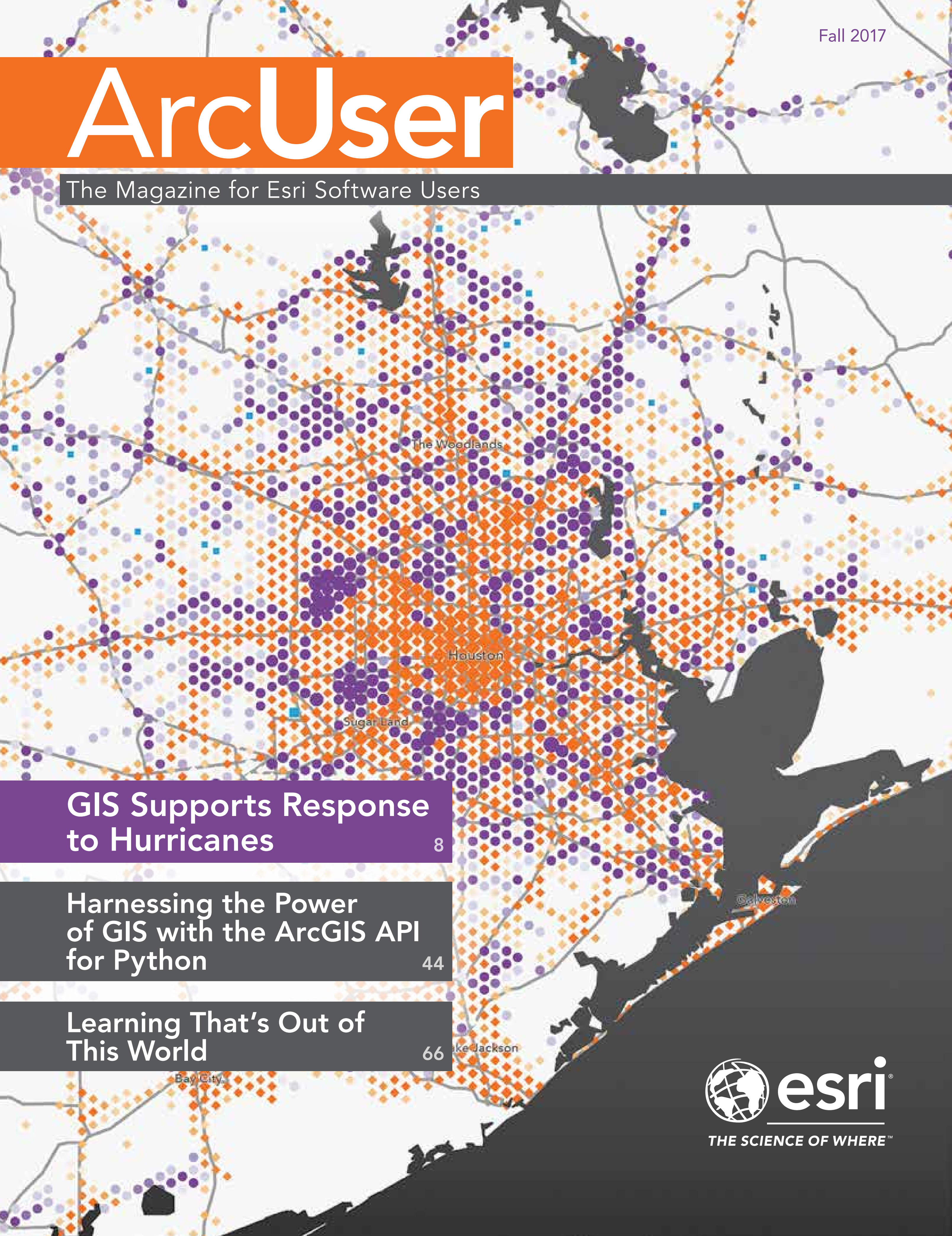
Fall 2017

ArcUser

The Magazine for Esri Software Users



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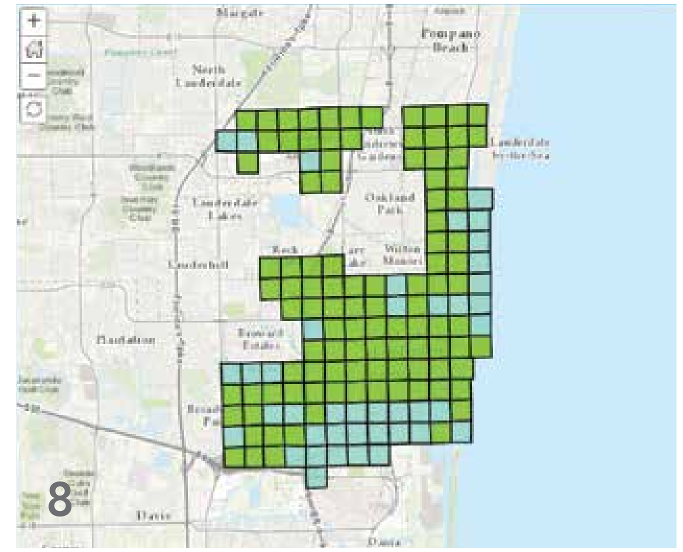

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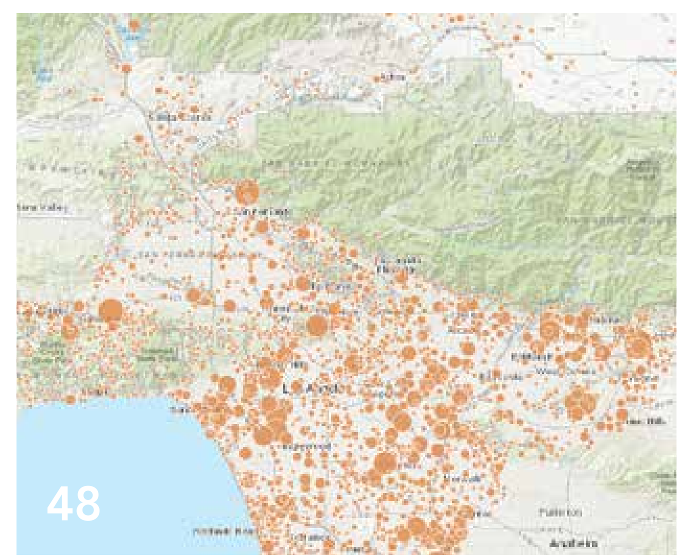

Special Section

A Promise Fulfilled

The articles in this issue illustrate how the promise of Web GIS envisioned 17 years ago is being realized. The Geography Network, introduced during the 2000 Esri User Conference, created a community of users who shared maps, data, and related services to make better decisions. What the Geography Network—and to a far greater degree its successor, ArcGIS Online—enabled is something that has always been fundamental to GIS: collaboration.

GIS has been a sharing technology since its inception. At a time when divisiveness seems to be on the upswing, GIS demonstrates that working together improves outcomes. Whether we are dealing with natural disasters, planning more livable communities, or gaining a better understanding of the Earth and its systems.

During its response to Hurricane Irma, the GIS Division at the City of Fort Lauderdale used Web GIS apps to coordinate response activities, work with departments throughout the city to monitor the status of infrastructure and help preserve it while safeguarding city personnel and residents.

Faced with the demands of a rapidly growing population, Placer County has been using GeoPlanner for ArcGIS to iteratively evaluate the fiscal and environmental impacts of various land-use scenarios. Non-GIS staff can interact with scenarios using simple drawing and painting tools.

Esri partner Weather Decision Technologies, Inc. takes advantage of the scaling capabilities of the ArcGIS platform with Amazon Web Services to analyze terabytes of sensor data to provide weather forecasting and map services to many industries in real time.

Esri continues to move toward the vision that Jack Dangermond, Esri's president, articulated in 2005. He saw GIS networks fueled by a geodata-rich environment that provided situational awareness and collaboration in real time that would benefit both individuals and organizations. By sharing services, "Individual systems would be connected into a kind of system of systems."

Monica Pratt
ArcUser Editor

ArcUser

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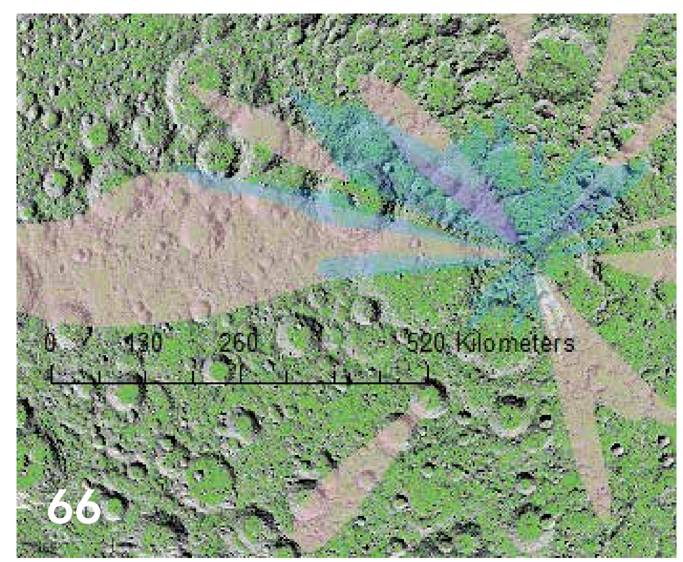
Departments



On the Cover

Hurricane Harvey has been characterized as possibly the worst disaster in Texas' history. When it made landfall in August 2017, how many people stayed in their homes and how many decided to leave and where did they go?

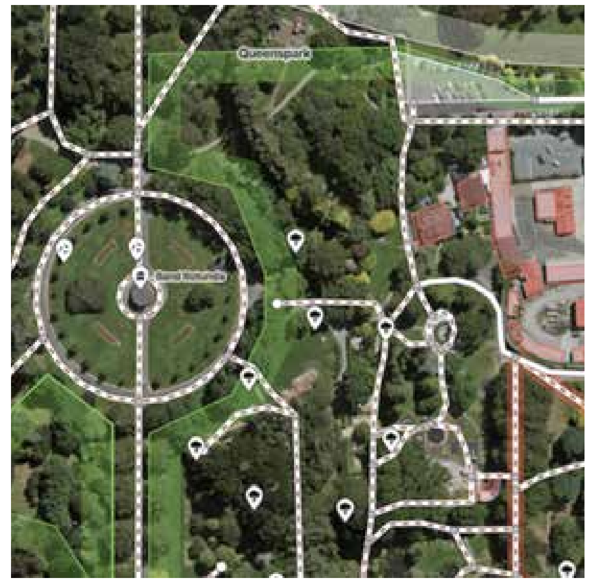
Esri cartographer Jennifer Bell created a map of Houston and the surrounding area to help answer those questions. This map shows the movements of residents during that time using mobility data from Teralytics, which applies machine learning to billions of signals aggregated from cell towers and other unique primary data sources.

Areas where the population was the same the week before and during the hurricane are symbolized by blue squares. This is a close representation of where people decided to stay, either waiting out the storm or unable to afford relocation. Orange diamonds represent areas where people left and purple circles symbolize areas where people arrived.

Briefly Noted

Esri's Satellite Imagery Available to OpenStreetMap Users

Esri is making its global satellite imagery layers available to the more than four million OpenStreetMap (OSM) users directly inside the OSM iD editor. OSM mappers update OSM using satellite imagery as the reference, so it is important that they access the most up-to-date, high-resolution imagery. OSM users will be able to access regularly updated satellite and aerial photography at one meter or better resolution in the continental United States and parts of Western Europe and lower-resolution satellite imagery across the globe from Esri's World Imagery Service. Access to this service was made possible with the support of Esri's commercial imagery providers DigitalGlobe, Earthstar Geographics, CNES/Airbus DS, GeoEye, United States Department of Agriculture Farm Service Agency, United States Geological Survey, Getmapping, AeroGRID, Institut Géographique National (IGN), and IGP as well as the contributors to the Community Maps Program.



OpenStreetMap (OSM) users can now use Esri's World Imagery Service to update maps.

Clustering Makes Sense of Point Data

If you have ever wanted to map a dataset that has too many points at the scale you wish to use, the clustering capabilities available in ArcGIS Online will help.

A method for simplifying the display of point data, clustering aggregates points interactively. Tightly spaced points are dynamically clustered. Dynamic clustering aggregates points as a single symbol at a small scale, but aggregated symbols separate when selected. Clusters of points are proportionally sized by feature count, which indicates the relative number of items clustered in that location. At larger scales, points are displayed as individual symbols.

Clustering helps you find new patterns in the data that might otherwise be hidden. Along with other tools in ArcGIS Online such as filtering, hot spot mapping, and heat mapping, clustering will help you find meaningful information in point data. The tool you use will depend on the nature of your data and the purpose of your map.

If a feature layer you add to an ArcGIS Online map contains points, the clustering option will appear in the More menu. The slider that appears once the clustering option is chosen allows you to control how much clustering will be applied to the point data. You can also customize cluster pop-ups based on the attribute you want to display, and that can include numeric attributes.

For even more control of the data, clustering can be combined with filtering. Create new attributes from existing data on the fly with ArcGIS Arcade expressions that can be used with clustering. For more information on using clustering, read the Configuring clustering topic in the ArcGIS Online help.

Esri & The Science of Where Podcasts

Esri & The Science of Where Podcast features interviews with thought leaders, industry analysts, technologists, and Esri experts who demystify topics such as digital transformation and share user success stories. To listen to the podcasts, visit esri.com/about/newsroom/podcast/ or subscribe to the podcast on iTunes, Google Play, Stitcher, or other podcasting apps.

Digital Esri Workbooks Benefit Students

The move from printed textbooks to digital workbooks for instructor-led classes at the Esri Training Center will ensure that training materials keep pace with the more rapid Esri software release cycle and add features like color illustrations and productivity tools that enhance learning while keeping course costs down.

When software releases were measured in years, printed books made sense. Now that software releases happen on a quarterly basis, the speed and ease of updating digital books makes the move to a digital format the best way to keep teaching materials in sync with current versions of Esri software.

To make it easy to refer to digital workbooks during class, Esri is adding a second monitor to each classroom workspace so students can view the digital coursebook on one monitor while following along with the course presentation and interacting with Esri software on the other monitor.

Many organizations have limited training budgets, so Esri tries to keep the cost of instructor-led courses more affordable. Digital workbooks help keep the cost of courses down by eliminating paper costs and costs associated with printing and shipping hardcopy books.

With the digital coursebook, color has become cost-effective. Now maps, diagrams, and charts will appear in color. Features such as search capabilities, text highlighting, digital notes, and bookmarks make it easy to interact with texts and find information. The digital delivery of workbooks also complements more than 400 e-Learning resources in the *Esri Training* catalog.

At the beginning of each course, students download the digital workbook. At the end of class, students upload their annotated coursebook to the Esri Training website. Coursebooks can be downloaded from the training site to a local drive and easily referenced at any time.

Fort Lauderdale's GIS Supports Response to

Hurricane Irma

By Monica Pratt, *ArcUser* Editor

When Hurricane Irma first made landfall in the Florida Keys on September 10, 2017, it brought destructive 70 mph winds and storm surges and left widespread power outages and downed trees and debris on Florida streets.

The city of Fort Lauderdale, located on the east coast of Florida, is no stranger to major weather events, but the city's mature and robust GIS provided vital information to public safety, public works, and other departments so city staff could quickly but safely respond to residents' needs during the event and support recovery efforts after the storm had passed.

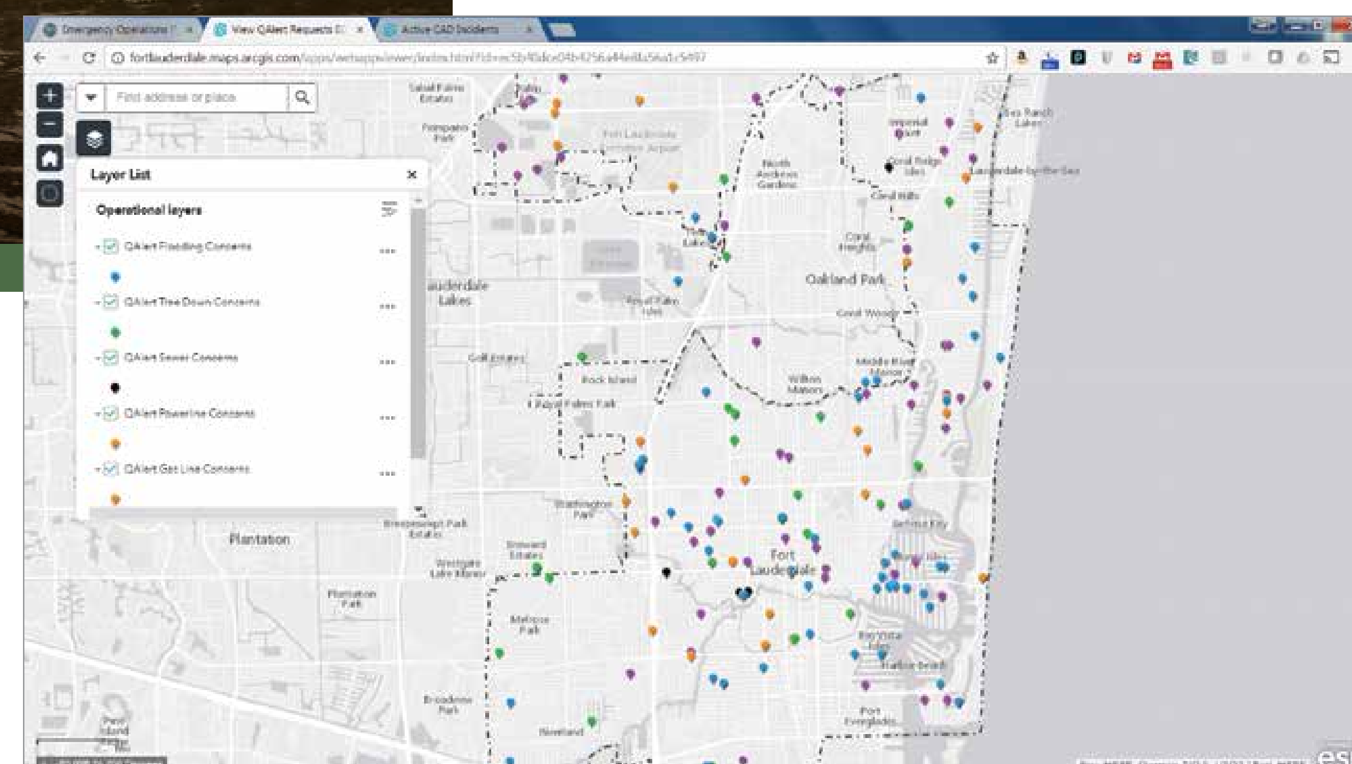
"The city showed that it was well prepared for an event like Irma, and GIS was crucial to that preparedness," said Ian Wint, GIS manager for Fort Lauderdale. "The EOC *[emergency operations center]* and its occupants have become increasingly reliant on GIS and the way it presents information. EOC occupants often leaned on GIS as the first source for information. It's telling that for about the first three or four hours of the recovery, EOC occupants requested that all seven large displays in the EOC show a GIS application. Perhaps just as impressive was the reality that GIS staff printed no more than five or six maps in the five days the EOC was activated. Staff were more interested in interactive solutions."

The GIS Division used ArcGIS Online, ArcGIS Online application templates, Esri Story Maps apps, and the regular edition of Web AppBuilder for ArcGIS to compile and analyze data and disseminate information on the status of the hurricane, city infrastructure, and response efforts. Customized web apps embedded in an Esri Story Maps app called the Emergency Operations Portal gave staff from various city departments and work units access to information relevant to their responsibilities. A simple symbolization scheme let them monitor the status of hurricane-related issues: open issues were red, in-progress issues were yellow, and closed issues were green.

> The city showed that it was well prepared for an event like Irma, and GIS was crucial to that preparedness.

In addition to its own GIS data and existing apps, Fort Lauderdale had access to relatively current high-resolution aerials as well as shelter and evacuation zone information from Broward County.

Prior to Irma making landfall and especially after the storm passed, the GIS Division relied on LauderServ (also known as QAlert), its 311-like system, to crowdsource information. City residents and staff use the system to report nonemergency issues via its web page, mobile app, or by telephone. Requests from LauderServ are



Fort Lauderdale relied on LauderServ (also known as QAlert), its 311-like system, to crowdsource information.

pulled into ArcGIS in real time and served out in a web app. City work units can filter requests to identify ones that fall in their area of responsibility.

Decision-makers in the EOC were granted real-time access to LauderServ requests via an ArcGIS Online viewer app. Fire-Rescue, Police, Public Works, and other department staff needed request information to provide aid to residents as quickly as possible and effectively coordinate field activities.

During the second day of the Irma response, a member of the Fire-Rescue command staff observed that an interactive mapping interface would allow for querying and filtering data and provide a better view of 911 calls than the interface and access method available to them at the time. As a result, a web app was developed using Web AppBuilder for ArcGIS that map enabled the 911 dispatch system. Using internal 911 calls for service data, the location and priority calls for service were mapped, color-coded, and annotated with a priority code.

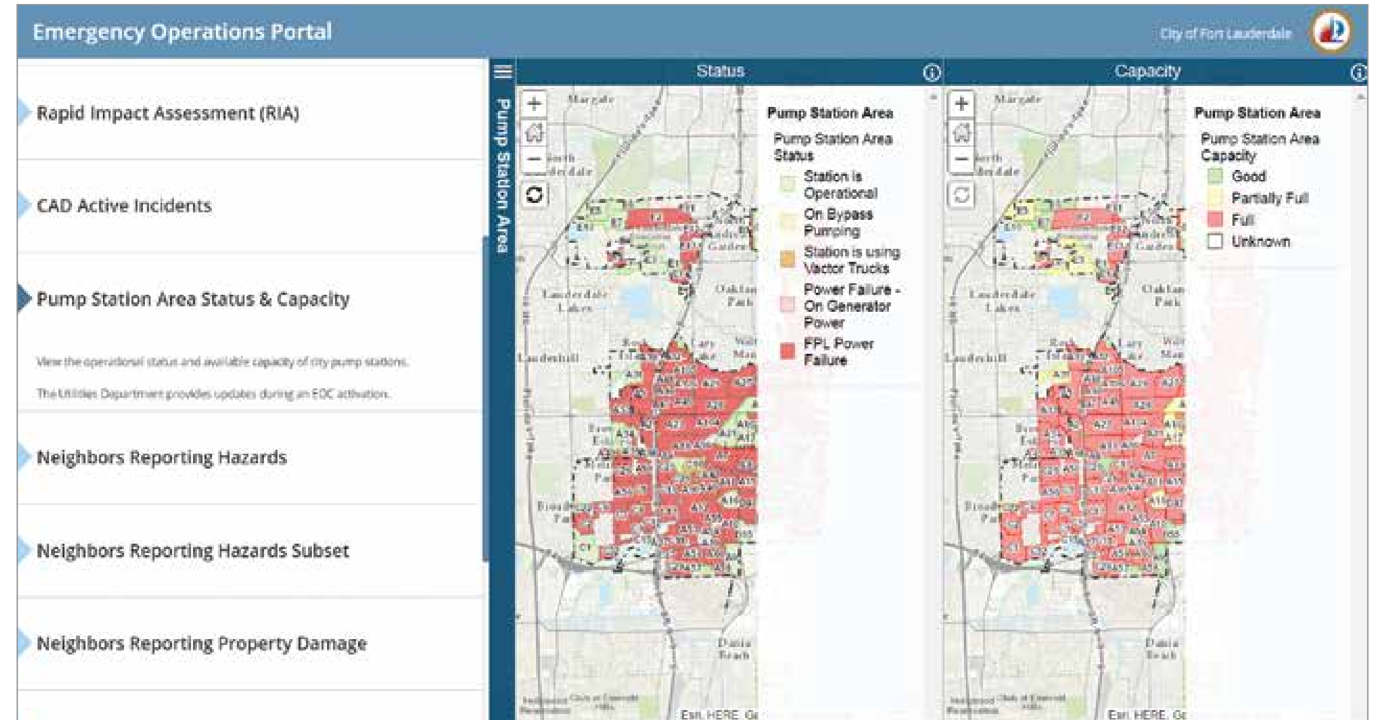
"The application showing Fire-Rescue and Police Calls for Service was born from years of working with the Fire-Rescue Department and showing them what is possible," said Wint. "By map enabling the 911 dispatch system in this way, command staff gained greater insight into storm-related incidents, such as two cases of breaking and entering of commercial properties that occurred before the storm's arrival."

