Edited by D. R. Fraser Taylor and Tracey P. Lauriault

D. R. Fraser Taylor coined the term *cybercartography* and defined it as "The organization, presentation, analysis, and communication of spatially referenced information on a wide variety of topics of interest to society in an interactive, dynamic, multisensory format with the use of multimedia and multimodal interfaces." The fifth volume in this Modern Cartography series from Elsevier Science explores the practice of partnering with indigenous people to map traditional knowledge and present these maps as cybercartographic atlases. This second edition reflects the many changes that have occurred in this area of cartography since the publication of the first edition in 2005. Ninety percent of this edition is either new or has been revised and includes several new cybercartographic atlases that have been created in cooperation with Inuit and First Nations groups. It also features an interactive companion website that supplies links to related websites, additional illustrations, and information on the dynamic and interactive elements of cybercartography.

Taylor is a distinguished research professor and director of the Geomatics and Cartographic Research Centre at Carleton University, Ottawa, Canada. Recognized as one of the world's leading cartographers, he served as the president of the International Cartographic Association from 1987 to 1995. He pioneered the use of computers for cartography and introduced two of the first computer atlases in 1970. Lauriault is a postdoctoral researcher at the National Institute for Regional and Spatial Analysis at National University of Ireland, Maynooth, Ireland. Elsevier Science, 2014, 390 pp., ISBN-13: 978-0444627131



Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython

By Wes McKinney

Because SciPy was integrated with ArcGIS in November 2014, *Python for Data Analysis* will be of special interest to users of ArcGIS. It contains sections devoted to SciPy and NumPy, a package that has been integrated with ArcGIS for several releases, as well as sections on pandas, matplotlib, and IPython. This is a practical book that provides information for working on data-intensive applications using Python. It also serves as a hands-on introduction to the analytical methods of scientific computing using Python. Its intended audience is analysts who are new to Python and Python programmers who are new to scientific computing. The book's author, Wes McKinney, is the main author of the pandas library. O'Reilly Media, 2012, 466 pp., ISBN-13: 978-1449319793

Taking ArcGIS Online for a Test-Drive

In September 2014, Esri offered a massive open online course (MOOC) that let learners test-drive the spatial analysis capabilities of ArcGIS Online. Following the success of that pilot course, *Going Places with Spatial Analysis*, enrollment in the MOOC has been increased and the course will be offered two or three times in 2015, depending on demand. Another MOOC is also planned.

Going Places with Spatial Analysis is a six-week online course that includes free access to an ArcGIS Online organizational account. Initially 1,200 students were invited to sign up. Of the 800 students who registered, 600 participated actively, and 200 completed all course content. This is a higher completion rate than most MOOCs.

As an addition to its decades of support for teachers and curriculum development, Esri decided to experiment with MOOCs as a way to directly support students. David DiBiase, director of Esri's Education Outreach team, believes "we need to spark a grassroots interest in and demand for not just our technologies but for the fundamental geographic approach that our technologies bring to life."

Although most higher education institutions use the ArcGIS platform to some extent and many maintain Esri education site licenses, GIS is concentrated in a few departments. Most college students never encounter GIS during their college careers. MOOCs provide a channel for reaching students in disciplines that do not traditionally include mapping and GIS.

MOOCs are different than other Esri educational offerings. Instead of serving people who already use GIS, these courses reach people who may not know what GIS is or haven't heard of Esri. They are a low-cost, low-risk method of engaging people who are curious about the power of spatial thinking and geospatial technologies. This format also appeals to the thousands of current students and recent graduates who seek a competitive edge in the job market.

Esri sees MOOCs as complementing offerings by colleges and universities, not competing with them. Educators can use these no-cost, noncredit MOOCs as assignments or supplementary activities for credit courses. Esri also provides technology and staff support to institutions that request it for their own MOOCs.

The primary audience envisioned for this first MOOC course was tech-savvy young professionals already familiar with data analysis who want to learn more about the special capabilities of spatial data analysis. In October 2014, more than 10,000 people were invited to join the second offering of *Going Places* and more than 3,500 participated actively. Students included experienced ArcGIS users as well as those new to Esri software.

Current students and recent graduates of business schools are the target audience for the second MOOC currently under development. It will be designed to demonstrate to business school graduates how location analytics make them more attractive to potential employers.