At the request of the EOC staff, GIS apps showing the status of the storm and response to it were displayed on the large screens in the EOC. Photo courtesy of Ian Wint

During the early stages of Irma, data on wind speed was critical to ensuring the safety of city staff involved in response efforts. The city used map services that provided Esri live feeds of National Oceanic and Atmospheric Administration (NOAA) data on wind speed and direction and NOAA storm reports. When conditions permitted staff to respond, sustained wind speeds and recorded gust data helped determine the most appropriate type of vehicle to use.

GIS also made sensor data from the Utility Operations supervisory control and data acquisition (SCADA) system actionable and helped utility staff manage the pumps and pressure of the city's wastewater system during the storm. Heavy rain and floodwater from a major storm can drain through surface level manholes and into the wastewater system. If this happens in areas where pump stations are malfunctioning, it can result in sewage backups that reach the surface.

Utility staff members used a web-based editor application created by the GIS division to enter SCADA information in the GIS. As the storm progressed, EOC occupants and utility managers monitored the status and capacity of the sewer pump stations through the use of a viewer app. They watched as the interactive map, initially mostly green, became dominated with red. With constantly updated information on which pump stations were experiencing power failure and approaching capacity limits, decision-makers could quickly respond to this situation after the storm.



EOC occupants and utility managers were kept abreast of the status and capacity of sewer pump stations through the use of this viewer app available from the Emergency Operations Portal.

A powerful storm such as Irma leaves hazards that must be dealt with promptly. If Broward County activates its EOC as the result of a severe weather event, each municipality must conduct a Rapid Impact Assessment (RIA) once it is safe to do so. To systematically perform the RIA, Broward

A powerful storm such as Irma leaves hazards that must be dealt with promptly.

County is divided into grids, each one a quarter mile in size.

Municipalities perform the RIA as a "windshield survey," or quick drive-by inspection, to assess any damage that has been sustained and provide a numerical rating for the wind and flood damage sustained in each grid in their jurisdiction. The rating scale ranges from 0 (no damage) to 4 (catastrophic damage). The field information gathered by the RIA helps managers better understand needs so they can make better-informed decisions when deploying resources.

In Fort Lauderdale, the Fire-Rescue and building inspection staffs team up to conduct this assessment. The Fort Lauderdale RIA Viewer, a web mapping app, was used by the EOC to track damages throughout the city as they were reported.

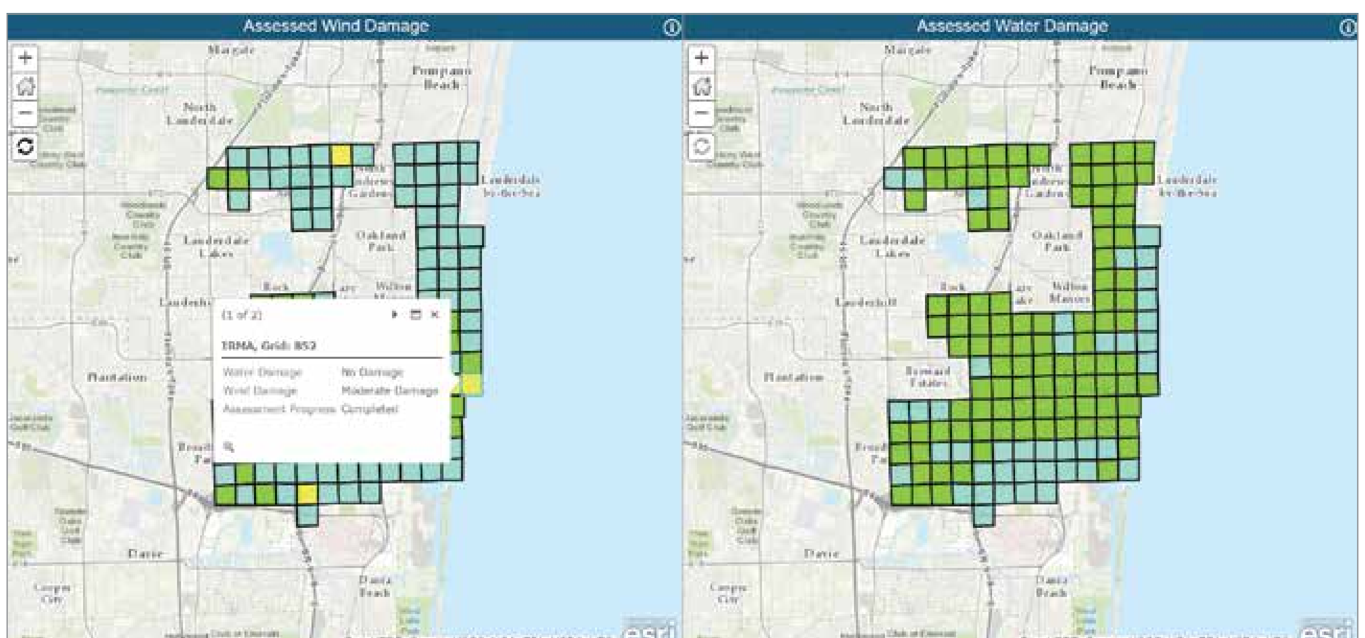
The GIS Division has an ongoing role supporting the city's disaster preparedness plan. Each year Fort Lauderdale conducts at least one mock exercise. The GIS Division uses that event as an opportunity to learn more about EOC's needs and educate staff about GIS capabilities.

The web offers many advantages including allowing us to reach a wider audience.

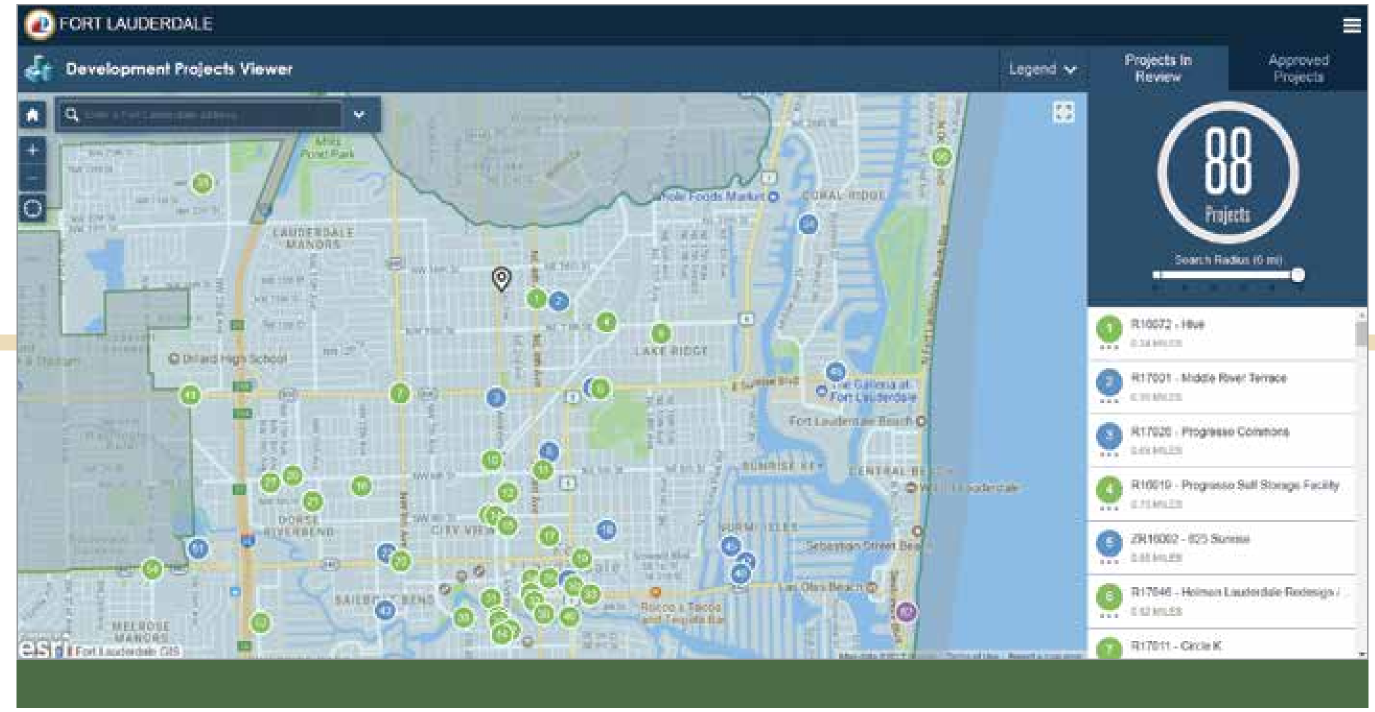
With every disaster, the GIS Division learns more. During Hurricane Matthew in 2016, the GIS Division stood up apps based on ArcGIS templates during the event. Following Hurricane Irma, there have been requests to retain the Fire-Rescue and Police Calls for Service app that was created during Hurricane Irma. Although the SCADA network is currently separated from the city's regular network, post-Irma there is a strong interest in modifying the network design to allow GIS to read directly from SCADA without human intervention in a way that does not make the utility networks vulnerable to security exploits.

The GIS Division was so effective in helping the city deal with Hurricane Irma, in part, because it has been developing a solid portfolio of solutions over many years that have improved the city's processes while building relationships with city departments. When Wint joined the city in 1999, he doubled the city's GIS staff. The GIS coordinator since 2000, Wint has overseen the steady growth of GIS at Fort Lauderdale during that 17-year period.

That growth has been enhanced in recent years by a strategy of embracing Web GIS. Wint explained the reasons behind this strategy. "The GIS Division has always viewed web technology as a way to serve more customers and in a way that is usually more efficient than solely relying on desktop technology or as an order desk. The default mindset when developing a solution to a problem or displaying results is to first ask the question of whether it would be appropriate for a web application. The web offers many advantages including allowing us to reach a wider audience."



Poststorm activity starts at the crack of dawn with the Rapid Impact Assessment of the entire city. Decision-makers in the EOC were granted real-time access to the status of the assessments via this viewer application.



Because Fort Lauderdale GIS notifies all city departments of new apps it develops, city staff often find that apps built for one purpose can be used for another. LauderStreet, which provides information on scheduled road closures, was reworked to become the LauderWorks for tracking city-managed construction and repair projects, then became the Development Project Viewer, which shows land development projects in the city's review system.

Not only can the GIS Division reach more users using web technology, but it can also reach them at a lower cost to the city because web-based solutions are centrally maintained.

To multiply the impact of each solution, the GIS Division introduces new apps or enhanced services in a way that encourages city staff to see new uses for the technology. The division emails the announcement to every city staff member.

"So, staff in Engineering may see the announcement for a new application we created for Transportation and Mobility even though on the surface the new application may not concern Engineering. This does two things: First, it reminds Engineering and others that GIS exists within the city; and second, it gives them ideas on a solution created for one work group *[that]* can benefit their work group."

Wint saw that happen when the LauderStreet app was released. LauderStreet provides location and other information on scheduled road closures. It morphed into LauderWorks, which lets city residents know about city-managed construction and repair projects. LauderStreet had yet another reincarnation when the Urban Design and Planning Department requested the GIS staff spin off an app called Development Project Viewer that shows land development projects in the city's review system.

These and other projects that the GIS Division undertakes support its overarching goal of making local government more efficient. It strives to empower the city with tools to access the most accurate, timely, and useful information—especially information that might not otherwise be easily accessed—through user-friendly graphic interfaces.

These tools become even more valuable to the city when responding to events like Hurricane Irma.

Acknowledgments

Several Fort Lauderdale staff members played critical roles during the response to Hurricane Irma. GIS analyst Lucia Hogan built most of the response apps. GIS analyst Rollin Maycumber assisted in the EOC. Former staff member Jon Stahl implemented the sewer pump station solution. A year ago, when the EOC was made the primary site for all on-premise GIS, the city's IT system administration, network, and database teams—and particularly GIS applications developer Haiting Huang—created the IT infrastructure that made this possible. This foundation allowed the GIS Division to work effectively during the event.

Forecasting Weather
with Big Data in the Cloud

With an abundance of satellites and remote-sensing devices monitoring weather systems all over the world, meteorologists now have more data available to them than ever before. But more data doesn't necessarily translate into improved predictions.

Because of the size and complexity of weather patterns, they can be very difficult to predict more than a few days in advance. Researchers continually refine their instruments and processes to better understand the climate and make more accurate weather forecasts.

Esri partner Weather Decision Technologies, Inc. (WDT), uses advanced GIS from Esri to better organize and analyze this big data. WDT provides weather forecasting and mapping services to many industries: energy corporations to help them predict electrical outages and keep offshore oil rigs safe; agriculture agencies for crop insurance; freight transportation companies to aid with route design; and concert and sporting event organizers for planning and safety.

"The amount of data that we collect is enormous, about one terabyte per day," said Matt Gaffner, GIS solutions expert at WDT. "Over the years, we have assembled an archive of almost half a petabyte of weather data."

Analyzing Clouds in the Cloud

The company currently uses ArcGIS Server to develop all its map services for customers, though it plans to upgrade to ArcGIS Enterprise later this year.

"One of the great things about the ArcGIS Server platform is that it's extremely easy to publish live, dynamic, rapidly updated data and then host it as a service for use with other applications," said Gaffner. "This allows our users to quickly add past, present, and future weather data to their maps and apps." It also enables WDT's partners that build apps for specific vertical markets, such as utilities, to add weather data to their apps using WDT's map services.

Cloud computing is key to WDT's operations. The company uses Amazon Web Services (AWS) to deploy the analytical and mapping services that ArcGIS Server provides. "There are so many advantages available to us by using Amazon Web Services," Gaffner pointed out.

With cloud services, the company can stand up multiple machine instances of ArcGIS Server to determine the operational stack that runs the best. "For one thing, it allows us to implement the 'fail faster' mantra. Using the ArcGIS Amazon Machine Image (AMI) capability, we can easily stand up a version of the server in the cloud and try something new—like using different machine hardware specifications or configuring data services differently—to see if it works or not. If it works, great. If it doesn't work, then we stand up another instance and try something else."

"AWS provides us with reliability because if something goes wrong, we can easily replicate ArcGIS on another machine in the cloud," Gaffner said. "It also provides us with load balancing—that is, we can redistribute the many requests we receive for weather data and map services between our servers. This extra demand normally happens when the weather changes and storms begin to develop. Our datasets increase in size then because there is more radar data accumulating, and our customers need access to that data."

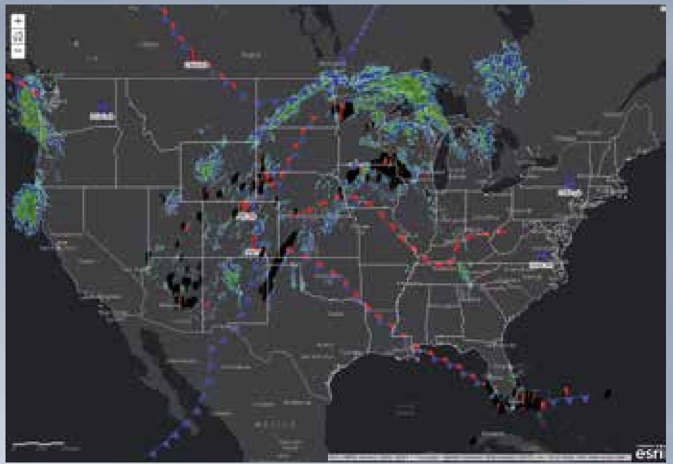
WDT is currently doing a lot with time-enabled map services. For example, users can loop through the last 60 minutes of radar data to see where a storm has been and where it is headed. WDT is also launching a time-enabled global forecasts map service that will provide both daily and hourly forecasts for all the normal weather variables—temperature, precipitation, wind speed, and direction—out to 10 days. Because the company is serving out bigger datasets to accommodate more requests, using cloud services makes WDT's servers scalable at critical times.

Environmental Conditions Affect Businesses—and Decisions

WDT's ever-growing collection of big geospatial datasets allows users to conduct unique analyses across time and space. For example, one of its customers—an oil and gas company—wanted to determine how much the weather affected the productivity of its crews in Oklahoma versus Colorado.

"They wanted to figure out the productivity of each, but they wanted to statistically normalize that comparison by taking into consideration the local weather conditions," explained Gaffner.

During the summer, it could be 90 degrees in both Oklahoma and eastern Colorado, but with more humidity in Oklahoma, the heat index would likely be higher than in Colorado. "By using historical weather data," said Gaffner, "we were able to perform this analysis and found that weather can impact crews in two ways: decrease worker efficiency under heat stress and push the heat index above a critical threshold where workers are required to take mandatory breaks."

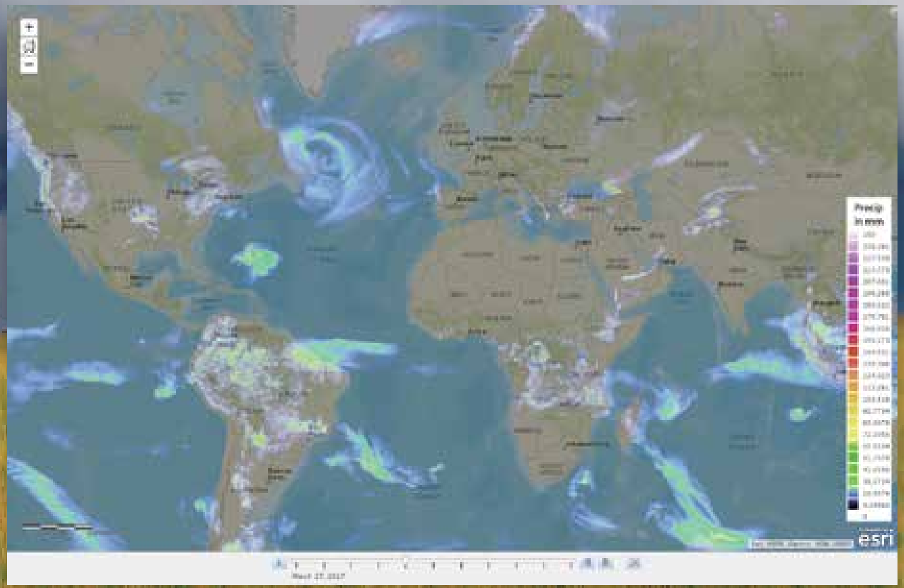


The ArcGIS platform makes it easy to publish live, dynamic, rapidly updated data. This real-time map service shows frontal analysis that is updated every three hours, North American Radar data that is updated every five minutes, and lightning data that is updated every minute.

WDT is also considering the impact that the Internet of Things (IoT) will have on geospatial analysis.

"Take, for example, the connected car," said Gaffner. "We can provide real-time weather or a weather forecast to your car that might tell you, 'Hey, you should probably stop driving to avoid that storm,' or, 'There's a line of thunderstorms moving through your area; you might as well stay at work for another 20 minutes and wait until it passes through and then drive home.'"

If weather and environmental data is combined, it can help mitigate risk and enable people to make smarter decisions. And, as Gaffner hopes, the confluence of big data with smart analysis can save lives and property in the long run.



For more information on WDT, visit wdtinc.com.

With Weather Decision Technologies' time-enabled global forecasts map service, users can see each day of a 10-day precipitation forecast.

Placer County, California extends from the agricultural region of the Sacramento Valley through the Sierra Nevada mountains to scenic Lake Tahoe.

Placer County Sees Planning Decision Impacts in Real Time

To ensure that it preserves the quality of life for residents while accommodating the demands of an expanding population, Placer County began using GIS in-house to iteratively evaluate the impacts of various land-use scenarios.

In 2016, Placer County had the second-highest increase in population among California's 58 counties, according to the California Department of Finance. The county's diverse economic base includes a mix of manufacturing, high-technology, retail, and business services companies. This has supported the strong population growth the county has experienced for more than a decade. For the period between 2003 and 2013, it was the fastest-growing county in the Sacramento region with a population growth of 26 percent.

Placer County, California, is a vast county that covers 1,506 square miles. It extends from the agricultural region of the Sacramento Valley through the Sierra Nevada mountains to scenic Lake Tahoe. Because of Placer County's appeal as a place to work, live, and play, it has become one of the fastest-growing counties in California. The need to supply services to this growing population continues to be the major focus of Placer County's land-use planning strategies.

Planning for Growth

Placer County routinely performs financial analysis for future development. This analysis of revenues and expenditures evaluates the financial impacts of land use within developments or specific plans. County officials evaluate potential revenues, such as property or sales taxes, provided by a development. That figure is balanced with county expenditures resulting from the development for public safety, general government, roads, and other costs.

Historically, Placer County has relied heavily on consultants to perform this type of analysis along with the multiple revisions that are sometimes necessary. As with most development projects, land-use projects go through changes during the planning process. Placer County needed a more efficient and cost-effective way to analyze changes and perform financial impact analysis in-house and in real time.

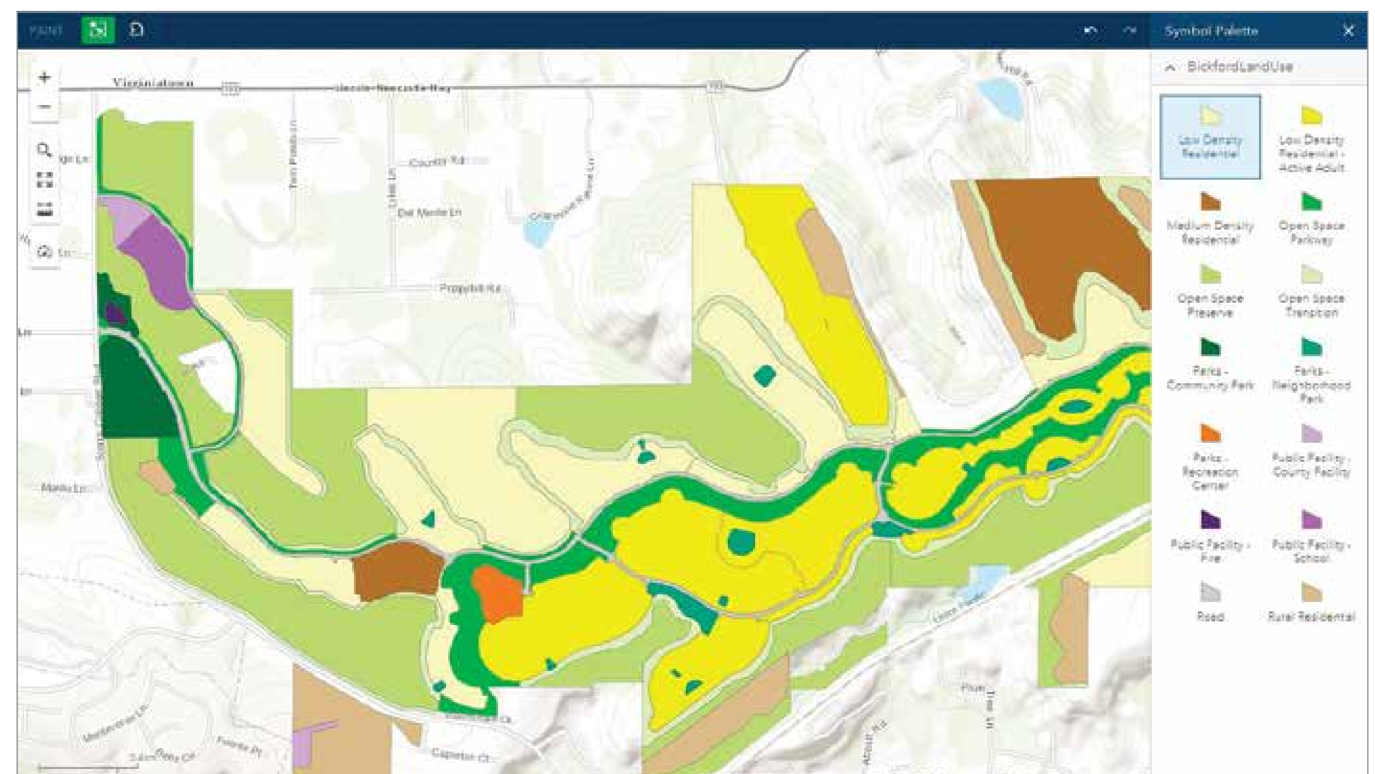
Taking Cost-Benefit Analysis In-House

Placer County acquired GeoPlanner for ArcGIS to assist it in performing financial impact analysis. GeoPlanner for ArcGIS empowers users to plan, test, and evaluate city, regional, and landscape-scale scenarios in a collaborative, iterative environment.

A web-based planning tool, GeoPlanner lets Placer County apply geodesign principles and uses data on intact areas from the National Intact Habitat Cores database provided by Esri to identify green infrastructure and preserve it. GeoPlanner can provide a more complete understanding of how an area performs or behaves.

"We can see in real time the impacts of decisions, maximize land use, and minimize costs to develop a strong land-use plan that will benefit the citizens, the developers, and the county."

Kelly Berger
Placer County GIS Coordinator



Non-GIS professionals at Placer County use GeoPlanner to draw and paint different land-use scenarios.

Placer County can look at key performance indicators (KPIs) displayed in easy-to-read gauges and charts that provide immediate feedback on design decisions by visualizing their impacts in real time.

Once a project is created in GeoPlanner, other users in the organization are invited to collaborate and become part of the project team. As team members, they can access and work with project scenarios by sketching and drawing using symbols and drawing tools.

GeoPlanner dashboards display qualitative and quantitative information about the scenario under consideration through information on key performance indicators (KPIs) displayed in easy-to-read gauges and charts that provide immediate feedback on design decisions by visualizing their impacts in real time. The impacts of multiple KPIs can be tracked at the same time the advantages and disadvantages of scenarios can be evaluated to aid in balancing multiple competing priorities.

Using GeoPlanner, Placer County can run spatial analysis on the fly, compare scenarios, and produce data-informed plans using the real-time dashboards and KPIs. This helps county government staff and stakeholders understand the quality, performance, and impact of plans as they are designed.

Placer County uses KPIs to model the financial impacts of different land-use scenarios. Using the KPI Report, the county explores many scenarios by measuring their effects on KPI values. In its comparisons, Placer County uses metrics that include estimates for residential units, population, jobs, areas of different land use, areas of commercial developments, revenues, and expenditures.

Non-GIS professionals at Placer County use GeoPlanner to draw and paint different land-use scenarios. As planners and analysts change land-use patterns—such as from low- to high-density residential—KPIs immediately reflect changes in revenue and expenditure estimates. Placer County's GIS group uses GeoPlanner to develop the layer of base land use and build out the KPIs.

"Using GeoPlanner, we see and understand in real time the financial impacts of land use change on a project," said Kelly Berger, Placer County GIS coordinator.

"As land use changes in the plans, GeoPlanner helps us explore the greatest cost benefit to the county and its citizens," Berger said.

Understanding Impacts

As Placer County continues to grow, decision-makers can further analyze and understand the financial impacts of development. Through the iterative process of developing a land-use plan, GeoPlanner helps Placer County contain costs each time the analysis needs to be performed.

"GeoPlanner saves considerable time and money by empowering us to perform the analysis in-house prior to finalizing it through consultants," Berger said. "We can see in real time the impacts of decisions, maximize land use, and minimize costs to develop a strong land-use plan that will benefit the citizens, the developers, and the county."

See "Local Officials Ride the Wave of Baby Boomers: Community Analyst helps make Placer County more friendly to retirees" in the Summer 2011 issue of *ArcUser*. (esri.com/news/arcuser/0611/local-officials-ride-the-wave-of-baby-boomers.html) to read more about Placer County's use of GIS in planning.

Maricopa County Quickly Builds Customized Parcel Viewer

The Maricopa County Assessor's Office modernized its parcel visualization app using the developer edition of Web AppBuilder for ArcGIS. GIS Programmer analyst Kacie Baker built the app then extended its capabilities using the ArcGIS API for JavaScript.

It is now easier than ever for parcel assessors, real estate agents, appraisers, and other interested parties to review national boundaries, jurisdiction, zoning, and ad valorem valuation in Arizona's Maricopa County.

"Our Parcel Viewer application helps staff and the public identify, classify, and value real property parcels within Maricopa County, Arizona," Baker said. "The application serves up several years of aerial photography, zoning, and flood layers, along with links to third-party services."

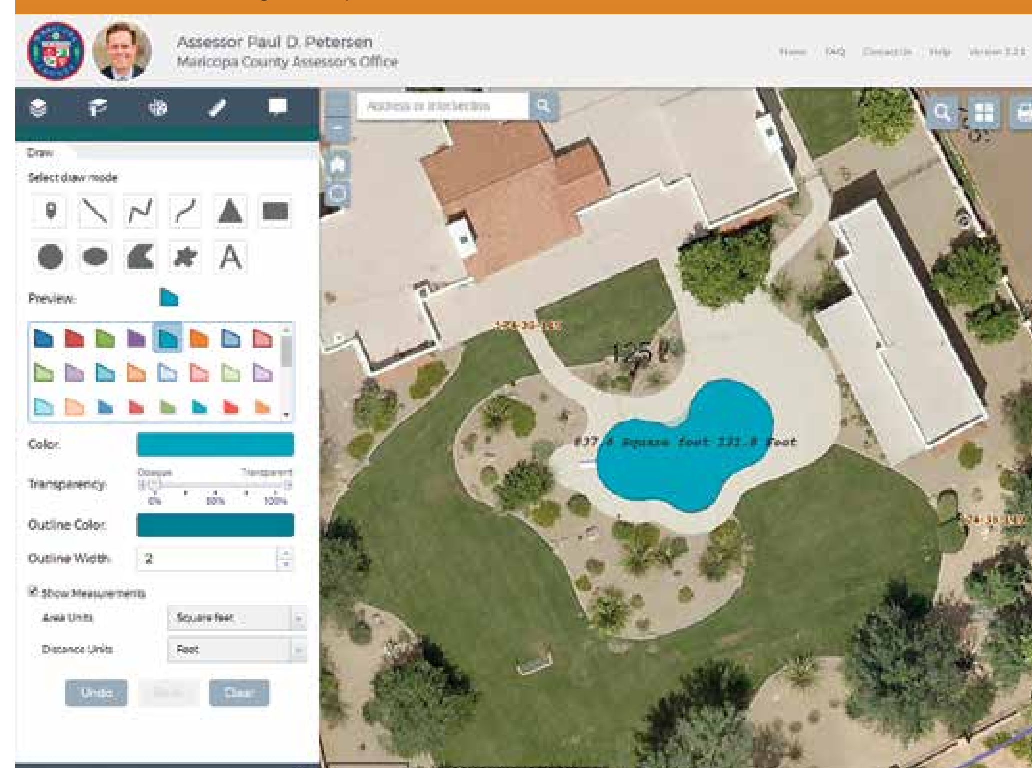
Within a two-month timeframe, Baker and her team built the web app they needed. She broke down the app's search capability by categories, then added aerial photographs and basemaps to show zoning, flood lines, and other options for each parcel. The app also allows users to annotate parcels with additional information by drawing on and adding text to parcels. Baker added a "My Location Finder" so users, such as assessors in the field, can click a GPS icon and zoom to their location.

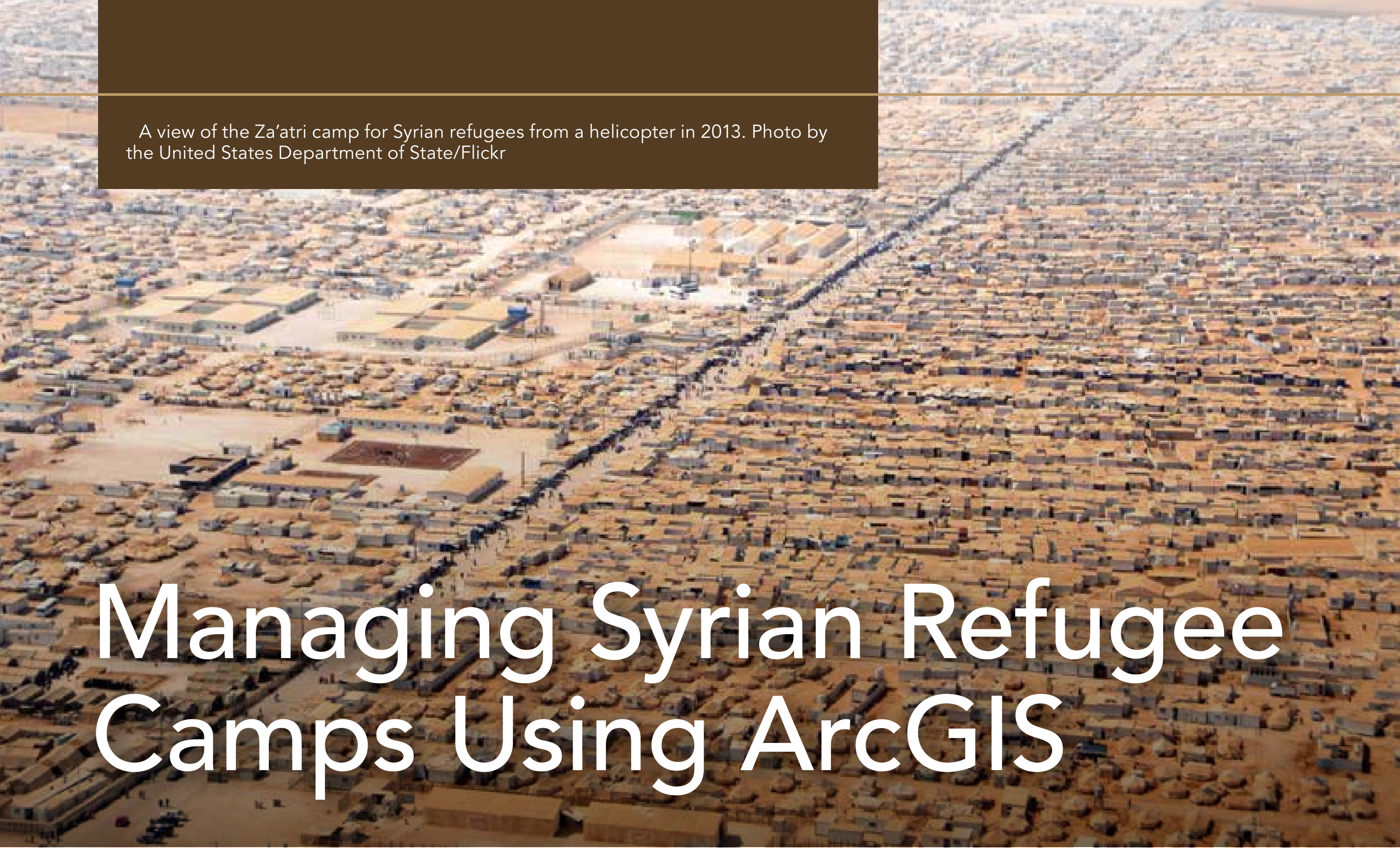
"Web AppBuilder did a lot of the start-up work for us," Baker said. "It gave me a structure and saved a whole bunch of time as it is streamlined and easy to use. It allows me to customize as I need. I had to incorporate the Assessor's Office standards for color scheme and certain images, so I had to customize."

Change from the old public-facing maps was a bit difficult at first, Baker explained, but as people learned to use the new site, they appreciated its advanced functionality. For example, a buffer tool shows how many residential or commercial parcels are within a certain area. Users can export addresses for all those parcels—a tool that's especially useful to owners and their representatives who are working with city permitting.

"We're getting a positive response," Baker said. "People regularly email us to say that the site is clean and easy to use. We continue to collect feedback to make the app even more valuable in the future."

Parcel Viewer allows users to annotate parcels with additional information by drawing on and adding text to parcels.





A view of the Za'atri camp for Syrian refugees from a helicopter in 2013. Photo by the United States Department of State/Flickr

Managing Syrian Refugee Camps Using ArcGIS

By Eyad Ghattasheh, Openware

As the Syrian crisis enters its seventh year, civilians continue evacuating towns and cities seeking safety in other Syrian cities or neighboring countries. The need to manage refugee camp facilities has become a serious concern for humanitarian organizations and the governments of neighboring countries.

As of April 5, 2017, the United Nations High Commissioner for Refugees (UNHCR) and the Syria Regional Refugees Response (SRRR) report that Jordan hosts 656,913 "registered" Syrian refugees. Of this number, 140,990 (21.5 percent) are in refugee camps, while 515,923 (78.5 percent) are scattered across Jordanian urban territories. Al Za'atri camp, which has grown to encompass more than one camp, is the largest refugee camp in the world. Its population as of 2015 was 71,227, and it is the fourth largest populated place in Jordan.

Al Za'atri camp is also the most mapped refugee camp in the world. Originally, Al Za'atri camp was designed to accommodate 20,000 refugees, but because the situation in Syria has worsened, its area has grown accordingly.

In addition to water sources, hospitals, schools, mosques, kitchens, restrooms, showers, and sanitary dumps, Al Za'atri camp provides residents with other facilities. Managing these facilities became more challenging as the population exploded and the area served expanded. Management includes distributing facilities throughout the camp, monitoring the condition and efficient operation of facilities, and determining the need for additional facilities.

In 2010, REACH was started as a joint initiative as part of the IMPACT Initiative, Agence d'Aide a la Cooperation Technique et au Developpement (ACTED), and the United Nations Operational Satellite Applications Programme (UNOSAT) to provide information and maps for decision-making using GIS. The goal of using GIS is to enhance the delivery of all aid types to refugees in the conflict areas through the use of reliable and up-to-date information. In 2013, REACH began activities in Al Za'atri camp to improve access to facilities by familiarizing refugees with them through GIS maps.

REACH GIS experts created thematic maps to show statistics for the demographic data on Syrian refugees. ArcGIS for Desktop is used to map all camp facilities and analyze the accessibility of these facilities. As part of this proximity analysis, Theissen polygons were created to calculate the number of tents served by a water tank, kitchen, restroom, or other specific facility. After calculating these statistics, facilities could be rearranged to provide equitable access to them.

The first map of Al Za'atri camp was created using a UNOSAT satellite image as a guide. Inside the camp, field crews equipped with Garmin eTrex GPS devices, collected the positions of facilities to assist in the creation of vector data. Information, such as Arabic streets names as they were spelled by refugees, were written on hard copies of the satellite image. Because all camp residents are Muslim, it also was important that the map indicated the Qibla, the direction Muslims should face when praying.

Once this data was collected, GIS experts at REACH's Amman-Jordan base station downloaded it from the GPS devices and converted it to a geodatabase feature class. Information that had been written on the satellite image was added as an annotation feature class and placed in the same geodatabase. The map created from these feature classes represented all the facilities, landmarks, and street names for Al Za'atri camp in one powerful static map. This map was a decision-making tool for the humanitarian community and the refugee population in the camp.

As the camp was extended and camp shelters changed from tents to caravans in most parts of the camp, it was necessary to create a basic wastewater network. Caravans are equipped with wash or restrooms and kitchens. REACH accordingly—and in cooperation with The United Nations Children's Fund (UNICEF)—enhanced its mapping by also creating a public-facing web map using ArcGIS for Desktop and JavaScript.

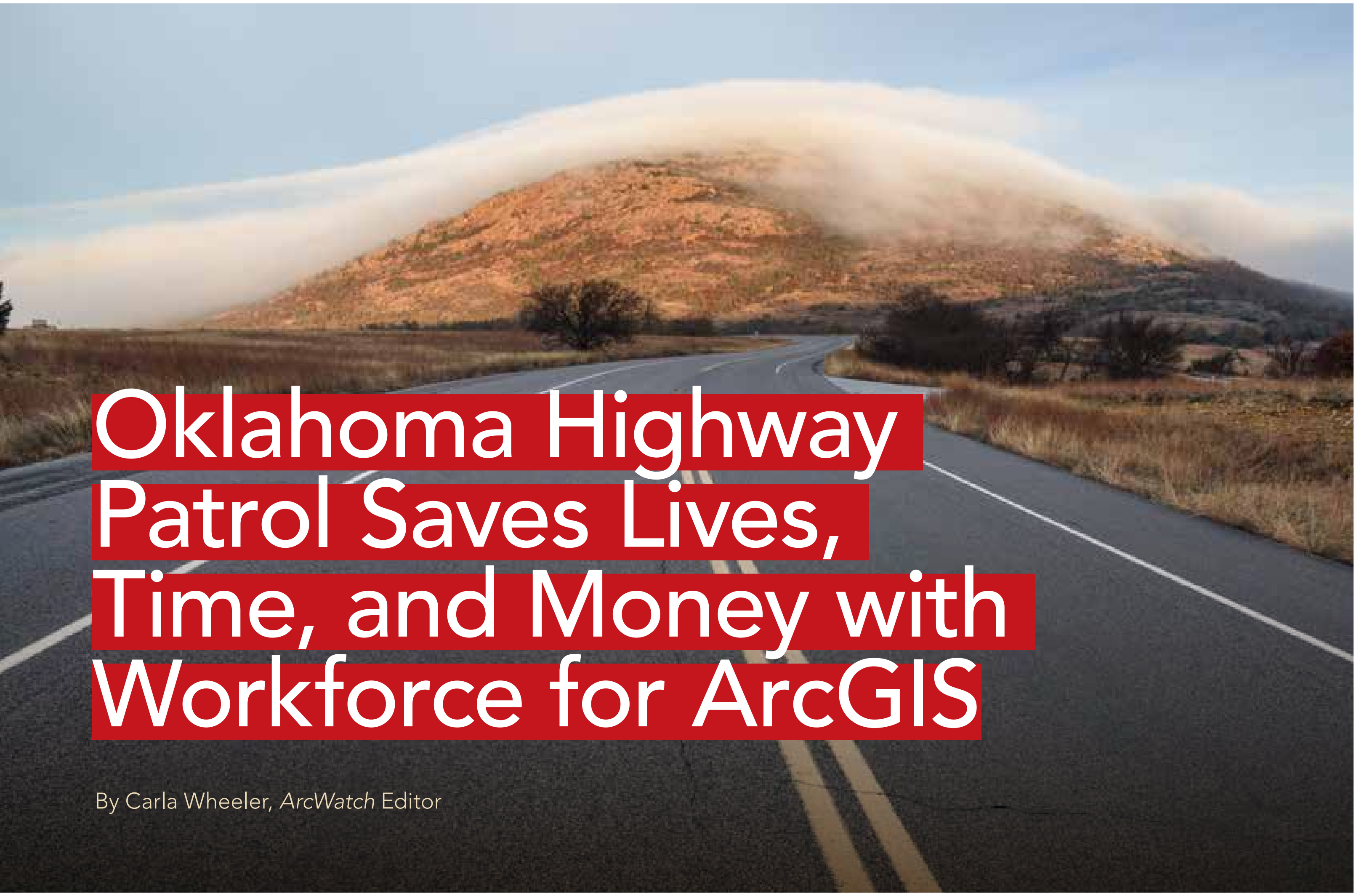
The data collection process is the responsibility of ACTED, Japan Emergency NGO (JEN), and Oxfam. Data verification is the responsibility of the United Nations Office for Project Services (UNOPS), and development is REACH's responsibility. The final product is an interactive map showing the entire wastewater network (pipes and four sizes of septic tanks) for Al Za'atri camp with filtering capabilities, along with the camp basemap showing the streets, caravans, tents, and services. The map is updated periodically to incorporate any work done by stakeholders and partners.

The ArcGIS platform enlightened all stockholders and partners about the refugees' life inside and outside the camp and made taking action easier and faster.

For more information, contact Eyad Ghattasheh, GIS consultant, Openware via email at e.Ghattasheh@openware.com.kw or by telephone at 00965-60402910.

About the Author

Eyad Ghattasheh has been working in the GIS industry since 2000. He has applied his GIS skills in his work for many entities, both local and international, including Jordan's Department of Statistics; the Norwegian People's Aid on Syria-Jordan demining and the Unexploded Ordnance Disposal Project; the Institut Français du Proche-Orient (IFPO) on the Jordan Atlas project, Information Management System for Mine Action (IMSMA) and ACTED/REACH on support for the Syrian crisis refugee camps in Jordan. In 2013, he joined Openware, the Esri distributor in Kuwait, as a GIS consultant and supports many projects. Ghattasheh has a bachelor's degree in geomatics from the University of Palestine, Gaza.



Oklahoma Highway Patrol Saves Lives, Time, and Money with Workforce for ArcGIS

By Carla Wheeler, *ArcWatch* Editor

When the Oklahoma Highway Patrol (OHP) joined the search for a man suspected of killing a sheriff's deputy earlier this year, the law enforcement agency used ArcGIS Online and Workforce for ArcGIS to properly position more than 100 troopers as the dragnet tightened.

"We were able to keep track of all of [the troopers] with Workforce for ArcGIS," said Captain Ronnie Hampton, commander of the Futures, Capabilities, and Plans Division of OHP. Hampton spoke about his agency's use of Esri technology during the Esri National Security and Public Safety Summit that was held last July in San Diego, California.

All 800 OHP troopers have downloaded the Workforce for ArcGIS mobile app onto their smartphones and enabled location tracking, letting dispatchers see each on-duty officer's GPS location on a customized Dispatch Map in ArcGIS Online. Workforce for ArcGIS is included at no extra cost in an ArcGIS Online organizational subscription. The troopers and about 90 dispatchers have ArcGIS Online accounts.

Hampton said that during the manhunt for the shooting suspect on April 18, 2017, incident commanders could see where each officer was stationed in real time on the map. That locational information helped the commanders decide where to place troopers that were needed for the operation while a search perimeter was set up. "We were able to send in over 100 troopers, sealing off a two-mile area," Hampton said. "We could see the boots on the ground." The Oklahoma County Sheriff's SWAT team captured the suspect later that day after several hours.

Other types of organizations typically use Workforce for ArcGIS to create projects and assign them to staff in the field. Often, the projects involve service, maintenance, and inspection requests or follow-ups to sales leads.

OHP leadership realized the app could provide a critical, real-time view of where all its on-duty troopers were as they patrol more than 111,000 miles of roads and highways, waterways, and the state capitol grounds. The location of each trooper appears as a green icon next to the officer's call number on the Dispatch Map. Knowing each trooper's position lets communication center dispatchers instantly send the closest officer to the scene of an accident or other incident.

This is a big change. Until Workforce for ArcGIS was launched throughout the organization in the summer of 2016, dispatchers at OHP's 13 communications centers were only responsible for dispatching troopers assigned to their specific district. For example, if a traffic collision occurred in the district covered by Troop A, only an officer from Troop A would be sent to the scene—even if an officer in Troop B was 20 miles closer, because the dispatcher wouldn't know the position of officers in other areas.

Now, dispatchers can summon anyone on staff to respond to an incident based on their present location.

"Our chief requires everybody, including himself, to use Workforce as they commute to work," Hampton said. "So, everyone in the entire agency is an assignable asset." Hampton said that OHP chief Ricky G. Adams is very much a champion of technology and keeping people safer.

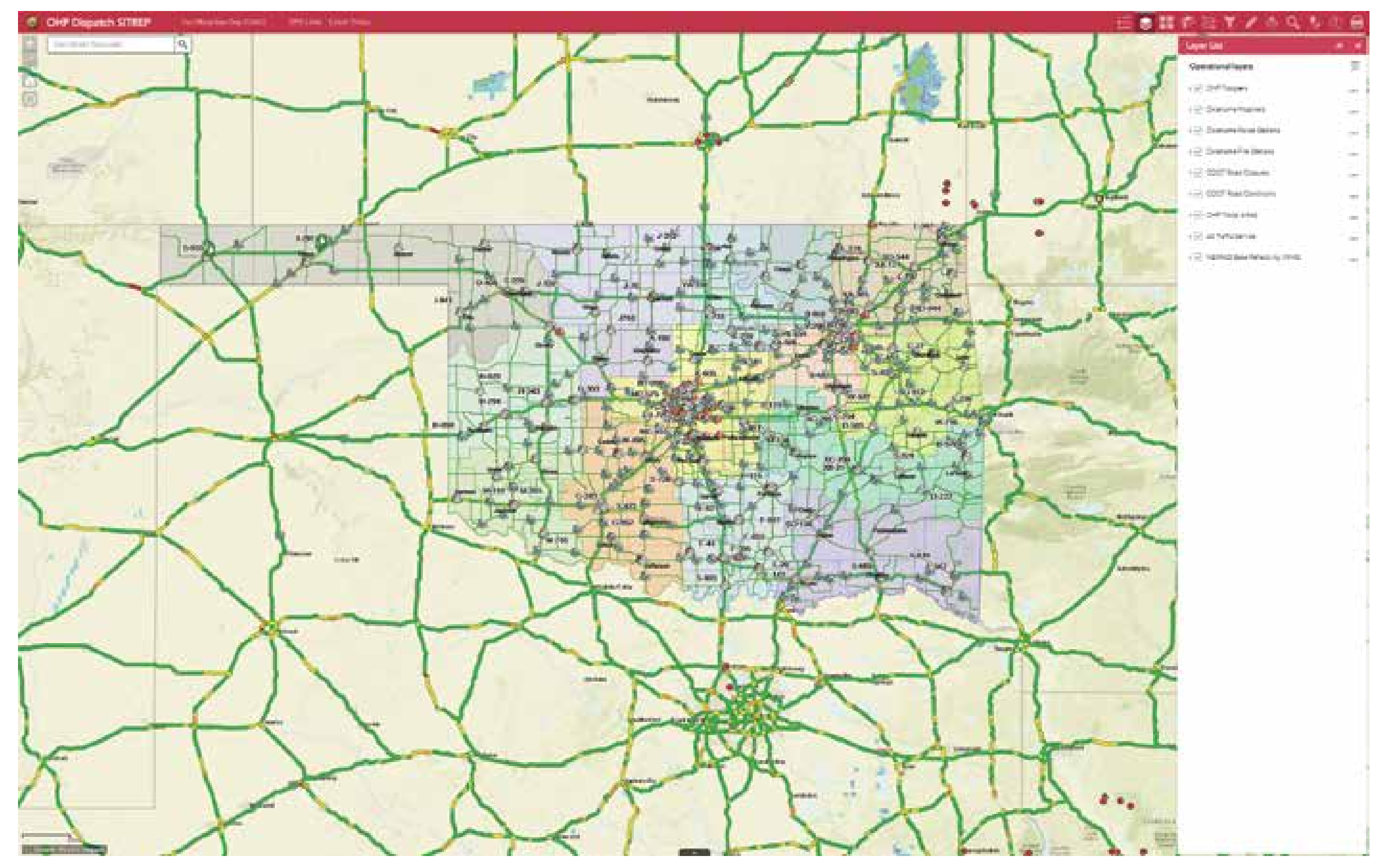
Last year, OHP conducted a 90-day test to find out how many hours and miles in travel time would be saved by using Workforce for ArcGIS to make dispatch decisions. In responding to 28 collisions and 23 cases where motorists needed assistance, the test showed a savings of 889 miles and 14 hours in travel time, Hampton said. "Mileage is a savings of fuel. Hours *[saved mean]* a quicker response for the public," he said. The greatest benefit for Oklahomans is the faster response times, especially in rural areas, Hampton said. "The people that benefit from this are the public, by being able to have someone at the scene in 3 or 4 minutes versus…45 or 50 minutes," he said. "That's where your hours of savings come in."