At the conclusion of each MOOC, some additional steps are suggested. Students may take self-paced web courses and seminars offered by Esri's Training Services Group (training.esri.com) or access the case-based self-study modules available at Learn GIS (learn.arcgis.com), Esri's newest education website. They can also purchase a year's license for ArcGIS for Home Use (www.esri.com/software/arcgis/arcgis-for-home). This enables anyone to run ArcGIS for Desktop on a personal computer for noncommercial use and comes with an ArcGIS Online subscription account. Esri staff are also happy to discuss formal education opportunities at leading institutions, both online and on campus.

In assessing the value of MOOCs, DiBiase said, "I believe this is one of the best strategies we have for helping the wider world understand the power of the geographic perspective and the effectiveness of geospatial technologies to bring geography to life."

Credential Creep in the GIS Field: For Good or Ill?

By David DiBiase, Esri Director of Education

Have you noticed the proliferation of GIS credentials?

Hundreds of GIS certificate programs, dozens of specialized master's degrees, and even a few bachelor's degree programs have sprung up at colleges and universities at an accelerating rate since the 1990s. The absence of standards and accountability for academic certification contributed in part to the rise of GIS professional certification programs. These credentials are conferred by a few professional societies rather than many individual academic institutions.

American Society for Photogrammetry and Remote Sensing (ASPRS) launched its Certified Mapping Scientist program in 1988. This was followed by the launch of the GISP program by the GIS Certification Institute in 2004. Now a third professional certification for GIS analysts is in the works from the US Geospatial Intelligence Foundation. On top of all this, in 2010, the Esri Technical Certification program was launched.

What's driving all these credentialing schemes? Who wants these credentials and why?

Certainly the maturation of GIS technology and the professionalization of the GIS workforce accounts for part of the interest in affirming academic achievement and professional and technical competence. However, the phenomenon is also consistent with a broader trend variously called upcredentialing, credential inflation, or—most colorfully—*credential creep*.

The trend is evident in the number of academic degrees awarded per capita in the United States, which has increased at a much higher rate than population growth since the 1980s. One commentator has proclaimed that master's degrees are the new bachelor's degree. Similar trends are evident elsewhere in the developed and developing worlds, to varying extents. Furthermore, a recent study by Burning Glass Technologies demonstrates that many occupations that didn't require bachelor's degrees in the past—such as surveyor or mapping technician—now often do require such degrees. The reason, analysts suggest, is that employers use credentials to prescreen applicants and streamline the hiring process.

The proliferation of academic, professional, and technical credentials in the GIS field implies that many employers as well as job seekers value credentials. However, the trend raises a concern about whether credentialing programs are converging toward the worthy goal of fostering competence and strengthening the GIS profession or diverging toward a jumble of meaningless but costly tokens.

Two educational innovations are encouraging. One is the creation of a free market for credentialing through "microcredentials" like badges. You know about badges if you were a Boy or Girl Scout who earned merit badges to demonstrate personal advancement.

With support from the MacArthur Foundation, Mozilla has developed an Open Badges framework, which enables any organization to confer digital badges and individuals to display badges via "digital backpacks" linked to social media. Earlier this year, Elmhurst College awarded badges to students who completed its massive open online course (MOOC) *Skills for the Digital Earth*.

Esri believes that badges and other microcredentials have the potential to enrich education and training by providing finer-grained evidence of accomplishment that advances the positive trend toward volunteered geographic education.

A second innovation is the emergence of competency-based credentialing, which represents the legitimization of experience as a valid mode of learning. In the United States, Western Governors University was perhaps the first public higher education institution founded on a commitment to award credentials based on demonstrated achievement, rather than on "seat-time" in classrooms.

Precedents for the competency-based approach abound, including the tutorial system at the Universities of Oxford and Cambridge. However, the establishment of an entire institution predicated on the notion that adult learners should receive credit for what they know, regardless of how they learned it, was a watershed event.

More recently, the University of Wisconsin became the first major US university system to embrace competency-based learning with its flexible option program. A flexible option master's degree in geodesign that is currently in the planning stage at the University of Wisconsin—Stevens Point could become the first competency-based academic program directly related to GIS. Esri believes that even more innovative academic programs in GIS will adopt competency-based credentialing in the coming years.