Following the test's success, OHP made Workforce for ArcGIS and ArcGIS Online available to all troopers last August. All officers downloaded the app onto their OHP-issued Samsung Galaxy S5 smartphones from the Google Play store. (The app is also available from the Apple App Store and Amazon.)

Staff in all 13 communications centers now use one comprehensive statewide Dispatch Map in ArcGIS Online to keep track of officers' locations. The dispatchers can use the built-in Near Me widget to find the officer closest to the scene of an incident. They also can turn on layers in the map to obtain weather information; traffic conditions; and the locations and phone numbers of police, fire, and ambulance stations.

To create the Dispatch Map, the feature data service layer from Workforce for ArcGIS that contains the officers' locations and green icons was added to

Staff in all 13 communications centers now use one comprehensive statewide Dispatch Map in ArcGIS Online to keep track of officers' locations. Application designed by Christopher L. Rogers, Oklahoma Department of Public Safety.



ArcGIS Online. Widgets, such as Near Me, Basemap Gallery, Filter, Legend, and Measurement, were added using Web AppBuilder for ArcGIS. Weather data from the National Oceanic and Atmospheric Administration (NOAA) also was brought in, along with traffic information from Esri's World Traffic Service. The GPS coordinates for police, fire, and ambulance agencies in Oklahoma and contact information, such as the phone numbers for each agency, were also added to the map.

Most of the information and capabilities in the Dispatch Map are available to on-duty officers using the Trooper Field Map in ArcGIS Online, accessible via the computers mounted in their patrol cars. The troopers also have access to useful links on the toolbar that, for instance, retrieve information on court dates for each of Oklahoma's 77 counties.

Troopers also can use tools in ArcGIS Online to set up buffer zones after an accident. When a trucker suffered a heart attack and crashed his vehicle into the beam of a highway underpass, causing a sulfuric acid spill, an OHP lieutenant on the scene used the Create Buffers tool to establish a zone with a half-mile radius around the incident. He shared the map with colleagues so they could block off the area to traffic and onlookers.

Workforce for ArcGIS and ArcGIS Online also provide situational awareness for OHP officers. During the pursuit of a suspect on a rural road, a trooper on duty 80 miles away in another county saw where the pursuing officer was located on the Trooper Field Map. When that trooper turned on satellite view, he noticed that the officer in pursuit was coming to a T-intersection and radioed to warn him to slow down. The suspect then veered off into a cow pasture. Continuing to monitor the satellite view, the trooper advised pursuing officers where openings in the pasture's fencing were located to blockade them and prevent the suspect from escaping. "We caught that guy," said Hampton.

Hampton said ArcGIS Online and Workforce for ArcGIS are being embraced in his department, especially by the younger officers who grew up with technology. "I've had other police agencies ask, 'How do your troopers feel about people being able to see *[their location on a map]*?' Some of our older troopers were resistant at first, but our younger troopers are super excited," Hampton said. "It used to be, we had to rely on that person who needed help to give out his physical location. Now, all he has to do is say, 'I need help,' and *everybody* can see where he's at."

OHP also is putting Esri Story Maps apps to use. One story map created by the agency shows where in Oklahoma motorcyclists were killed or severely injured in 2015, and presented statistics on how many of those riders had been wearing helmets. Fifty-six percent of the people killed in 2015 in motorcycle accidents were not wearing helmets, according to the story map.

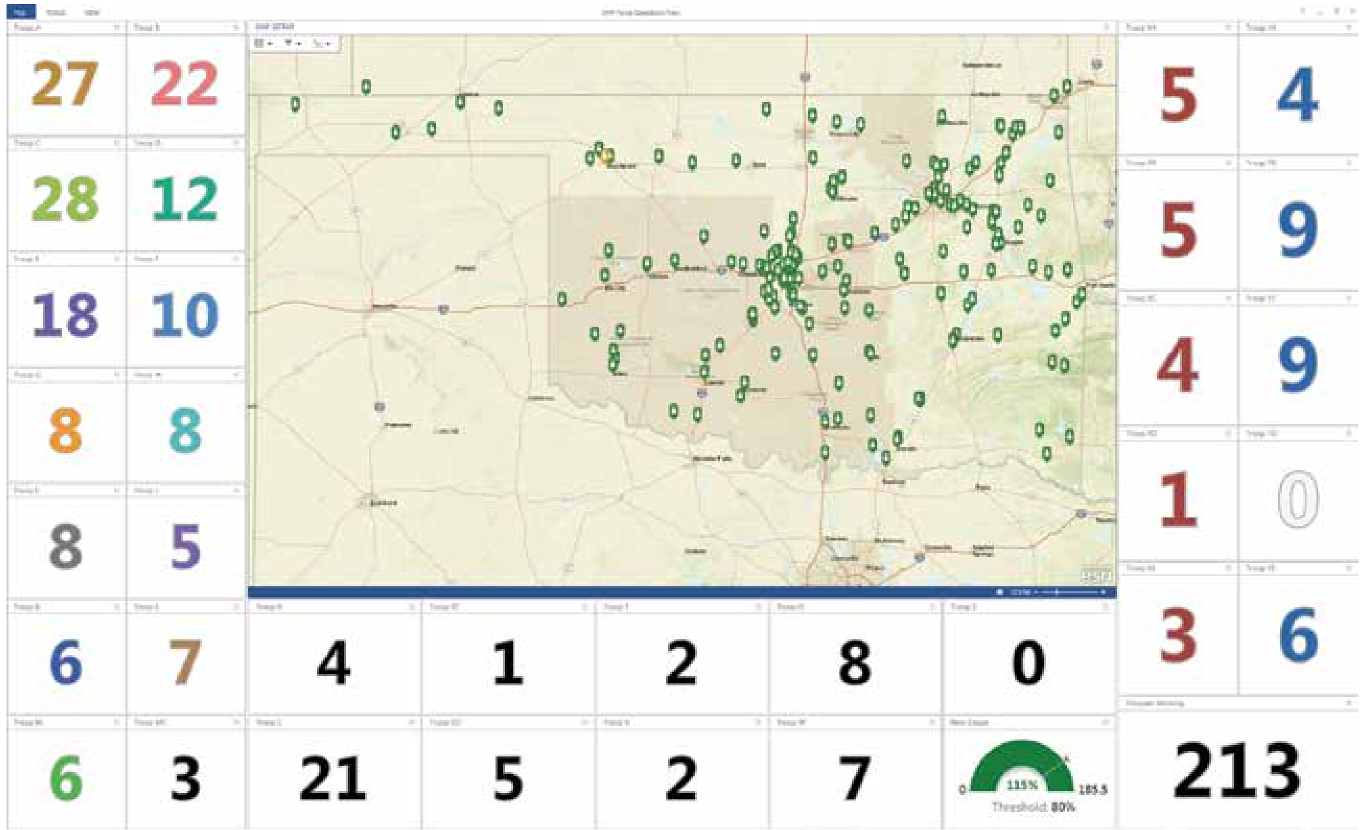
Story maps may also be used in the future to document homicide cases that stem from traffic collisions caused by people driving while intoxicated, Hampton said. He thinks they may be useful to the district attorney in explaining to the jury what happened. If OHP collects information from the time the 911 call comes in and documents everything in story maps, it will be easier for an investigator to present the case to the district attorney because all the information will be there. The district attorney can present that story to the jury.

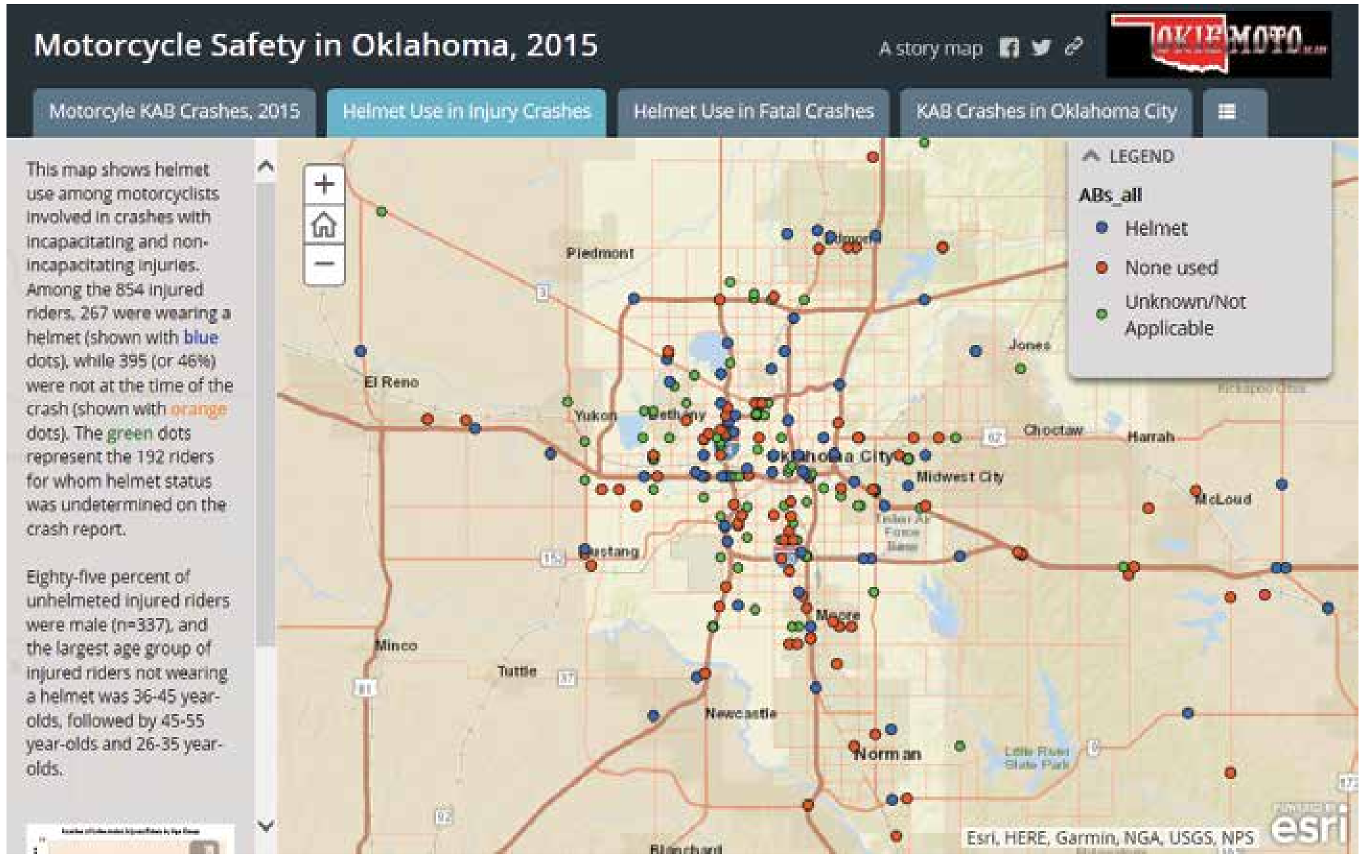
In the coming months, OHP also plans to process imagery from some traffic collision scenes using Drone2Map for ArcGIS. Hampton said that OHP plans to initially acquire 13 drones to capture imagery of accidents that block busy roads. "We can't control cleanup, but we can control how much time we keep the road closed [while] doing the accident reconstruction," Hampton said. Rather than walking the scene and taking photos and measurements, the drone would take images of the accident aftermath. "With a drone, we can thoroughly document and collect video and photographs of a crash scene in about six minutes," he said.

OHP would use Drone2Map for ArcGIS to process the imagery and create products for use in investigations and—if necessary—court cases. "We can take a frame of a video and produce a two-dimensional picture. We can take still photography we shot with the drone and produce the two-dimensional picture," Hampton said. "If that case needs to go to court or if we want to revisit the scene the way we found it later, now we can watch the video of what we flew two years ago. If that case ends up being prosecutable, one of the things Drone2Map allows us to do is to create a 3D model." He notes that, unlike the crime scene investigation shows on television that often show investigators walking a jury through an animation, they will be able to use actual footage of a scene. "Why animate something when you can actually take them back and let them fly through the scene?"

For more information, contact Captain Ronnie Hampton, commander of the Futures, Capabilities, and Plans Division of OHP at Ronnie.Hampton@dps.ok.gov.

The Force Operations Dashboard shows how many officers are available from each troop and their current locations. Application designed by Christopher L. Rogers, Oklahoma Department of Public Safety.





The agency is using Esri Story Maps apps to share information. This story map shows motorcyclists killed or severely injured in 2015 and presents statistics on whether those riders were wearing helmets. Story map authored by Amy Graham, Oklahoma Highway Safety Office.

Supporting Critical Air Force Operations with GeoBase Apps

By Jim Baumann, Esri Writer

The United States Air Force Global Strike Command (AFGSC), tasked with developing and providing combat-ready forces for strategic deterrence and global strike operations, uses GIS in many ways, from mapping critical facilities to providing situational awareness in emergency management response to overseeing infrastructure management.

AFGSC controls all Air Force nuclear bombers, missiles, and more than 31,000 personnel. This arsenal includes two-thirds of the United States' nuclear armament capabilities. Critical nuclear facilities are mapped for operational and strategic decision-making purposes.

The US Air Force (USAF) GeoBase mapping platform was implemented more than 15 years ago. ArcGIS is deployed at the USAF GeoBase offices and provides analytical mapping support and maintains standard and custom web applications designed to sustain the specific missions of individual bases and the groups attached to those bases.

In an emergency, a base response team may require a web application that specifies the incident location, current route conditions, and directions to nearby hospitals. For the same emergency, the security forces group will need the identical response team intelligence, but its app will also include digital elevation models, locations of limited visibility in the response area, and standard weapon locations.

The geospatial software architecture is consistent at each GeoBase office. All GeoBase work adheres to the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE), which was adopted by Defense Installation Spatial Data Infrastructure in 2006 to provide standards for the US Department of Defense.

Sam Bushell, geospatial intelligence analyst with Datum Software, Inc., has supported the 90th Missile Wing GeoBase Office at the Francis E. Warren Air Force Base (Warren AFB) near Cheyenne, Wyoming, for several years. "Basically, we use various components of the ArcGIS platform and incorporate the SDSFIE standard to improve workflows for AFGSC," said Bushell. "For example, if a need is identified to enable better visualization of the utility systems on the base or improve emergency management capabilities, we use ArcGIS to provide the required service to our end users."

The 90th Missile Wing GeoBase Office employs three ArcGIS extensions—Spatial Analyst, 3D Analyst, and Network Analyst—to improve AFGSC workflows. ArcGIS Data Reviewer is used for quality assurance and as part of the data management strategy. ArcGIS API for JavaScript is used extensively in the workflows and applications developed by Datum Software.

At Warren AFB, the 90th Missile Wing currently runs more than 100 services and supports 16 web editor and viewer applications that incorporate real-time intelligence, routing, security, and data migration and standardization applications.

"ArcGIS Server is a critical component for emergency management within AFGSC," said Bushell. "The feature access enabled web services we develop allow incident managers in Emergency Operations Centers, across the command, to provide real-time situational awareness for on-scene commanders, first responders, and security forces personnel. As an emergency situation unfolds, the ArcGIS Server application provides the backbone for the incident management process and the response proceeds in this way."

First responders provide the initial reports of the incident. Their information is plotted in the web application to show management teams in the affected area. Data is updated continuously in real time and disseminated through the application to other teams such as security forces battle staff and tactical response force.

After it is compiled, this information is shared with local and federal law enforcement, fire crews, and emergency medical technicians involved in the response. Internal sources provide data on traffic control, evacuation zones, safe routes, affected facilities, locations of response personnel, civilian monitoring, and contingency operations. External data sources allow incident commanders to monitor chemical, biological, radiological, nuclear, and high explosives and incorporate publicly available datasets.

"The combination of this data, through the functionality of the ArcGIS platform, is key to providing incident commanders with situational awareness in an emergency scenario," said Bushell.

All construction and maintenance of base infrastructure must be closely monitored at the historic Warren AFB, the oldest continuously active military installation and a designated National Historic Landmark. To preserve the base, AFGSC commissioned the development of a web mapping application for GeoBase that is used by wing planners, engineers, archaeologists,

Warren AFB was once part of the intercontinental ballistic missile (ICBM) program. The static display of Peacekeeper, Minuteman-III, and Minuteman-I missiles is located at the front gate. Photo courtesy of 90th Missile Wing Public Affairs Office

and others, to identify areas where potential new construction and sensitive areas of cultural, environmental, and historical significance overlap.

The application tracks excavation permits on base and coordinates with municipal power and communications organizations. Through a single web viewer, it identifies all critical data layers and ensures the entire organization is on the same page throughout the process.

This is particularly important because the US Air Force and the State of Wyoming are currently working together to renovate a nearby mission alert facility and open it as a public attraction in 2019. The site was part of the Cold War era intercontinental ballistic missile (ICBM) program that housed MX nuclear missiles, commonly known as Peacekeepers, until it was deactivated in 2005.

"When thinking about our work for Global Strike Command, I believe that one of the greatest benefits provided by implementing these mission critical GIS applications is that it gives service personnel the opportunity to learn a new technology that can be applied in so many different areas," concluded Bushell. "This gives them training that they will apply throughout their military career and can take with them if they leave the service. I believe the ArcGIS platform creates a significant return on investment for the air force and helps ensure mission success."

For additional stories about the US Air Force's GeoBase program, see "Innovative Strategy for Facility Upgrading" in the Fall 2011 issue of *ArcUser* and "Where's the Trash?" in the July–September 2005 issue of *ArcUser*.

The opinions contained herein are those of Esri and contributors to this article and in no way represent an official statement or endorsement from the US Air Force.

Finding, Evaluating, and Prioritizing GIS Opportunities

By Matthew Lewin, Esri Canada

Building an effective GIS strategy involves identifying meaningful opportunities, determining their value, and setting priorities.

Strategic planning can be tough. Despite all the different tools and guidance available, devising a strategy that is both visionary and practical can seem intimidating. For most, the work required and the fear of failure outweigh the potential benefits. It's no wonder that when it comes to building a GIS strategy (or a location strategy), a lot of managers avoid the exercise altogether.

For some, the problem relates to uncovering meaningful opportunities to use GIS inside their business. For others, it's about showing clearly where and how these opportunities are delivering business value. Still others struggle with prioritizing opportunities and figuring out where to start.

The reality is that an effective GIS strategy addresses each of these requirements, and you have to do a bit of work on all of them. The good news is that getting there is easier than it sounds. With a bit of focus and some flexible tools, we can draw a straight line between opportunities, business value, and priorities. Let's look at three steps for incorporating GIS and location into your business and how to get to the heart of what matters.

Step 1
Uncovering Opportunities

Simply identifying the ways in which GIS can be used is often one of the more challenging steps in building a strategy. With so many options available in the world of geospatial technology, it can be overwhelming to narrow down the potential solutions. At the same time, understanding the numerous functions that a business performs and then recognizing authentic business needs at an enterprise level can be a Herculean task.

Often it's about finding the right "altitude" at which to conduct strategic planning. If we work at the business strategy level, we can be stuck defining GIS solutions that are too abstract to be practical. If we drill down to the business process level, we risk identifying solutions for areas of business that are constantly changing or don't address challenges that cut across the organization.

What we need is a structured way of matching the core capabilities of an enterprise GIS platform with the core capabilities of the business. Fortunately, there's an effective way to do this. The process involves mapping the core GIS patterns of use to an organization's business capability model.

The core GIS patterns of use represent the common geospatial functions that recur across organizations and are supported by most GIS platforms. Consider these patterns the essential capabilities of modern GIS that are enabled by a vast ecosystem of geospatial technologies.

Business capabilities are the key abilities of an organization. They are an articulation of what an organization must achieve to fulfill its mission as opposed to how it achieves it. In practice, capabilities are composed of people, processes, technology, and governance. Because business capabilities are connected to business outcomes, they can be measured for performance. This is key to mapping GIS solutions to the organizational need.

As an example, let's look at the business capability model for a property and casualty insurance company. Insurance companies insure property owners against liabilities and risks related to ownership of property. The model breaks down the capabilities of the business into three core areas: core value creating, operational, and shared capabilities. Each capability can be broken down further into subcapabilities. For this example, let's pick customer service and look at an important facet of customer service in the insurance industry: claims management.

Table 1: The GIS patterns of use

Location Enablement	Discover, use, make, and share maps at work—anywhere, anytime
Constituent Engagement	Facilitate and manage communication with stakeholders
Decision Support	Inform executives and management with maps and location intelligence
Field Mobility	Get authoritative information into and out of the field
Analytics	Describe, predict, and improve business performance
Location Data Management	Collect and organize location data about assets and resources

CLAIMS MANAGEMENT	Location Enablement	Constituent Engagement	Decision Support	Field Mobility	Analytics	Location Data Management
Intake	Claims Location Event Maps	Predictive Social Media Alert	Claims Forecasting Models		Predictive Loss Exposure Models	
Investigation			Damage Impact Assessment Maps	Adjuster Deployment Tools	Fraud Pattern Detection Models	UAV Imagery Capture for Roof Inspection
Negotiation			Outstanding Claims Dashboard			
Settlement	Claims Settlement Maps				Settlement Guidance Models	

Table 2: Mapping GIS patterns

In general, claims management involves intake, investigation, negotiation, and settlement of insurance claims. From the filing of a claim to its final payout, insurance companies spend considerable effort managing and improving how the claim is handled to ensure a high level of customer service.

Identifying where and how GIS can be used to support this function is a process of mapping the GIS patterns of use to claims management business capabilities.

Table 2 shows how patterns are mapped to business capabilities. Look at all these opportunities—and these are only some of the possibilities. Let's look at each capability area in turn.

Claims intake is the ability to manage the notification, assignment, and actions relating to an incoming insurance claim. GIS is ideally suited to support this area. Maps of claims locations categorized by the event type allow the business to manage and expedite claims as an overall event situation. Predictive parsing of social media posts lets the business anticipate the location and impact of insurance events. Claims forecasting models anticipate claims by event and location. Predictive loss exposure models estimate losses based on the known loss exposure for a given area.

Claims investigation determines the conditions and context associated with a claim. This is typically analytical and human-intensive work. GIS as a platform for location-based analysis and mobility presents numerous opportunities for investigation support. Damage impact assessment maps show the extent and degree of damage. Adjuster deployment tools automate the submission of claims information to adjusters in the field and expedite the investigation process. Fraud pattern detection models predict fraudulent claims based on location patterns. Unmanned aerial vehicles (also known as UAVs or drones) can quickly and accurately capture aerial photos and video of damage to building rooftops.

In the claims negotiation process, the parties arrive at an outcome that satisfies insurance terms and the interests of the policyholder and policy provider. The negotiation process can be a long, drawn out affair. GIS can play a role in monitoring and resolving issues related to claims negotiations through the use of outstanding claims dashboards. Managers can monitor where in the process claims are hung up and if there are observable trends based on location or event type.

During the claims settlement process, the claim is settled, paid, and closed to the satisfaction of the policyholder. Settlement is the final phase in handling a claim and the end of the customer service experience associated with a specific claim. GIS supports consistent handling of claims settlements with claims settlement maps that provide details by area and event to ensure consistent handling of similar events. Settlement guidance models are prescriptive and can guide an agent through processing a claim and suggest a settlement for a known event based on defined criteria.

These are just a few of the opportunities for applying GIS that are available. Capability mapping can be applied to any business area and any organization regardless of industry. The key is identifying the business capabilities of relevance to your GIS strategy and diligently mapping them to the patterns of use.

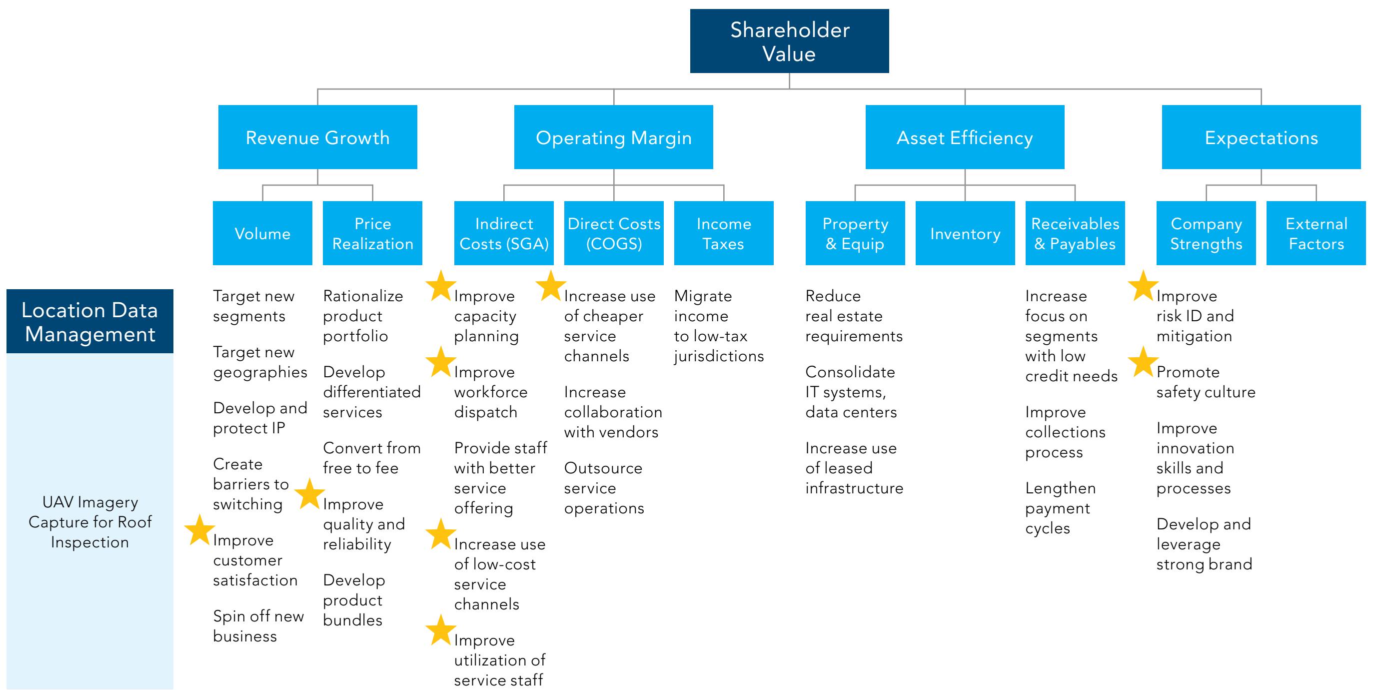
When uncovering opportunities, remember to

- Work at the capability level—both in terms of business and GIS.
- Diligently identify your organization's business capabilities: focus broadly, not deeply.
- Analyze the patterns of use to identify where and how GIS can enable your business capabilities.

Step 2
Linking to Business Value

At this point, we've unearthed a handful of interesting opportunities where GIS could be used to support key business areas. But it begs the question: How do we assign specific business value to these GIS solutions? And how do we demonstrate the value to stakeholders?

An enterprise value map is a powerful tool for understanding how value is created within a business (i.e., the value drivers). It



Mapping a GIS solution to the insurance claims enterprise value map

also identifies the value levers that are the specific actions an organization can take to create value. The generic version of the map assumes that value to shareholders is created through a combination of strong revenue growth, a healthy operating margin, efficient use of corporate assets, and the ability of the management team to sustain the value. The challenge is to identify activities or solutions that drive value by pulling on the value levers.

The benefit of the enterprise value map is that it pinpoints the kind of value that actions and solutions create. This helps with prioritization. For example, a director might say, "Based on our organization's strategy, we favor actions that grow revenue over those that improve asset efficiency." The enterprise value map makes this clear and explicit.

The accompanying diagram shows an abbreviated enterprise value map that lists a selection of value levers that we can apply to the insurance company example as they relate to the UAV rooftop inspection solution. There is a lot of intuitive value in a solution like this, but once we link the ways the solution drives value on the enterprise value map, we can see that it might have even more potential than first thought.

We can see where and how the UAV solution creates value. A remote inspection solution would enable the business to process claims faster with greater consistency. This would improve customer satisfaction and the quality and reliability of services—all levers associated with revenue growth. The UAV solution could also significantly reduce the time required to conduct an investigation, which would improve staff capacity planning and utilization and lower costs—levers that improve operating margins.

Using UAVs keeps investigators off rooftops. This could dramatically improve safety and lower the risk associated with this type of work. It would also enhance the perception of the business in the eyes of external stakeholders as a sustainable enterprise—levers associated with shareholder expectations.

The benefit of the enterprise value map approach is in the process. Initially, a solution like the UAV solution might be thought of as a time-saving opportunity. But by mapping this solution to value levers, we see many other benefits. These additional benefits could elevate the UAV solution from a tactical opportunity to a move that supports the organization's most important strategic objectives.

Another interesting feature of an enterprise value map is its ability to demonstrate why a solution fails to create any significant value. In the case of the UAV solution, not much is being improved in terms of asset efficiency. If asset efficiency is a strategic priority for the business, this can be the catalyst for further exploration into solutions that do impact asset efficiency. In this way, the enterprise value map is very much an iterative tool. Not only does it show the link between a solution and the value created, but when it is applied in reverse, it can also aid in identifying gaps in value creation—identifying areas where opportunity discovery should be focused.

Although the enterprise value map can be applied to any industry, it is particularly suited to the private sector. For public sector organizations that measure value in terms of social outcomes and public values, a value map that incorporates societal themes would provide a broader and better picture.

Remember...

- Use the enterprise value map to link GIS solutions to the source of value.
- Work iteratively, move from solution to value and vice versa to address gaps in value creation.
- For public sector organizations, supplement the enterprise value map with social drivers.

Step 3

Setting Priorities

So far, we've uncovered a bunch of great GIS opportunities and showed where and how they create business value. It's an impressive list! But we haven't determined if the return on investment makes these opportunities viable. Most organizations have limited resources and can't take on every opportunity. We need a way to set some priorities.

Key to setting priorities is evaluating the cost and risk of an opportunity against its value. The process involves determining the risk and value factors most important to the organization and developing a method of scoring each opportunity across the range of factors. These factors can be operational, tactical, or strategic. Opportunities that provide a positive balance of cost versus risk versus value are good investments and should be prioritized for implementation.

For cost, we want to assess the total financial cost of implementation and ongoing operational costs. This includes software, hardware, and human resourcing (project and operational). Ongoing costs must not be ignored. Too often, we see organizations do a good job of summing up the initial implementation costs but a poor job of considering the cost of sustainment.

On the risk side, we need to look at a composite of factors—these include capacity and complexity. For capacity, we want to evaluate the organization's ability related to delivery and support of the solution. If ability is low, it may indicate the need for capability building. For complexity, we need to assess the technical complexity involved with implementation of the solution as well as the organizational complexity involved in integrating the solution into the business. Other factors can be included in risk analysis, but these form the baseline.

On the value side, we previously showed where and how value is created using the enterprise value map but not its relative importance. To do that, we need to identify the composite of value factors. Typical factors include strategic alignment, financial benefit, and competitive advantage. When combined, these factors demonstrate the relative value of an investment from an operational, tactical, and strategic perspective.

To use the insurance company example, we can create a chart that shows cost-risk-value prioritization. The solutions are distributed across the chart, but based on some judgement calls, we can group them into three loose clusters.

The high value-low risk opportunities could be called the Quick Wins cluster. The UAV rooftop inspection solution falls into this category, as the range of value it delivers, relative strategic importance, moderate cost, and moderate risk make it a worthwhile investment. The high value-high risk and low value-low risk groups can be called the Plan cluster. These are opportunities that need further exploration or capacity building to implement. The final cluster is the Defer cluster. These are the low value-high risk opportunities. These solutions should be reevaluated or avoided altogether.

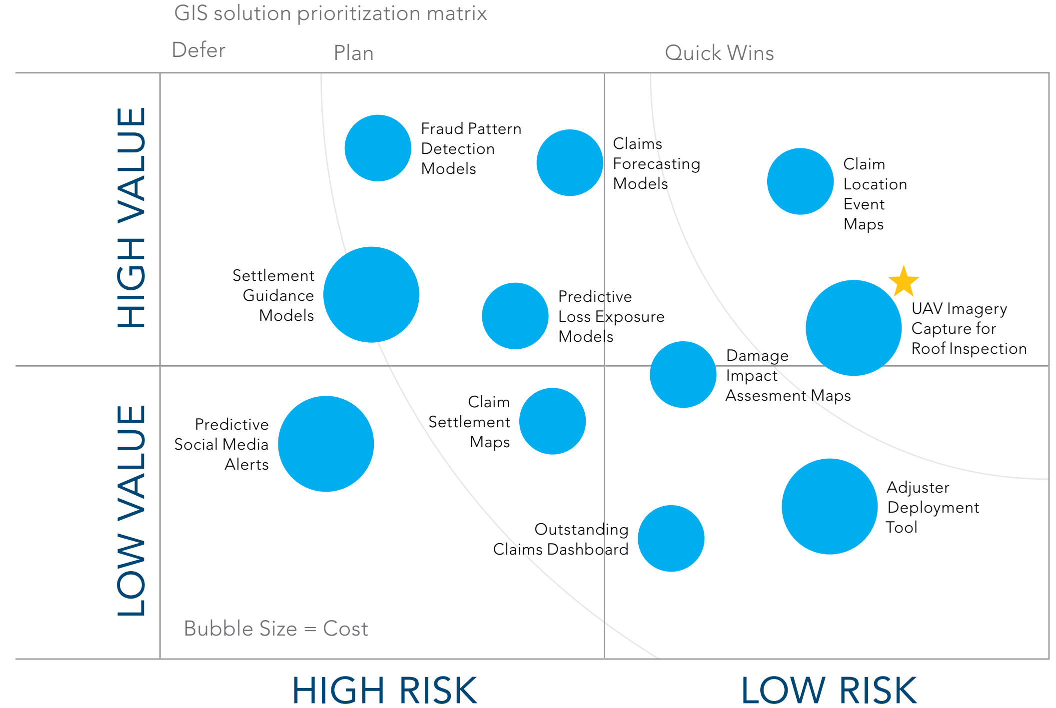
The main point of prioritization is to have a structured and justifiable way of deciding which opportunities you should tackle. Once prioritized, the implementation road map is quite straightforward.

Remember...

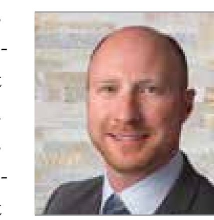
- Prioritize opportunities based on cost, risk, and value.
- Use a composite of factors when developing risk and value criteria.
- Be methodical and be honest when you prioritize!

Strategy, by definition, involves a degree of uncertainty. Focusing on discovering meaningful opportunities, linking them to value, and setting priorities can help to ease doubts and strengthen your GIS strategy. With a little bit of work, you'll get a better strategy that you can communicate up and down your organization.

GIS solution prioritization matrix



About the Author



Matthew Lewin is the practice manager of management consulting for Esri Canada. His efforts are focused on helping management teams optimize and transform their business through GIS and location-based strategies. As a seasoned consultant, Lewin has provided organizations in the public and private sectors with practical strategies that enable GIS as an enterprise business capability. The intersection of business and technology is where Lewin's interests lie, and he thrives on helping organizations bridge the gap to achieve their most challenging GIS ambitions.

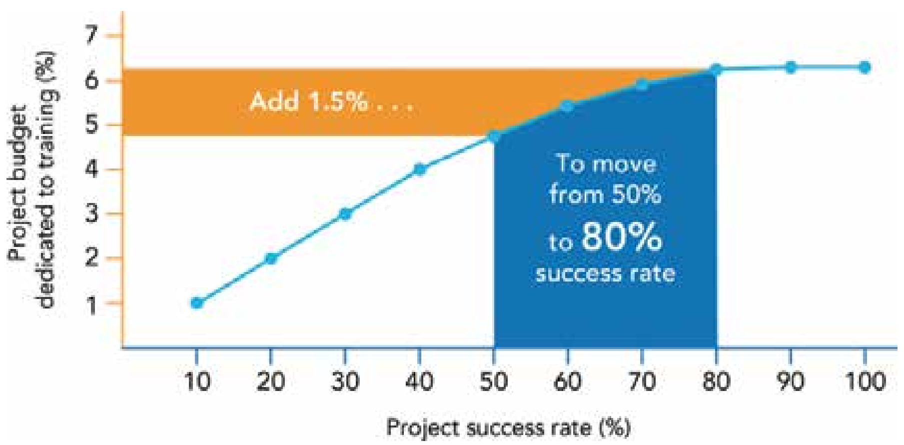
This article was originally published in the *Esri Canada Blog* (resources.esri.ca/management-consulting).

Your Training Budget Is the Key to Success

By Suzanne Boden, Esri Training Services

As a manager, you may be busy finalizing priorities and project plans for the year ahead. Before finalizing those project plans, pause and consider whether your team is prepared to successfully execute those projects. Your team may need workforce training to support new initiatives.

A survey conducted by International Data Corporation (IDC) of IT managers who were responsible for more than 500 IT projects revealed that increasing a project's training budget by only 1.5 percent increases the project success rate by 30 percent. Further, survey respondents rated the skill and dedication of the project team as the factor with the most impact on project success. (Source: IDC, Training's Impact on Projects Survey, 2011.)



A small increase in a project's training budget has significant impact on project success.

The late Dr. Roger Tomlinson, credited with inventing GIS, noted in his highly regarded book, *Thinking About GIS, Geographic Information System Planning for Managers:*

> "The two most important components of a successful GIS are good planning and good people. Keep in mind, though, that all the planning in the world is useless if you do not have adequately trained people to operate your system."

Clearly, it's beneficial to evaluate planned technology projects from the perspective of team readiness. Are there skill gaps that need to be filled prior to project kickoff? If so, address these proactively, because project success relies heavily on the skills of the people involved. Document these training needs as part of your planning activities. It is the perfect time to make sure training is easy to access when your teams need it.

The Esri Training Pass (esri.com/training/training-for-organizations) is designed to help organizations get the most value out of their ArcGIS software investment. With Esri Training Pass, it's easy to prepare teams for upcoming projects and build the workforce skills needed to use ArcGIS to its full potential to achieve operational efficiency, gain deeper insight into your enterprise data, and sustain business benefits over the long term.

An Esri training consultant partners with you to determine the appropriate number of training days based on your upcoming projects, existing staff skills, and project timelines. An actionable training plan is created, with a timeline for execution. You purchase a set number of training days, then redeem the training days as needed to access any combination of instructor-led classes, client coaching services, and technical certification vouchers.

Ensuring that your team has the right skills and knowledge in place is crucial for achieving the intended outcomes from a technology investment. The Esri Training Pass makes it easy to secure the right training, at the right time, to support your ArcGIS software-enabled workflows and initiatives.

The Training Pass is available for single and multiyear terms and is included on the Esri Federal GSA Schedule. For more information, contact GIStraining@esri.com or visit esri.com/trainingpass.

Easy as 1-2-3

1. Plan
Team with an Esri training consultant to determine the number of training days.

2. Purchase
With a single transaction, bypass the need for individual purchase approvals.

3. Access
Redeem training days as needed to support projects and build workforce skills.

USE A LOCATION-CENTRIC APPROACH TO SHARING INFORMATION

By Gary Johnson, Esri Australia

I love maps. They're beautiful. They can help reveal new patterns and relationships in data that couldn't be discovered in any other way such as finding the way to that elusive new secret whiskey bar.

Maps are everywhere. We have them in our cars and our phones and on websites from Airbnb to supermarkets to our health insurer.

But a map isn't always the right tool to help you understand what's around you. Sometimes we're too map centric. Sometimes we need to switch to a more location-centric view of the world.

My favorite example of this is the oh-so-common garbage collection map showing which day of the week my bins get emptied. When I go to my local council's website on my smartphone to find out if my green waste is going to be collected this week or next, I'm presented with a map of local government boundaries that is colored and hatched in various shades and styles. I zoom and pan around to find my street. Great. I've discovered my area is colored mauve with white diagonal hatching.

The next step is to look at the legend. Mauve tells me my bins are emptied on Tuesdays, and the hatching tells me my green waste is collected on odd weeks. No idea what that means but not to worry because there's a link to a PDF of a calendar that shows me (after panning and zooming around a bit) that this is an odd week. That means it's green bin day today. Hoorah!

MAP-CENTRIC	LOCATION-CENTRIC
Starts with data	Starts with purpose
Same view for every user	Tailored for the user
User must explore the data to find answers	Insight presented immediately
Multiple layers become confusing	Easy to include multiple themes
Hard to deliver good mobile experience	Simple mobile experience

The trash pickup map is uses the classic map-centric approach to delivering information.

This is what I refer to as the map-centric experience. I was presented with garbage collection information about my entire council area. Without wanting to be rude to my fellow residents, I can honestly say I don't care what day the bins are emptied on the other side of the council area or even on the next street.

This map-centric view is great for printed static material pushed into residents' letterboxes, but we can do better for online viewing.

I'm interested in my house, my street, my block. What's relevant to me starts with me (the user). Show me what's relevant to me. Rather than calling this approach location-centric, you might call it egocentric because it's all about me!

That's where the location-centric approach works well. Let's start with the user and an important location, the user's address. A location-centric approach takes the user's geospatial data and presents it in a highly relevant way by understanding what locations the user is going to be interested in.

In the example of the garbage collection map, start with a simple question: What's your address? Instead of making the user find his address, try to use the browser location to derive, or at least narrow down, the area viewed by address. If the user has been on the site before, remember the address or area of interest between visits using cookies.

With this simple step, the user is immediately presented with a relevant message such as "Your next bin day is Tuesday 18 July." No map. No exploration. No superfluous data.

A great example of location centricity is the simple taxi booking app. When I use it, I'm presented with three choices for selecting my pickup location: where I am now, where I have been in the past, or a location I specify through address input or map navigation. The app assumes that I will most likely want to book a taxi from my current location or one of the places I have booked from before. It doesn't start by displaying a map of Australia and asking me to find my pickup point on it.

Here's a comparison showing some of the key differences between map-centric and location-centric applications.

Of course, being location-centric doesn't mean there's no place for a map. A location-centric approach can work great in combination with a map. If I want to go to the library and then to the dog park, it will be a lot easier to choose the best options from a map rather than seeing two lists of the closest three facilities. If I want to understand how planning developments will affect me, proximity is important. The map helps me understand how I'm impacted.

Even with a map, we need to start with the user. Start with the question: Why is the user here today? What does the user want to discover? Here are some tips for a location-centric approach to sharing your information:

- Think about why users will come to your application.
- Clearly understand the purpose of your application.
- One size does not fit all. Your application needs to be designed to match its purpose.
- Ask yourself if a map makes it harder or easier for the user to get the desired information.
- Use the user's current location to tailor information delivery.
- Present the user with answers—not data.

The next time you're asked to publish a map, ask yourself if a map is the answer or if you can achieve a better user experience by hiding the map and presenting the user with answers instead.

About the Author

Gary Johnson, the chief solutions strategist for Esri Australia, is responsible for leading innovation and new market activity. Johnson has helped businesses from around the world leverage geographic insight to deliver innovative solutions and transform their operations. He believes smart mapping and location-based analytics can change the way organizations do business and specializes in applying the technology to business strategies. He holds an honors degree in computer science and has worked throughout the world, including stints in the United Kingdom, Denmark, Thailand, and New Zealand.

This article was originally published in the Esri Australia blog.

MAKING THE LEAP TO WEB 3D

You might already have everything you need

By Julie Powell and Kristian Ekenes, Esri

Although 3D web apps provide stunning visualizations and a unique way of interacting with spatial data, the thought of building a 3D app might be a little intimidating.

Perhaps you don't know where to find or create 3D data or the technology seems sophisticated, and you aren't sure you are ready to learn a new technology.

What you may not know is that you already have the data, styling tools, and technology you need to build fully functional 3D web apps. And the best part—you can essentially use the same skills you use to build 2D apps to build 3D apps.

Style Your 2D Data for a 3D Experience

You don't actually need 3D data to build a 3D app. You can style your 2D data so it works well in a 3D environment.

ArcGIS Pro and Scene Viewer (available with ArcGIS Online and ArcGIS Enterprise) provide styling tools that you can use to style 2D data for 3D and then save and publish it as a web scene that you can use in a web app. You can also configure the styling manually using the ArcGIS API for JavaScript, which provides all styling options to you.

Symbols

Rather than visualize points with basic 2D symbols, you can use realistic 3D symbols. For example, represent trees with 3D tree symbols or street sign locations with 3D street sign symbols. You can represent points as simple volumetric point symbols such as spheres or cylinders or represent lines as tubes.

Polygon data in 2D can be extruded using a height value in the attribute data. This is often done with building footprints. In 2D, building footprints are drawn on the ground. If your data also includes building heights, you can add that data to a 3D scene and extrude the buildings by height value for each building so they look like 3D buildings.

Data-Driven Visualization

You can create data-driven visualizations using Smart Mapping to style your 3D layers as you do when mapping in 2D. The same concepts used in 2D are applied in 3D, only now you have another dimension to work with.

Attribute data can be used to drive symbol properties such as the color or size of 3D symbols. For example, when symbolizing tree data in a 2D map, you might symbolize trees using a circle icon, set the color to thematically represent the amount of carbon dioxide each tree sequesters, and set the diameter of the circle to be driven by the value of the diameter of the tree canopy.

When representing the same data in 3D, you can represent each point with a realistic 3D tree symbol rather than a simple icon. The width of the realistic tree canopy can still be driven by the attribute values, but tree height and the trunk width can also be driven by attribute data to accurately represent the tree in 3D.

With the ArcGIS API for JavaScript, you can also build 3D scenes below as well as above the ground surface to show the location and spatial relationship of features such as pipes, wells, and earthquake locations by using attribute values in the data to extrude points below the surface. To play around with subsurface visualization, see the code sample "Create a local scene" in the ArcGIS API for JavaScript documentation at js.arcgis.com.

Using Elevation to Make a 3D Scene Look Realistic

To make a 3D scene look realistic, you can add ground elevation to the scene rather than display a uniformly flat surface. The easiest way to do this is to use Esri's World Elevation layer, which is available from ArcGIS Online.

This elevation layer is a global collection of multiresolution and multisourced elevation data. It includes the best publicly available data and community-contributed data available at resolutions that range from 1,000 meters to 3 meters. This layer is added to web scenes by default in Scene Viewer, but you can choose to turn it off or use your own elevation layer.

If you create your 3D scene programmatically in the ArcGIS API for JavaScript, you can simply specify that you want to use the World Elevation layer for ground elevation using the code in Listing 1.

```
var map = new Map({
  basemap: "streets",
  ground: "world-elevation"
});
```

Listing 1

If you have high-resolution elevation data for a specific area that you want to use in your application, you can use it for that area and use the World Elevation Service for the rest of the globe.

Styling Considerations When Displaying Elevation

When you are including elevation in your app, you don't want your data to get buried. It should be draped over the landscape, and unless you configure it otherwise, this will happen by default for all geometry types.