Credential creep is happening in the GIS field. Labor market analysts warn that the phenomenon may worsen the runaway costs of higher education and cut off career opportunities for those who can't afford advanced training. However, a new generation of credentials that recognize experience and competence rather than seat-time herald better times ahead for adult education and workforce development.

A three-year study of northern Pacific humpback whales led to the identification of 8,000 individual animals.

Photo courtesy of Cascadia Research Collective

The Hidden Lives of Humpbacks Uncovered Using GIS

By A. J. Mangum

In 2004, marine researchers from 10 countries teamed up for an ambitious three-year effort to collect genetic samples from as many humpback whales as possible across the width and breadth of the northern Pacific Ocean. They created photoidentification records for each sighted humpback and recorded the geolocation of each sighting.

Researchers hoped the effort, which involved 400 biologists working on 50 teams, would lead to discoveries about the population structure and genetic diversity of humpbacks—a species once hunted to the brink of extinction—as well as their migration patterns.

Dubbed SPLASH (Structure of Populations, Levels of Abundance and Status of Humpbacks), the $3.7 million research effort was funded by the National Oceanic and Atmospheric Administration (NOAA), the Canadian government, and private sources. SPLASH was coordinated by the Olympia, Washington, nonprofit organization Cascadia Research Collective.

Researchers working in vessels ranging from oceangoing ships to canoes produced an abundance of data. Thousands of DNA samples and images collected in the whales' tropical breeding grounds and in their higher-latitude feeding grounds off the coasts of Russia, Alaska, British Columbia, and other locations, led to the identification of 8,000 individual humpbacks.

Four years ago, the task of mapping this data fell to Oregon State University (OSU) PhD candidate Dori Dick, a GIS specialist who

↑ Oregon State University professor Scott Baker and Cascadia Research Collective investigator John Calambokidis, collecting humpback whale data off California.

Photo courtesy of John Calambokidis

was completing her doctorate in earth, ocean, and atmospheric sciences. Working with Office of Naval Research (ONR) funding acquired by Esri chief scientist Dawn Wright and OSU professor Scott Baker, Dick developed an ArcGIS extension called geneGIS for viewing and analyzing SPLASH data. *[ONR is an executive branch agency of the Department of Defense that provides technical advice to the Chief of Naval Operations and the Secretary of the Navy.]*

"It's a natural thing when I have data. I want to map it right away and visualize what the data are showing me," Dick said. "When I received the *[humpback]* data, mapped it in GIS, and realized no one had ever seen it mapped before, what I saw was stunning."

Analysis of the photographic, DNA, and geolocation data led to dramatic discoveries about humpbacks' movements and genetics, as well as the very nature of the species' northern Pacific population.

A Cultural Inheritance

Humpback calves are born in tropical breeding and calving grounds in the winter and then follow their mothers to northern latitudes to feed for the summer. Come winter, mother-calf pairs then return to the tropics, where calves are weaned. SPLASH photo and DNA identifications, paired with geolocation data, showed that, as adults, those calves return to the same northern feeding grounds to which their mothers introduced them.

"We're now confident it's a matter of maternally inherited fidelity," said Baker, who teaches in OSU's department of fisheries and wildlife and serves as the associate director of the school's Marine Mammal Institute. The institute conducted genetic analysis for the SPLASH project and mainained the resultant DNA database. "In that first year of life, because of that maternal dependency, calves learn a migratory route and specific destinations, then return year after year, even though they're capable of learning other routes—we have seen some wander. This is not a genetic inheritance but a cultural inheritance."

Mapped sightings of DNA-profiled individuals also revealed previously unforeseen population complexities. There is greater genetic diversity in feeding grounds than in breeding grounds, which suggests that the population of a given breeding area can disperse to multiple feeding zones.

"Whales from Hawaii might spend the summer feeding off southeast Alaska," Baker explained. "But others from that same breeding ground might feed further north, off the Gulf of Alaska, or toward the Aleutian Islands. Even though they're part of the same breeding population, they'll spend more than half the year in different habitats." Understanding this behavior remains a challenge that is being addressed using ArcGIS.

Changing Conservation Practices

This discovery has dramatic implications for conservation efforts. For instance, protective strategies built solely on understandings of breeding ground populations will fail to account for the humpback population's genetic diversity and the species' actual use of its environment.