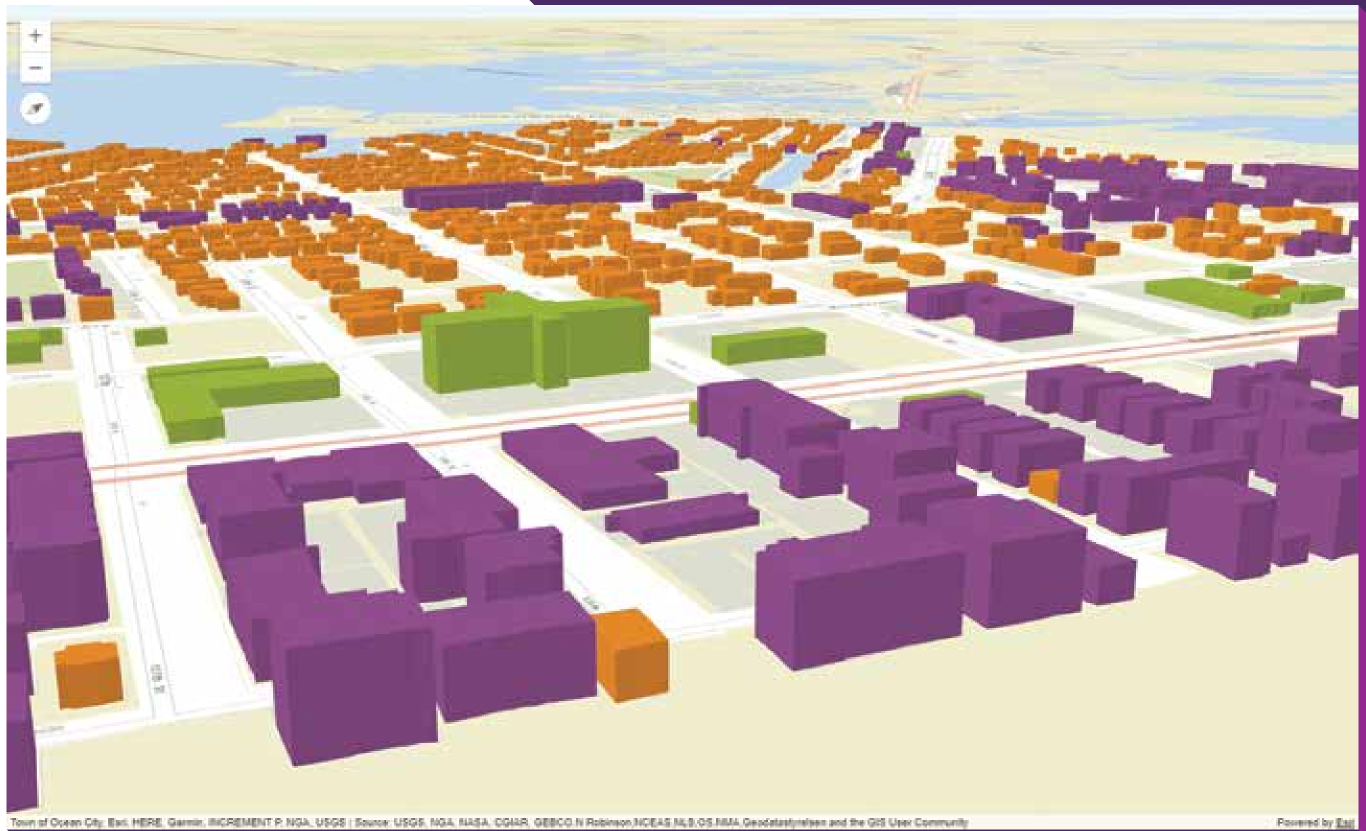
Another consideration has to do with the visibility of points when interacting with a 3D scene. If point symbols are drawn flat on the ground, it might be hard to see them as you navigate around the 3D scene. To mitigate this, use billboard symbols that almost float on the ground and always seem to face the viewing angle. Another option is to use line callouts (or leader lines) from icons or labels that indicate the location of each feature. This is a great option for displaying points of interest in a scene that either has varying elevations or buildings or other 3D objects that range in height and obscure point data.

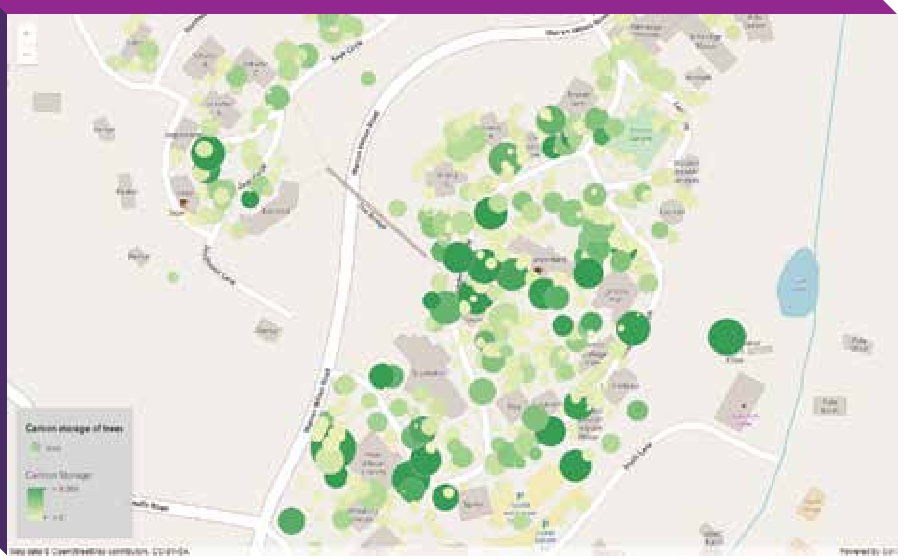
Build Your 3D Web App

You have multiple options when it comes to building your 3D web app. You can use Scene Viewer, Web AppBuilder for ArcGIS, or the ArcGIS API for JavaScript.

Right from Scene Viewer in ArcGIS Online, you can create a web app that consumes your web scene by choosing Share > CREATE A WEB APP from the Share pane. You are then presented with a selection of web application templates that you can

Polygon data in 2D can be extruded using a height value in the attribute data.





When representing the same data in 3D, you can represent each point with a realistic 3D tree symbol rather than a simple icon.

use to configure the app with styling and other preferences specific to each application. Choose a template and click CREATE A WEB APP. It will automatically be saved to your Content and shared with everyone. Go to your Content, open the item, and configure the options available for that template. Save your changes and launch the app.

Alternatively, from the Share > CREATE A WEB APP workflow, you can choose Web AppBuilder for ArcGIS to create your 3D web app. Web AppBuilder for ArcGIS lets you select a theme from several layout options and styles and add specific widgets to your app. When you're done configuring the app, save and publish it.

If you are a developer, you can create a custom 3D web application using the ArcGIS API for JavaScript. Because this will be a purely custom implementation, you can design the exact experience you'd like your app to provide. Because the configurable web templates available from Scene Viewer and Web AppBuilder for ArcGIS are built on the ArcGIS API for JavaScript, you can build similar capabilities into your application. Extensive documentation and samples to help you develop your app are available at js.arcgis.com.

Apply Your 2D Programming Knowledge

If you are familiar with developing a 2D app using the ArcGIS API for JavaScript, you can often apply the same programming patterns when developing a 3D web app. There are many cases in which the same code can be shared between a 2D map and a 3D scene. Some developers choose to build apps that offer both a 2D and 3D view.

3D apps can be just as interactive as 2D apps. Your 3D web app can have pop-ups, you can filter and query features based on the user's criteria, and you can access server-side capabilities such as geocoding and routing. The interaction you can build into a 3D app, combined with the rich experience that naturally comes with navigating data in 3D, can make a 3D app feel even more interactive than a 2D app.

What Are You Waiting For?

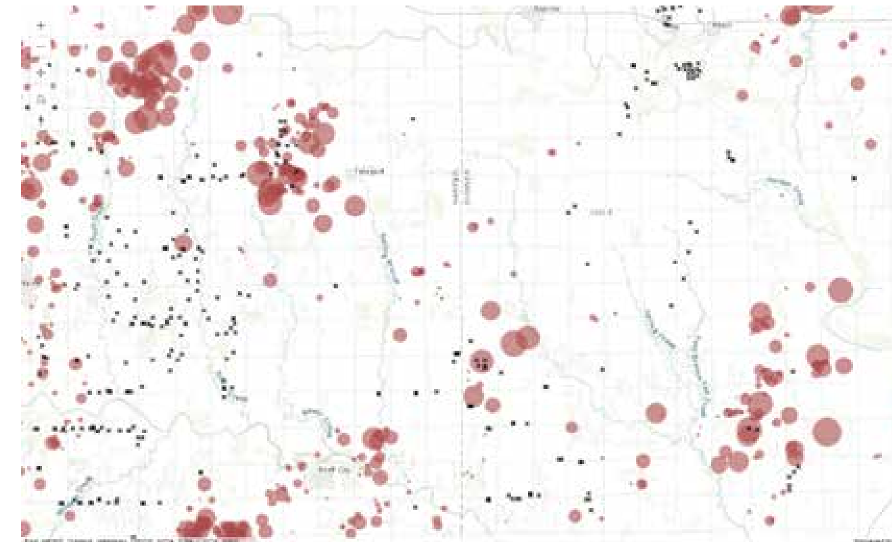
Play around with Scene Viewer using your data or any of the millions of datasets accessible in ArcGIS Online. A few of the many resources available to help you get started with your 3D web app are listed under 3D Resources. Let the fun begin!

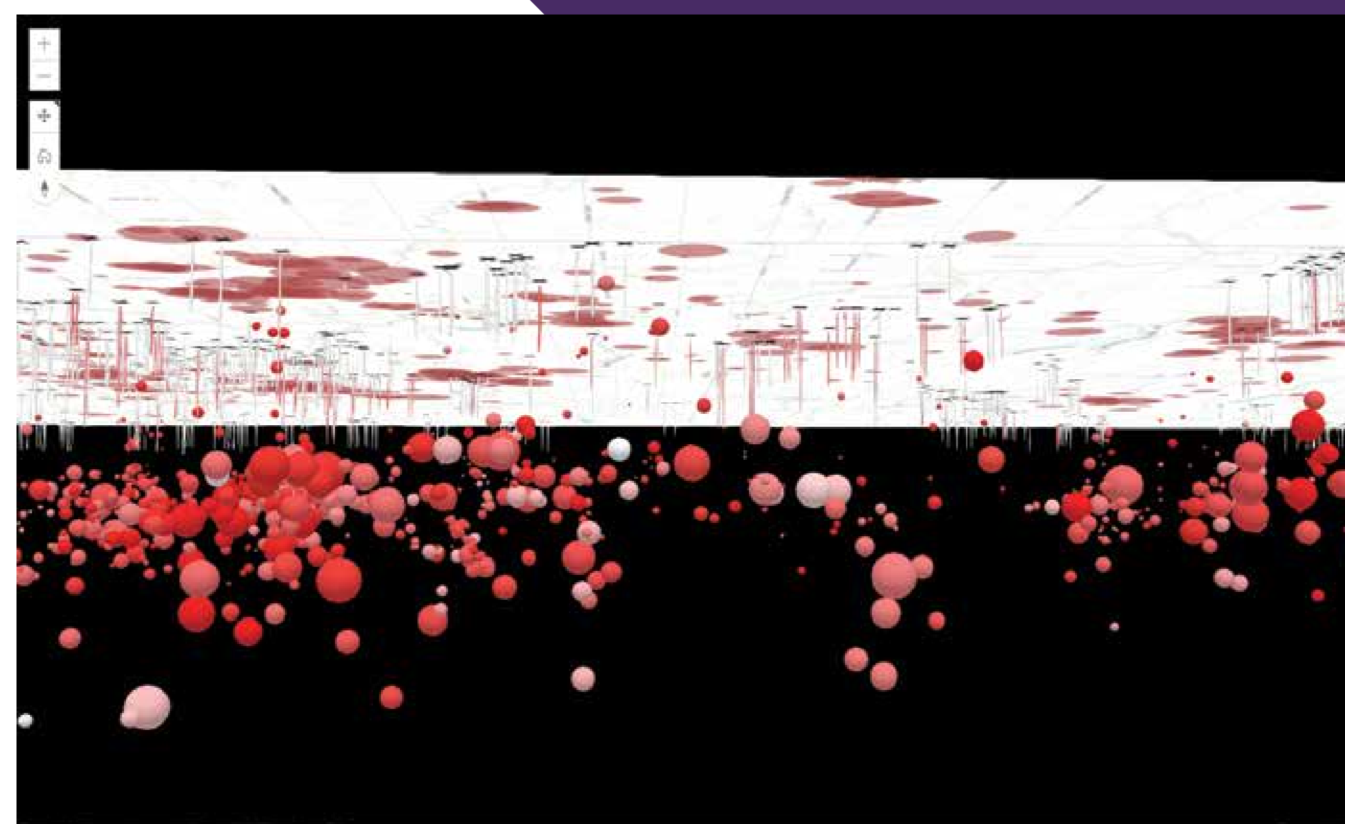
3D Resources

- ArcGIS Online Help topic "Creating 3D web apps using configurable app templates"
- Web AppBuilder for ArcGIS documentation (doc.arcgis.com/en/web-appbuilder/)
- ArcGIS API for JavaScript samples at developers.arcgis.com
- Esri training on the JavaScript API (esri.com/training)

About the Authors

Julie Powell is the product manager for the ArcGIS API for JavaScript. **Kristian Ekenes** is a product engineer on the ArcGIS API for JavaScript team.

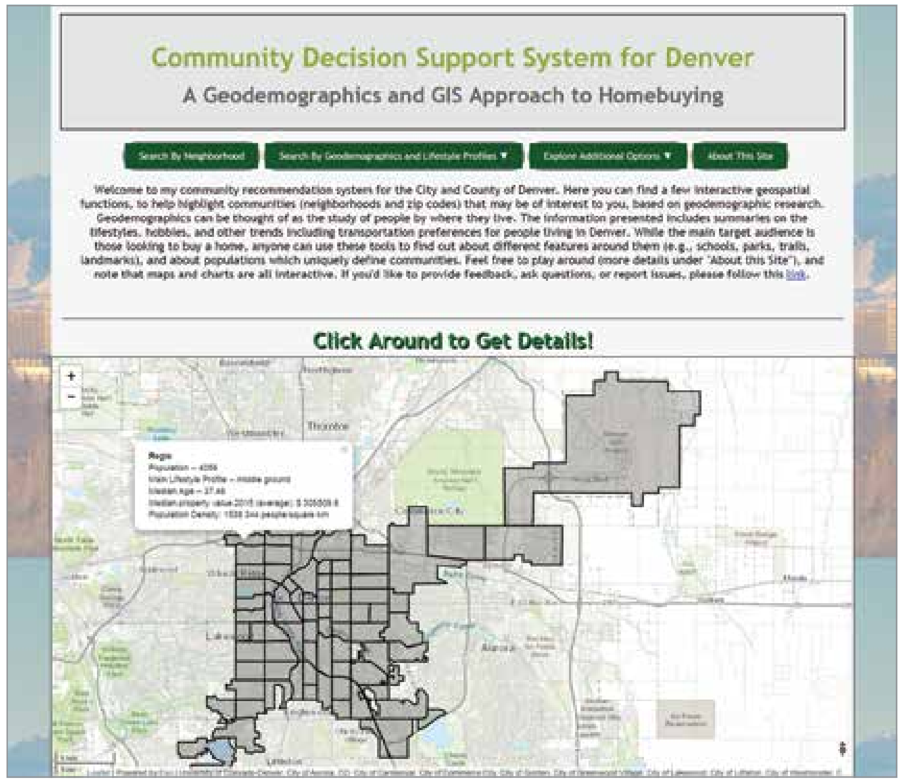




With ArcGIS API for JavaScript, you can extrude points below ground surface, as shown by point data for wells and earthquakes that has been extruded using attribute values in the data.

GIS Provides Context for Home Buyers

By Marta Blanco Castano, University of Denver, Colorado



Community Decision Support System for Denver website home page

Purchasing a home is a complex and expensive process, particularly in rapidly growing cities such as Denver, Colorado, where the increase in residents has limited the number of available properties and made property prices go up.

Searching for residential homes online is very popular in the United States, but traditional home buying recommendation engines like Zillow tend to be narrowly focused on property-based amenities and financials and often fail to include community perspectives that are critical to making better-informed decisions.

There has been significant interest by local real estate and research groups in data-driven solutions that can more dynamically describe changes in population, socioeconomic characteristics, transportation trends, lifestyle, and general urban living conditions in Denver. A system that provides enhanced geospatial tools or friendly summaries via visual analytics would empower buyers.

The author, a master's student in geographic information science at the University of Denver, set out to develop a spatial decision support system for Denver that would help address these challenges by providing a variety of urban perspectives while maintaining a business-oriented approach. The system would be freely accessible via the web.

Previously implemented real estate models and GIS lacked local context applicability because they had been developed for use in other cities or countries; were missing key attributes about populations and lifestyle; lacked geospatial functionality; or were expensive to develop and maintain.

The inherent spatial and temporal nature of the population and geography data led her to propose a GIS solution that could portray information spatially and in attribute format (via charts or other infographics).

The specific goal for the web prototype system was to assist local home buyers in gaining social, demographic, economic, and geographic perspectives on communities in the area. The author's knowledge of geospatial tools and applicable datasets immediately led her to Esri products.

She chose the Esri Leaflet API because it is lightweight, client side, and user-friendly compared to other API solutions that require server infrastructure. *[Esri Leaflet is a collection of API plug-ins for Leaflet, the open-source JavaScript mapping library. It is designed to make it easier to mash up data and services from ArcGIS Server and ArcGIS Online in Leaflet applications.]*

She was able to fulfill some of the application's data needs by leveraging Esri Tapestry Segmentation profiles to contextualize the city's geodemographics (i.e., the study of people based on where and how they live). The Tapestry data supplies community-focused information. It provided data on households, families, and housing preferences as well as employment, education, transportation, commuting preferences, shopping, entertainment, hobbies, and financial trends.

These characteristics are frequently mentioned in literature and studied by real estate and business marketing professionals. Understanding people, their lifestyle, and how they interact with their communities and environments is essential for making smarter decisions and providing strategic services.

Delivering a New Kind of Recommendation System

Since the goal was delivering a new kind of community recommendation tool that would complement existing ones from Zillow or Trulia, the next step was determining the specific functionality that would be built into the system.

After studying the Tapestry datasets and the functionality provided by the Esri Leaflet API, the best approach was to focus on helping prospective home buyers understand lifestyles in various communities that matched their own.

Unlike traditional real estate portals, this system would incorporate community recommendations to match home buyers with potentially suitable neighborhoods based on the answers those home buyers provided to questions about lifestyle and preferences related to shopping, entertainment, and commuting.

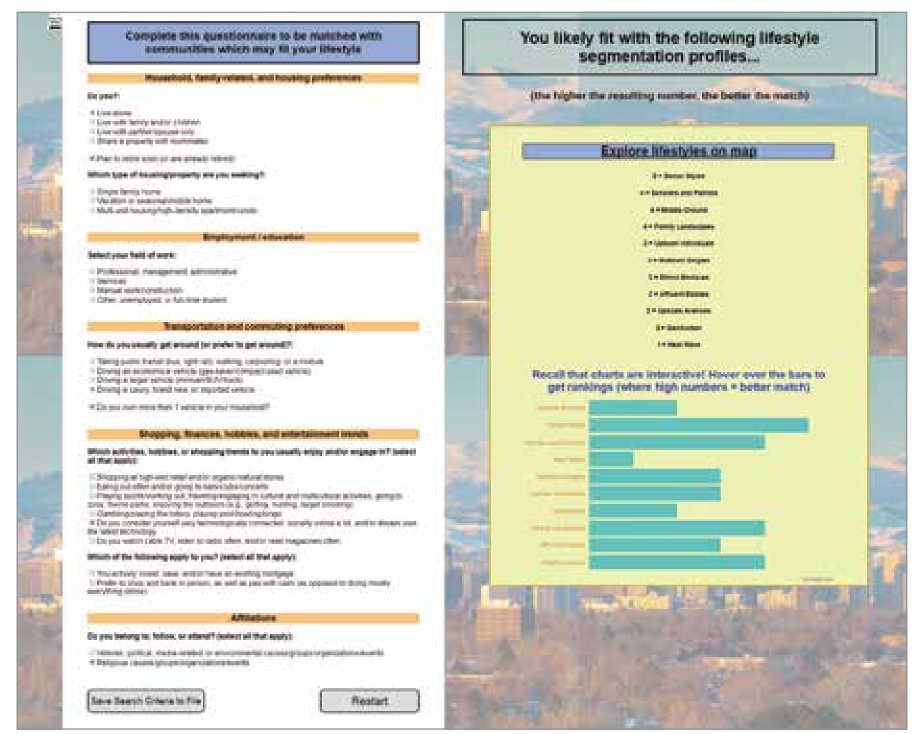
This introduced a level of complexity in recommendation provision that was possible thanks to attribute-rich Tapestry, consumer expenditure reports, and demographic datasets by Esri, which outline categories by which to summarize communities and their populations. All these application functions would additionally include interactivity and supply fairly rich attributes that could be explored both visually and analytically (with charts, graphs, tables, and maps).

The project involved aggregating Tapestry data at a local scale by joining block group administrative units into neighborhood boundaries, which are commonly used in home buyer systems. The JavaScript-based recommendation system was developed using the Esri Leaflet API that used survey answers. Its usefulness was that it provided information not available elsewhere.

Esri Leaflet API was used to leverage mapping and related GIS functionality on the website. The GIS analysis customization capabilities are almost endless with this API and enable users to maximize data exploration and knowledge acquisition about their communities. Furthermore, hosting GeoJSON layers (a lightweight format for encoding geographic data structures within websites) in ArcGIS Online was quick and easy.

The Community Decision Support System for Denver (d34th4hxov1wxv.cloudfront.net) can be viewed online. The main functions currently available on the website include:

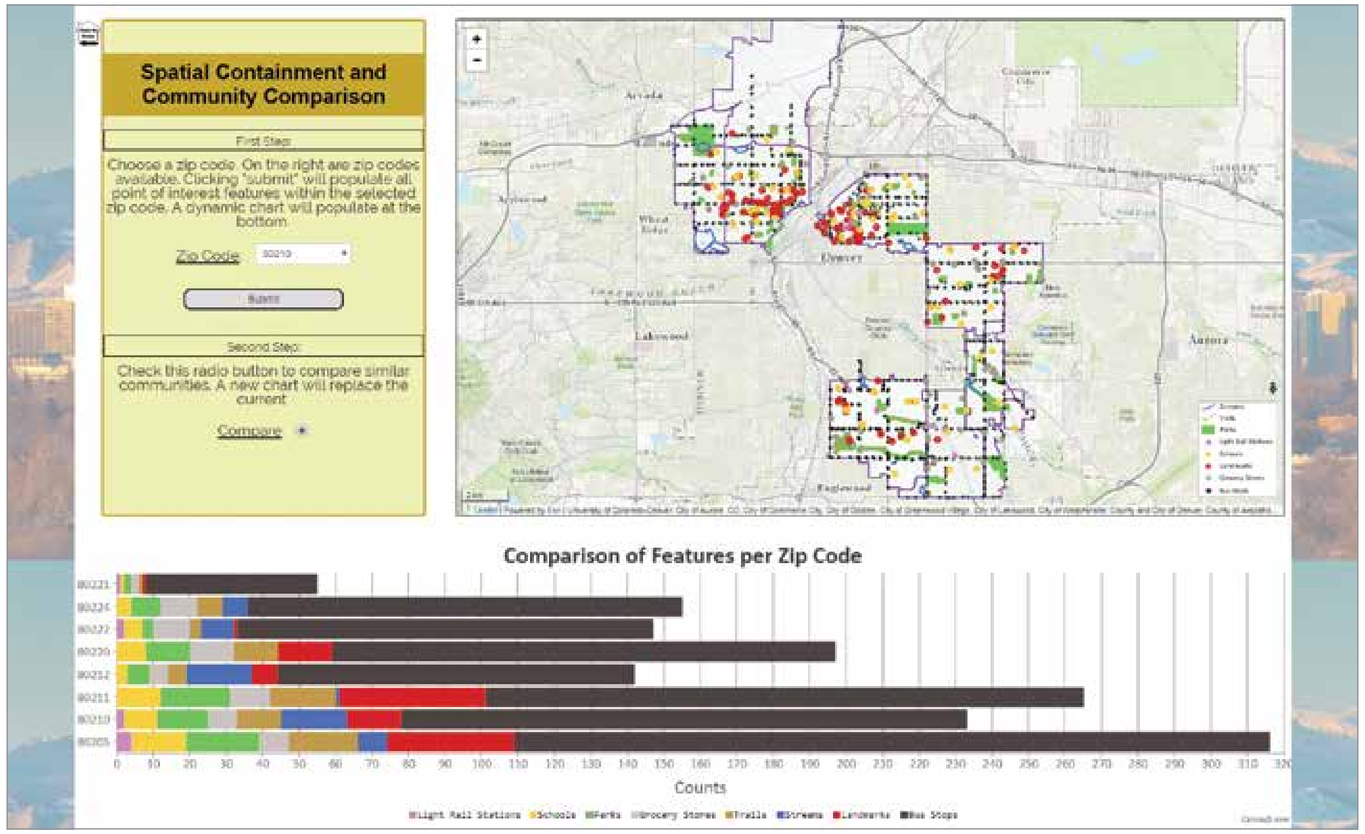
- Search by neighborhood to obtain visual and statistical information on that neighborhood.
- Search by Tapestry group based on a user's answers on a simple questionnaire that are used to rank neighborhoods within the same or similar lifestyles.
- Lifestyle mapping allows a user to review all the unique criteria of a lifestyle profile and visualize the results on an interactive map.
- Select features on the map within a specified proximity of a point of interest or address using a tool.
- Perform spatial queries to find all features contained within a ZIP code (containment area), and analyze the results shown by single and multiple ZIP code charts that can be used for comparison purposes.
- Manipulate heat maps to show patterns of different categories of crime over time.
- Calculate travel times and distances (by car) based on inputted addresses and live traffic data. A traffic visualization with historic trends is also available.

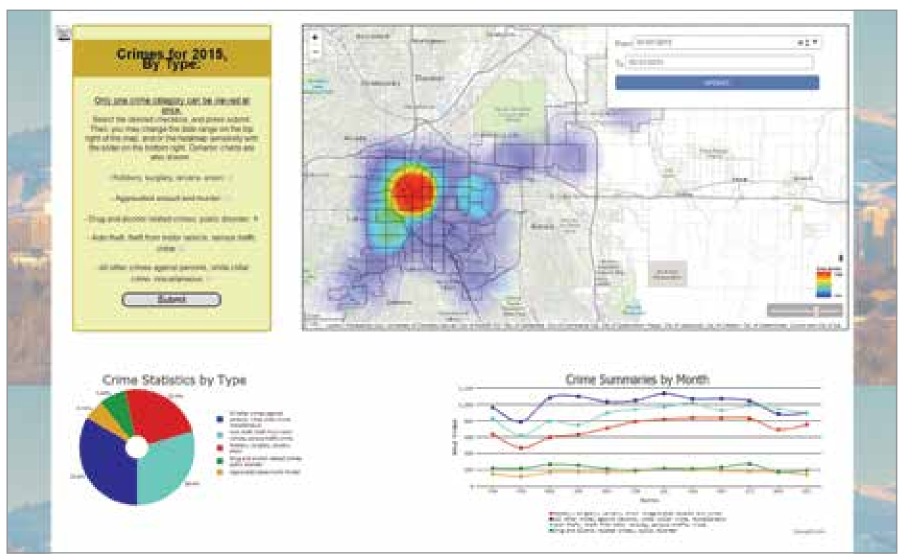


On the questionnaire recommendation page, users input details about their lifestyle and are provided with recommendations based on communities that match those lifestyle trends.

System Assessment and Enhancements

The developed system is merely a prototype and is not intended to replace or compete with popular real estate information providers. Website users were asked to complete a quick, anonymous user evaluation





The crime visualization function helps users understand, by crime category, the areas with the most and least crime.

Modifying the Esri Leaflet Spatial Containment function so the user can compare similar amenities for other communities based on Tapestry profiles

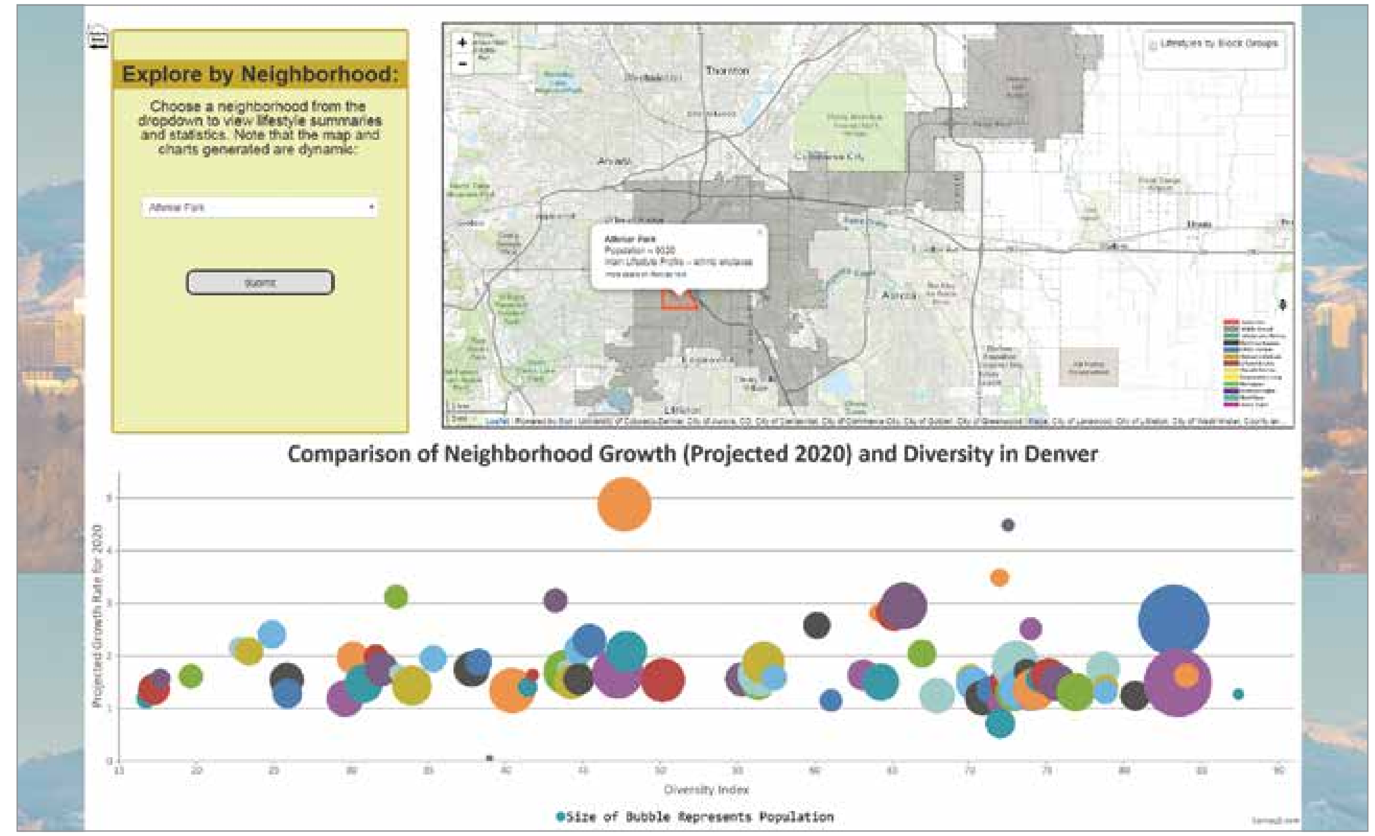
survey that furnished feedback, suggested updates, and tested site performance.

The nine-question survey asked about general-use aspects and included rating the system's effectiveness in delivering GIS functionality and performance. Users could also provide written comments and discuss ideas for future implementations.

As of June 2017, every user reported average to high scores for all questions. Furthermore, more than 60 percent of users claimed they would recommend this website to others looking to learn about communities in Denver. Those responding to the survey included potential home buyers, real estate professionals, business experts, and researchers.

From survey ratings and comments, it was concluded that the system delivered results accurate enough to be competitive if it were further developed and improved. In addition, the implemented methods and datasets were corroborated against other data sources, statistics, and systems and were deemed appropriate in terms of performance and delivery by a team at the University of Denver.

Although still in the early stages of testing, the popularity of the prototype is expected to continue growing. More real estate professionals recognize the growing power of this type of geospatial functionality and its usefulness when combined with holistic community- and lifestyle-based information. It can truly empower users in the business, marketing, and real estate industries. In the near future, the author anticipates maintaining the system and datasets in a cloud environment and pushing updates based on user requests, advisory team recommendations, or as needed to maintain technological and quality assurance standards.



This function queries for a selected neighborhood, then displays a chart summarizing diversity, projected neighborhood growth, and total population per neighborhood in Denver.

This project has been able to successfully leverage—even in a minor way due to its prototype nature—Esri Tapestry data and Esri Leaflet API functionality to deliver a GIS-based home buyer recommendation system for Denver, Colorado. Based on the feedback collected, it is clear that users find this type of system practical and benefit from geospatial tools and lifestyle-rich information currently unavailable at other sites.

Three recommendations have been proposed based on user feedback:

- Inclusion of additional datasets such as police station, farmers' markets, and bike path locations
- Enrichment of the site's graphic design
- More frequent updating of site information to reflect changes in geodemographic characteristics over time

The author intends to improve the system in the future but has learned that cooperative efforts would be more effective in delivering high-end products. She hopes to partner with local collaborators to enhance the system, test it within a larger market, and advertise it as a free tool.

Conclusion

Thanks to Esri Tapestry data and the Esri Leaflet API, publishing a new kind of community recommendation system with comprehensive socioeconomic, demographic, and geographic details has been possible. The prototype may easily be implemented at larger scales, coupled with traditional property-focused real estate systems to assist realty companies.

The tools can be refined to work for other locations, too, including rural areas. It is hoped that—for the sake of empowering home buyers and communities—the use of Tapestry data and geospatial functionality within real estate decision support frameworks will become the norm.

For more information, visit the Community Decision Support System for Denver website (http://d34th4hxov1wxv.cloudfront.net) or contact Marta Blanco Castano at marta.blanco-castano@alumni.du.edu.

About the Author

Marta Blanco Castano is a recent graduate of the University of Denver, where she received a master's in geographic information science. She currently works as a research assistant for the institution, helping develop geospatial solutions to support decision-making in various contexts. She is passionate about applying spatial analysis and data visualization methods to Web GIS, business geography, earth sciences, and urban planning and development to understand complex dynamics between societies and the natural and built environment. She has been involved in several geospatial technology design projects, including the US Geological Survey 3D Elevation Program and the Open Geospatial Consortium Testbed 13.

Harness the Power of GIS with the ArcGIS API for Python

The ArcGIS API for Python is a new Python library for working with maps and geospatial data that is powered by Web GIS, whether online or on-premises. It is a Pythonic API that uses Python best practices in its design and employs standard Python constructs and data structures with clean, readable idioms.

Use this API to work with your data and access ready-to-use maps and curated geographic data from Esri and other authoritative sources. It has simple and efficient tools for sophisticated vector and raster analysis, geocoding, mapmaking, routing, and generating directions, as well as for organizing and managing the users, groups, and content associated with an organization's Web GIS.

Because the Python language is developed under an open-source license, it is freely usable and distributable. The ArcGIS API for Python is also free. Both Python and the API can be installed on any number of machines, whether local computers or servers. The lightweight Python API is distributed through Conda, a popular package manager for Python libraries. It works well with open-source Python libraries, such as pandas, SciPy, and NumPy, and machine learning packages.

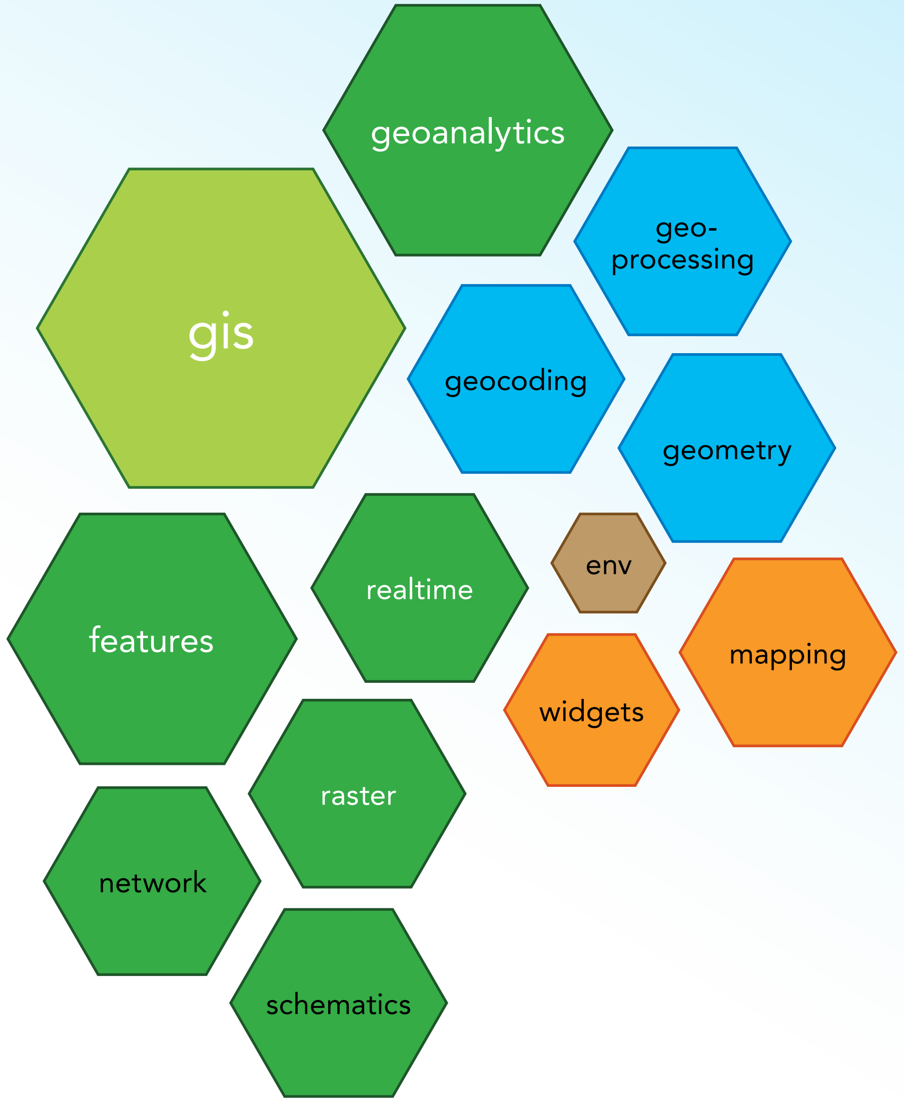
The Python API is intuitive and easy to learn and designed to lower the barrier of entry to both GIS and programming. It benefits experienced Python developers who want to quickly get started with GIS and seasoned GIS professionals who want to automate administrative tasks and perform analyses.

No matter what your role, objectives, or tasks, this API offers functionality that you can use. Through the Python API, you can harness the full power of your GIS to script and automate processes. This aspect of the API may remind longtime GIS users of the ARC Macro Language (AML) or the Avenue scripting language used with earlier versions of Esri GIS software.

Manage Your GIS Efficiently

GIS administrators or developer operations engineers can use the API to quickly automate the process of creating an organization in ArcGIS Enterprise or ArcGIS Online. User accounts can be batch created using a CSV file to assign roles to users and users to groups. Seed content can be published and assigned to each user. The API can be used to set up mirrors of the organization's portal so one can be used for development and the other for production.

The ArcGIS API for Python allows you to perform sophisticated spatial analysis as well as administer and manage the components of your Web GIS.



Architecture of the API
The gis module, in light green, provides the entry point into the GIS. Other modules in green are used to access spatial capabilities or geographic datasets in the GIS and include geoprocessing functions, types, and other helper objects for working with spatial data of a particular type. Blue modules provide additional functionality for workflows and include the geocoding, geometry, and geoprocessing modules. Orange modules are used to visualize GIS data and analysis and include the MapView Jupyter Notebook widget for visualizing maps and layers. The Mapping module shown in orange has types and functions for working with web maps and web layers.

The process of cloning the portal and keeping content, groups, and users synchronized can be efficiently scripted.

Automating day-to-day administrative tasks can save lots of time and effort. Listing all items belonging to a user, searching for content based on a particular criterion, listing content published before a specific date, creating a new user account for new group members, removing user accounts and their content when members leave, and sorting items based on their popularity are a few of the tasks that can be scripted.

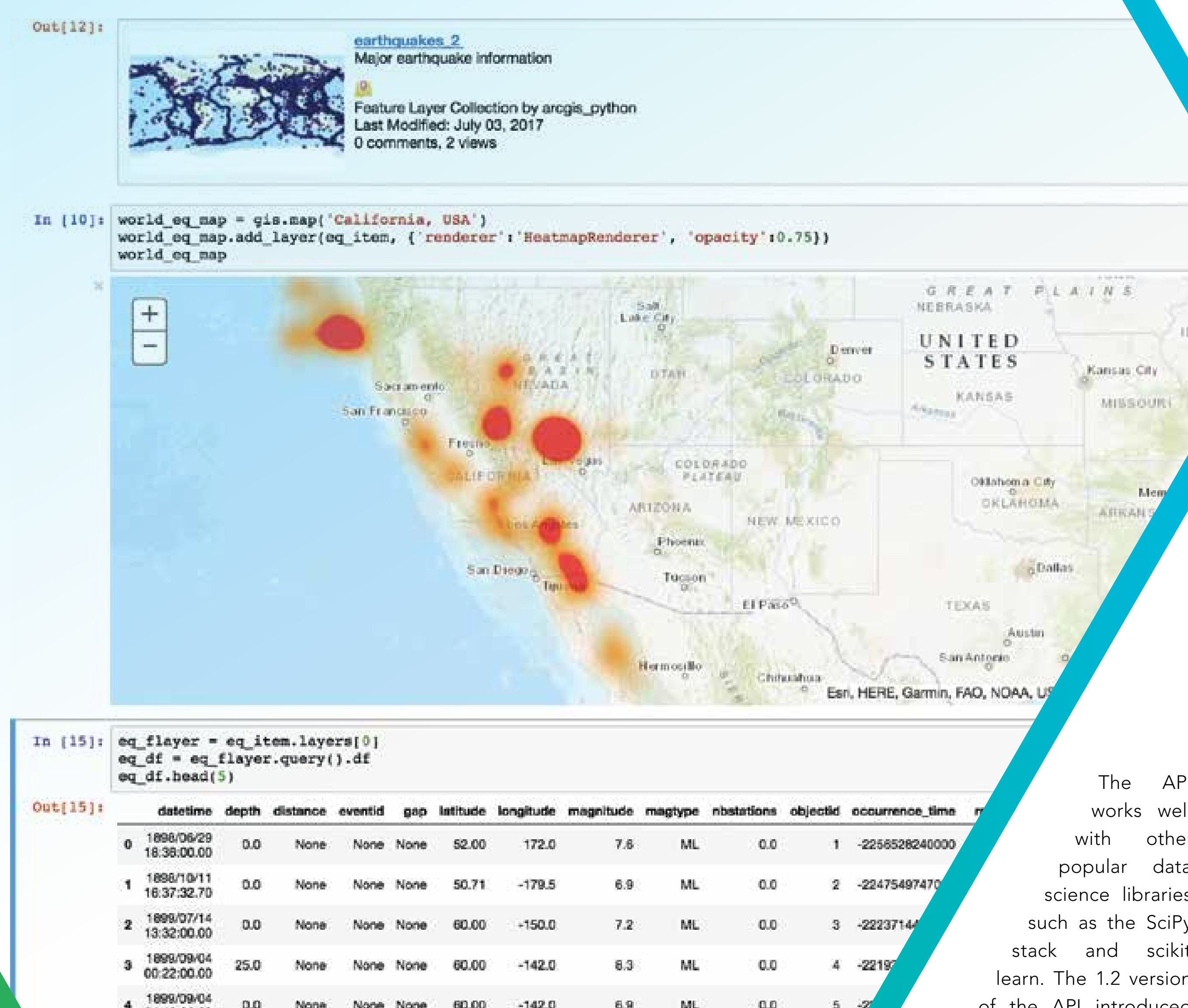
With a few lines of code, easily manage important tasks such as assigning licenses and entitlements to various ArcGIS apps, managing and monitoring ArcGIS Online credits, or migrating content from one user to another. The API provides rich features for querying server and portal logs and monitoring their health through usage metrics and statistics. Easily create charts of these statistics to identify choke points and optimize operations.

Use the API to publish and share web layers and web maps or list maps or scenes with broken links to layers and fix them. Keep content up to date through editing or overwriting web layers and schedule those tasks to run periodically during off-peak hours.

Use the Analytical Capabilities of GIS

Data scientists and GIS analysts can harness the full power of the rich analytical tools available in ArcGIS by not only executing spatial analyses but also performing distributed processing on big data by calling GeoAnalytics functionality and distributed raster analysis tools available with ArcGIS Enterprise. It can also perform geocoding and routing analyses and employ custom tools that have been exposed as geoprocessing web tasks.

Power users who know a lot about Web GIS, use it every day, and want to become more efficient by automating workflows can really benefit from the ArcGIS API for Python. The very readable and flexible Python language is well suited to new programmers. Conversely, Python programmers who are not very experienced with GIS will find that the ArcGIS API for Python provides a gentle introduction to



the concepts of a modern GIS through its simple and intuitive design.

How the API Is Structured

The elegant and modular design of the ArcGIS API for Python was built after studying and reflecting on other popular, well-designed Python APIs. It has been perfected through multiple initial iterations. At its core is the gis module, which provides an entry point to a Web GIS with a rich set of classes to search, monitor, and administer it. Other modules represent different aspects of the Web GIS platform.

The features module works with vector data in the form of feature layers or collections of feature layers hosted by the GIS. Analysis tools can be applied to this vector data to summarize data, analyze patterns, perform spatial enrichment, or perform proximity analysis using just a few lines of code. This module is tightly integrated with pandas, a Python library for data analysis, so the feature data can be queried into a pandas DataFrame object.

Pandas by itself provides a powerful set of analytical tools, and its integration with countless plotting and machine learning libraries means every ArcGIS API for Python user can not only use the tools available in ArcGIS but also the whole data science ecosystem that is built around Python. The API works well with other popular data science libraries such as the SciPy stack and scikit-learn. The 1.2 version of the API introduced SpatialDataFrames, which spatially extended the DataFrame object and allows importing and exporting of a greater variety of geospatial data; performing spatial queries and joins; and working with data in a "pandorable" manner.

The raster module provides a new way of working with imagery and raster datasets. The API allows raster analysis in an elegant and concise manner by exposing powerful, dynamic raster functions as native Python functions. For the first time, map algebra can be performed on Web GIS and processed at source resolution using the distributed raster analysis capability available from ArcGIS Image Server.

The geoanalytics module exposes a series of big data analytical tools. Once data is registered with the GeoAnalytics

Perform exploratory data analysis in Jupyter Notebook using the Python API.

Perform routing and directions analysis using the Python API in Jupyter Notebook.

Automating day-to-day administrative tasks can save lots of time and effort.

Server, the API can be used to aggregate and analyze it and even schedule scripts to run so that as new data comes into the system, it can be periodically analyzed. With the geocoding and network modules, address and point of interest (POI) information can be turned into spatial data and used in routing and direction analysis.

The realtime module enables work with streaming data. The geoprocessing module helps execute custom web tasks published as geoprocessing services. The geometry module provides the geometric representation of feature data that can be built using raw coordinates. Author and edit web maps and scenes using the mapping module. It works hand in hand with the widgets module, which provides interactive map and scene widgets that can be embedded in a Jupyter Notebook for visualizing GIS content. (For more information on using Jupyter Notebook with the ArcGIS API for Python, see the accompanying article, "A Whole New Way to Experience GIS.") The API provides a seamless experience because as you search for content or perform a spatial analysis task, it returns appropriate classes from different modules.