Perhaps most startling, DNA analysis also revealed the possibility of five genetically distinct northern Pacific humpback populations, each with a unique geographic distribution. In the United States, humpbacks are classified as endangered under the Endangered Species Act of 1973 but do not enjoy similar protection globally. The species is categorized as being of "least concern" by the International Union for the Conservation of Nature, an organization based in Switzerland that has substantial influence on environmental policies worldwide. The potential redefinition of the northern Pacific humpback demography as five smaller and distinct populations, Baker has suggested, could lead to strengthened protection for the whales under US and international regulations.

"If there are listings or delistings of populations, each one needs to be considered independently," Baker explained. "Each has a different history."

↑ Dori Dick, GIS specialist and Oregon State University PhD candidate, on a research trip to New Zealand

Photo courtesy of Dori Dick

The humpback's status as an endangered species has made it the object of research for generations of marine biologists. In the first half of the 20th century, humpbacks were hunted to such an extent that the global population dropped by an estimated 90 percent. An International Whaling Commission ban on hunting humpbacks, first put in place in the 1960s, is still in effect. The humpback population worldwide is now believed to be approximately 80,000, with a quarter of those whales in the north Pacific.

Past Paucity of Data

Biologists working to improve the species' chances for recovery have long been hampered by a lack of reliable data on humpback numbers, habitats, and migration patterns. Prior to the widespread availability of GPS technology, researchers and whalers alike documented humpback sightings, but information was recorded inconsistently and often with only vague geographic references. Without DNA analysis to confirm familial connections, researchers had to rely solely on firsthand observations of humpback cows and calves. The accuracy of the subsequent sighting of individual whales relied on guesswork to some degree.

"There hasn't been a good understanding of whether the population units suggested by historical data represent the true population structure," Dick said. "Obviously, if you're implementing protective measures in an area based on something less than a full awareness of the population structure of a group, you're missing a key component when making decisions."

Biology and GIS

That lack of actionable data led to what Dick describes as a "natural collaboration" between the fields of biology and GIS. SPLASH researchers working on the water used handheld GPS units to record the coordinates of humpback sighting locations. Photographs were taken of the undersides of humpbacks' flukes (or tails). Each humpback fluke bears a pattern that is as unique as a human fingerprint. Tissue samples needed for genetic analysis were collected using retrievable darts fired from small crossbows into whale backsides. The resultant SPLASH database included 19,000 fluke images and 6,000 tissue samples. ArcGIS and geneGIS were used to merge and study these records.

"We can now map where we see individuals in the ocean, the genetics of that population, and how the genetic structure is spread out across a spatial extent," Dick said. "With the coordinates of where whales have actually been found, we don't need to use *a priori* information researchers have used in the past. By bringing that data into ArcGIS and mapping it, we can then ask the right questions about population structure and genetic diversity."

Dick expects ArcGIS to become an increasingly important component of marine research and ocean-habitat management. Looking ahead to future efforts, she hopes to develop geneGIS tools that will use geolocation data for confirmed sightings of an individual whale to determine the most likely path it has traveled. She also plans to open a new area of research by using ArcGIS to create "finely tuned spatial structuring" in forage waters off Alaska in an effort to study the potential effects of the seascape itself on humpbacks' genetic diversity.

"If we really want to make a difference in the way in which oceans are managed that spatial element has to be incorporated into decision making," Dick said,

Given geneGIS's utility to any researcher working with a combination of genetic data and geolocation information, Dick expects the tool she's created to find applications beyond ocean-based research, in projects involving freshwater fish—such as salmon—or even terrestrial species.

"Any researcher with spatially referenced data can use these tools to gain new perspectives on how animals move about and use their environments," she said. "GeneGIS allowed me to look in a new way at a marine species that's been studied for years. Bringing that tool to other scientists so they can examine data in new ways … it gives you goose bumps."

A. J. Mangum is a Colorado-based writer, editor, and publisher.

Each humpback's fluke bears a pattern as unique as a human fingerprint.

Photo courtesy of Cascadia Research Collective

Esri Corporate Headquarters

380 New York Street
Redlands, CA 92373-8100 USA
T 909 793 2853
F 909 793 5953
info@esri.com
esri.com

Esri Technical Support
T 888 377 4575
F 909 792 0960
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