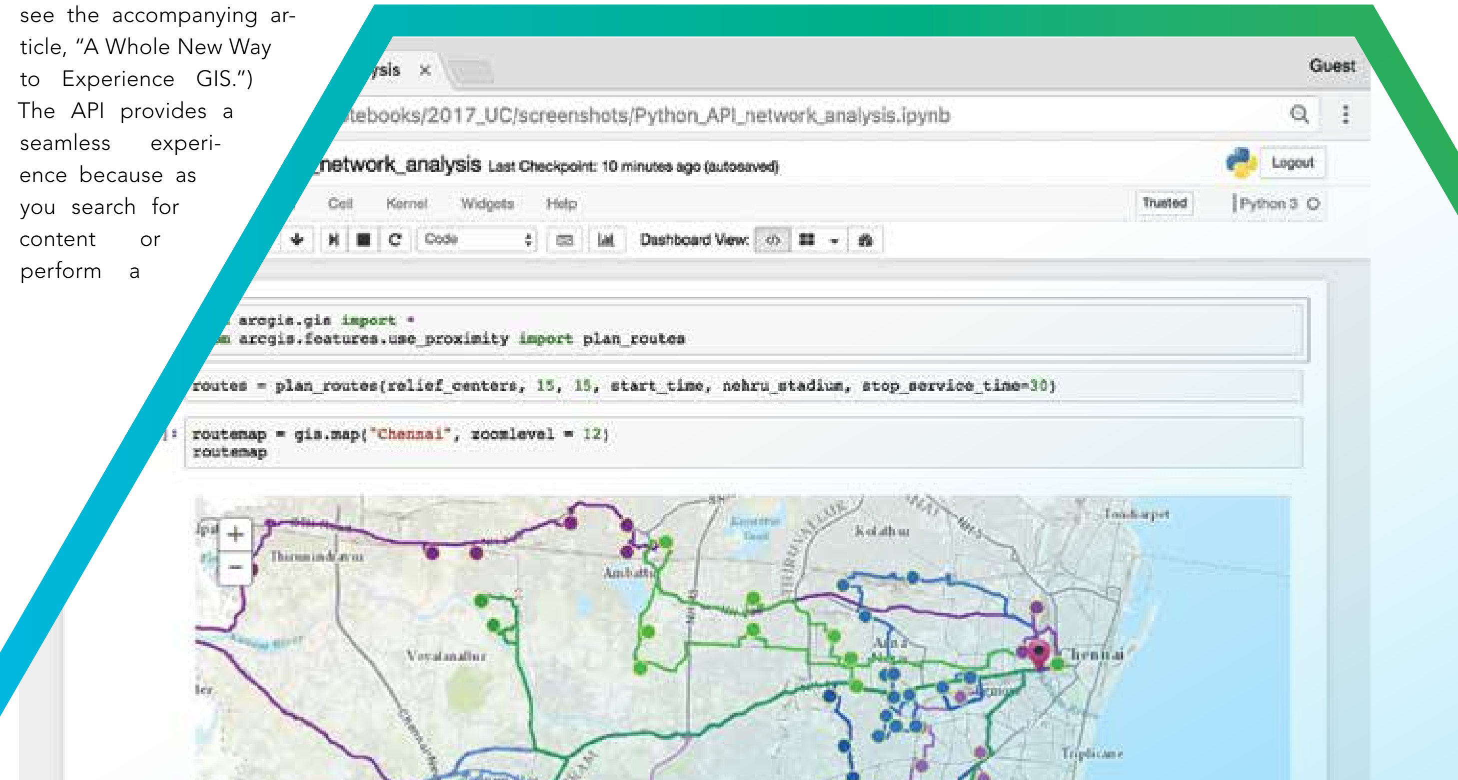
So Many Resources for Getting Started

All the information you need to start using this API—installation information, helpful guides, and getting started exercises presented in Jupyter Notebook format—is available at developers.arcgis.com/python. Case studies in Jupyter Notebook format explain how the various modules of the API can be put together to solve problems from an applications point of view. The Forum tab on the website will take you to the ArcGIS API for Python Group on GeoNet, Esri's question and answer network. All the guide chapters and samples from the website and talks delivered by the development team at various conferences are available in Jupyter Notebook format on GitHub at github.com/esri/arcgis-python-api.

One of the easiest ways to get started with the ArcGIS API for Python is to try it out live in the sandbox environment at notebooks.esri.com. Make sure to download any work because the site resets after you leave it. You can also download the samples from GitHub and run them locally.

Conclusion

The ArcGIS API for Python enables the use of a simple, expressive language that everyone—not just developers—can learn and use to work more efficiently by scripting and automating workflows and performing analyses. It not only exposes the rich analytical capabilities that are built in the ArcGIS platform but also integrates very well with the scientific Python ecosystem and includes rich support for pandas and Jupyter Notebook.



A Whole New Way to Experience GIS

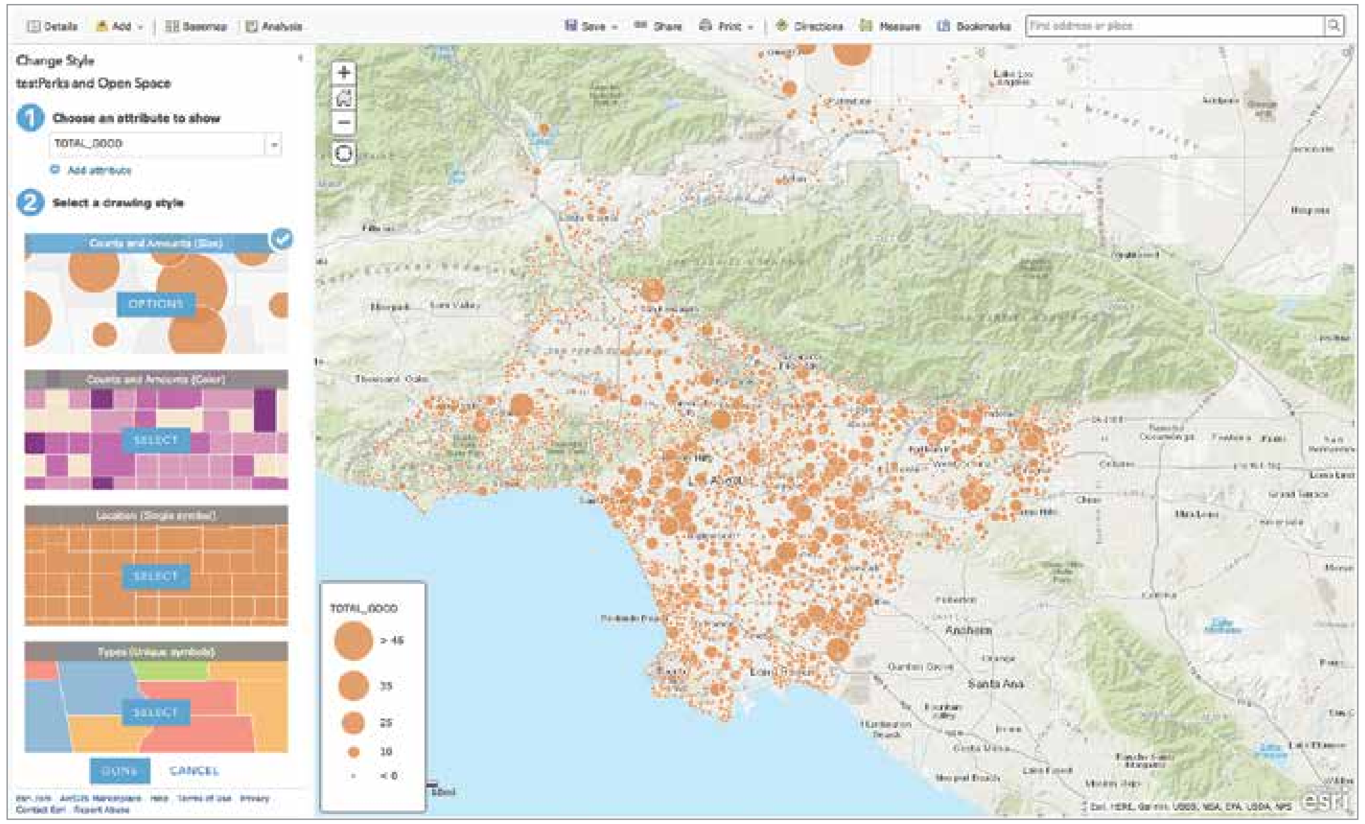
Learn, document, and share workflows using Jupyter Notebook with the ArcGIS API for Python

The ArcGIS API for Python is easy to learn and extremely useful for data scientists, GIS administrators, and GIS analysts. One of the features that makes this API so powerful is its integration with Jupyter Notebook.

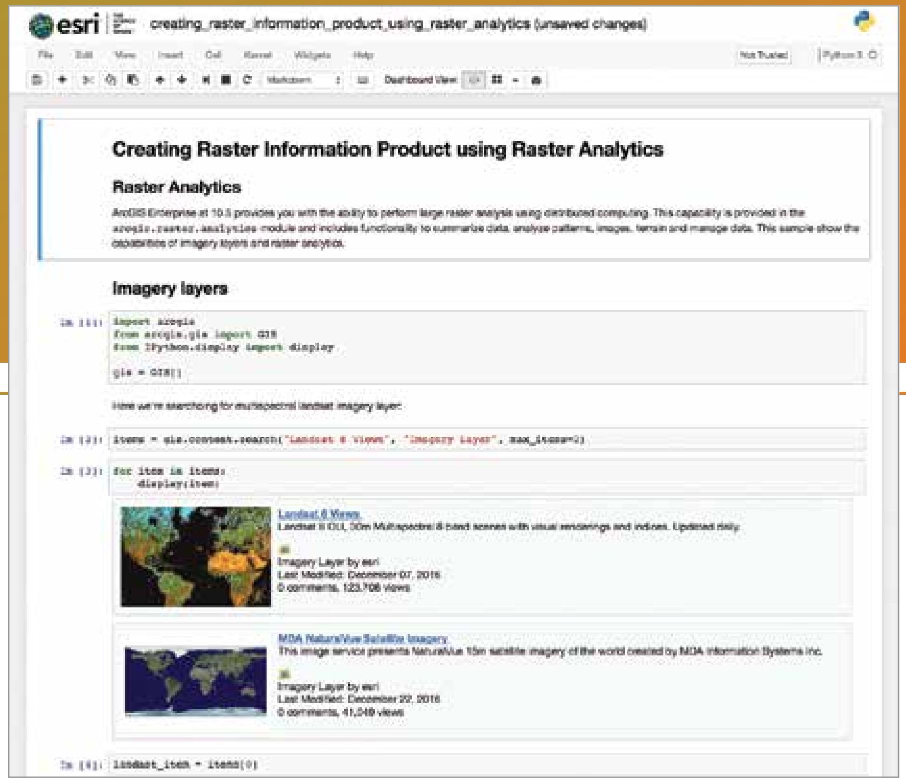
Jupyter Notebook is a web-based integrated development environment (IDE) for executing Python code. Unlike other traditional IDEs that are designed for developers, Jupyter Notebook provides a simple and easy-to-use interface that encourages the Read-Eval-Print Loop (REPL) process that is central to learning how to code in Python.

This approach originated with IPython Notebook. Project Jupyter took over the open-source project and opened it up to the Julia, Python, and R languages (hence the name Jupyter). Now many more languages are supported. Because these notebooks are free, open source, and platform independent, they can be run on any device that has a browser, allowing them to be easily shared.

Python and Jupyter Notebook are immensely popular in the data science community. Jupyter Notebook combines code execution, rich text, mathematics, plots, and rich media and has become the de facto medium for teaching Python and data science at schools and in online training programs.



Jupyter Notebook is a way to explore spatial data. Content can be added with its default symbology or—using smart mapping—the API can figure out how best to symbolize the data.



Immediately access the Jupyter Notebook samples at notebook.esri.com to learn how to take advantage of integrative capabilities of the ArcGIS API for Python such as tapping into raster functions.

The interactive Jupyter Notebook environment is built around the concept of cells that can contain executable code or text and illustrative graphics written in Markdown format. Cells can be run in any order and any number of times. When a cell is run, its output is displayed immediately below the cell. This encourages tweaking and rerunning code until the perfect solution is found—illustrating the REPL paradigm in action.

Because it is a web application running in a browser, Jupyter Notebook supports the display of graphic outputs. Write a snippet of Python code to plot a bar chart of household income of a county, and the chart will be displayed right below the cell containing that code.

Members of the passionate open-source community have created extensions for Jupyter Notebook that have made it a versatile tool that can be used for a variety of tasks beyond software development, from running presentations to grading student assignments in the classroom.

Jupyter Notebook is also a great medium to work with and explore spatial data. Using just a single line of code, a live interactive map can be inserted into a notebook. Another line of code can add content to that map that is the result of a search. That content can be added with its default symbology or—using smart mapping—the API can figure out how best to symbolize the data. SpatialDataFrame objects returned from a query for features in a feature layer can be visualized as a table in Jupyter Notebook.

The ArcGIS API for Python builds on the rich illustrative framework available in Jupyter Notebook. The API provides access to the spatial data exploration, mapping, visualization, and analysis capabilities of the ArcGIS platform. A published imagery layer can effortlessly be overlaid on the map. With support for raster functions as native Python functions in the Python API, analyses can be applied and rendered instantly on the map.

The Python API can also be used by GIS administrators to search for and display users, groups, or items from ArcGIS Online. Items will show up in rich HTML format with thumbnails and metadata information.

Jupyter Notebook is a great medium to teach not only programming but also GIS. The integrated, interactive Jupyter Notebook environment can help teach GIS concepts to decision-makers as well as new GIS users.

Workflows, data connections, outputs in the form of illustrative charts and maps, and informational text about conclusions—it can all be stored and worked with in a notebook. A Jupyter Notebook can become a functional record of a workflow that can be shared with anyone. All the recipient must do is run the cells to reproduce that workflow. Jupyter Notebook encourages research that is reproducible, since not only the findings but the code used to arrive at them is stored.

Get Started Now

To try the Jupyter Notebook live in a browser, go to notebook.esri.com No installation or login is required. This site is a sandbox environment that is preloaded with the ArcGIS API for Python and contains guide chapters and samples in a Jupyter Notebook. Because it is a sandbox, the site resets itself after use, so any work should be saved. Saved notebooks can be uploaded and run during subsequent visits to the site.

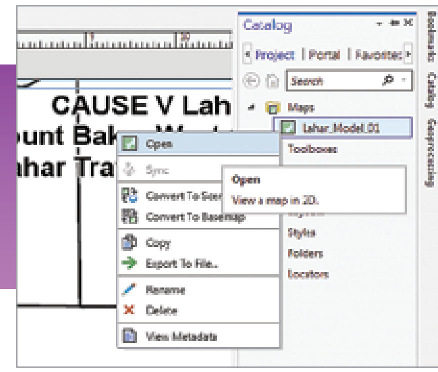
To install and run Jupyter Notebook locally, go to developers.arcgis.com/python and follow the installation instructions. Jupyter Notebook is bundled with ArcGIS API for Python and will be installed on your computer with the API, providing access to the rich analytical capabilities of the ArcGIS platform and powerful machine learning and data analysis libraries, right from within Jupyter Notebook. The ArcGIS API for Python and Jupyter Notebook give you a whole new way of experiencing GIS.

Modeling Volcanic Mudflow Travel Time with ArcGIS Pro and ArcGIS Network Analyst

What You Will Need

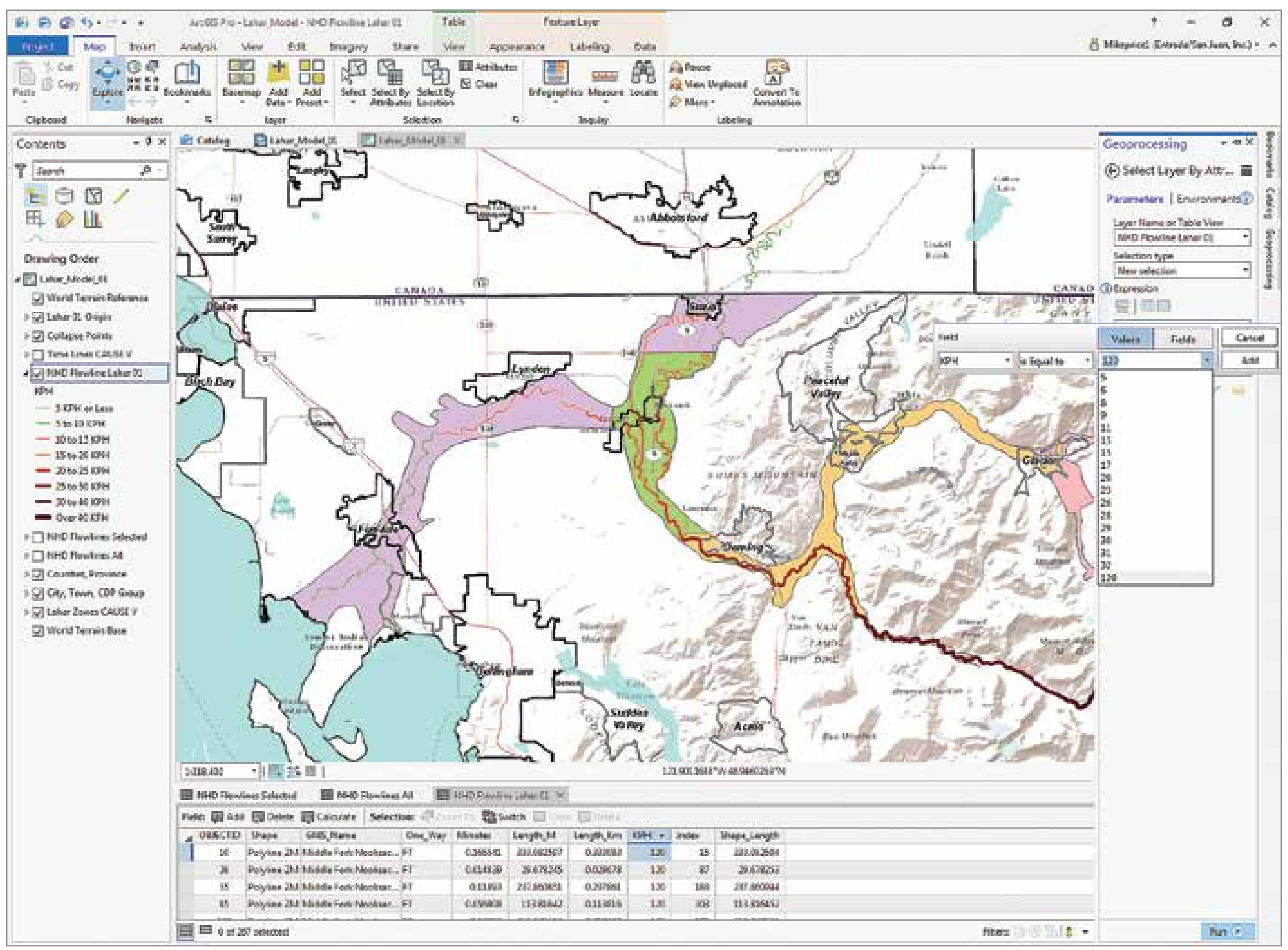
- An ArcGIS Pro 2.0 or 2.1 license
- ArcGIS Network Analyst license
- Sample dataset from the *ArcUser* website (esri.com/arcuser).
- Access to the Internet

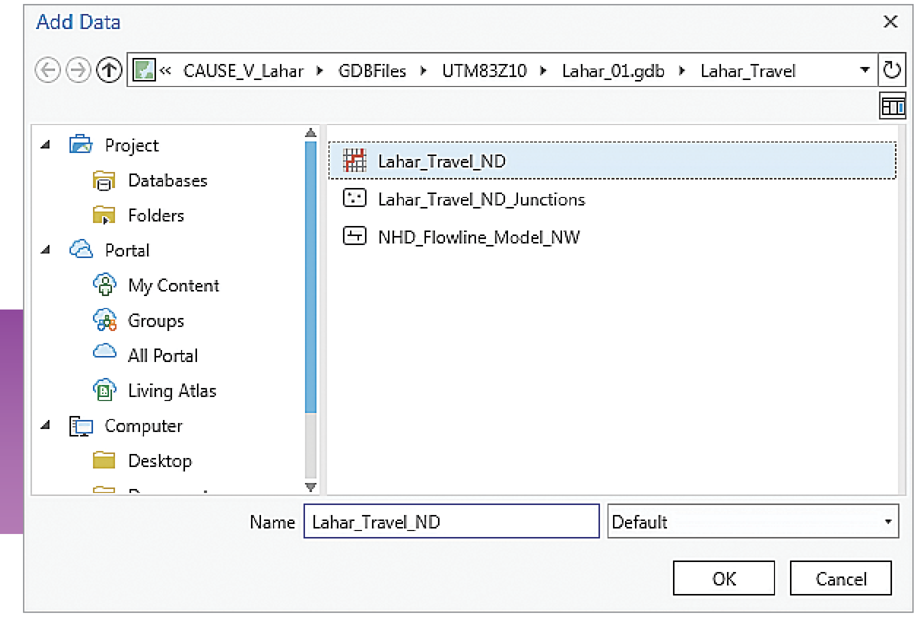
By Mike Price, Entrada/San Juan, Inc.



Right-click Maps > Open to open Lahar_Model_01. All modeling in this tutorial will be done in map view.

Select the highest velocity flowlines located high on Mount Baker that begin at Lahar 01 Origin.





A prebuilt network dataset using selected NHD flowlines that was prepared and included in the sample dataset should be loaded to create a service area analysis layer.

On November 15 and 16, 2017, public safety agencies in the United States and Canada and supporting government and industry entities plan to conduct a training and proof-of-concept exercise along the westernmost border between the United States and Canada called the Canada-US Enhanced Resiliency Experiment (CAUSE) V. This is the fifth in a series of CAUSE exercises held since 2011.

This exercise will involve a hypothetical crater collapse on Mount Baker, a 10,781-foot (or 3,286-meter) dormant composite volcano, located approximately 30 miles (49 kilometers) east of Bellingham, Washington. Now ready for deployment, it will simulate the effects of several major structural collapse events near the mountain's summit. The seismic activity that would accompany these events would result in volcanic mud and debris flows (lahars), riverine flooding, landslides, and other natural phenomena. Data from these events will be synthesized and sequenced to test response and recovery capabilities of the US and Canadian emergency agencies.

A significant result of the crater collapse would be several lahars, first in the western Nooksack River drainage and later in the Baker/Skagit River system of Mount Baker's eastern side. A key part will include modeling the extent and travel times of these lahars in several drainage systems.

This tutorial introduces a special use of ArcGIS Network Analyst, an ArcGIS Pro extension, to route and measure a lahar originating above the Middle Fork of the Nooksack River. The travel model uses prebuilt stream flowlines developed from the the National Hydrography Dataset (NHD). The empirical timing used in the exercise was developed from the study of a similar lahar that resulted from the May 1980 eruption of Mount St. Helens, also in Washington.

For more information about CAUSE V, see the accompanying article, "Testing Cross-Border Disaster Response Coordination." For background information on Mount Baker, see the accompanying article "Mount Baker (Briefly)."

Modeling Lahar Flow with NHD Flowlines

This tutorial uses data from NHD, which is managed by the US Geological Survey (USGS) as part of *The National Map*. NHD is a high-resolution compilation of drainage networks and related features, including rivers, streams, lakes, ponds, glaciers, and dams. Flowline data provided by NHD includes seamless stream centerlines and nonflowing water centerlines. Flowline connectivity and directionality support hydrologic network modeling.

This tutorial uses modified NHD Stream, River, and Artificial Path vectors to model lahar travel in the Nooksack River drainage. The flowlines are edited in one area to allow the network to cross a minor drainage divide and enter the Sumas River drainage.

For more information about NHD or to obtain NHD data, visit the Hydrography page of *The National Map* at nhd.usgs.gov/index.html.

Getting Started

Download the sample dataset archive, Cause_V_Lahar.zip, from the *ArcUser* website to a local machine and extract the data. This archive contains several file geodatabases, a prepared stream centerline dataset, and an MXD document that will be imported into ArcGIS Pro.

Start ArcGIS Pro, make sure you have an ArcGIS Network Analyst license available and active, and create a new Blank project. When prompted to Create a New Project, name it Lahar_Model and store it in Cause_V_Lahar\GDBFiles\UTM83Z10. Make sure you store the new project in this folder.

Once the new project has opened, click the Insert tab, then click Import Map. Navigate to Cause_V_Lahar, select Lahar_Model_01.mxd, and click OK.

Once it has opened, inspect the imported map. It uses the same layout as the original map, and its current extent shows the Nooksack River flowing west from Mount Baker into Puget Sound. Also, notice that this map shows Johnson Creek and the Sumas River flowing northeast into British Columbia. Inspect the Cities, Towns, and Census Designated Places (CDPs) and CAUSE V Lahar Zones layers and turn on the NHD Flowlines layer. Look at the Collapse Points layer, and note the two collapse points located on Mount Baker and at the Lahar 01 Origin.

Open the Catalog pane, right-click Maps > Open to open Lahar_Model_01. All modeling in this tutorial will be done in map view.

On the Map ribbon, click the Basemap dropdown, and select Terrain with Labels. Although the Canadian terrain will flash momentarily and then disappear, the labels for the area remain visible.

Testing Cross-Border Disaster Response Coordination

In 2011, Canada and the United States began holding a series of exercises to test communication technologies and information-sharing tools.

To date, four of these Canada-United States Enhanced Resiliency Experiment (CAUSE) exercises have been conducted along the US-Canada border, with the fifth and final experiment, CAUSE V, scheduled for November 15 and 16, 2017. CAUSE V will be conducted along the Washington-British Columbia border.

The CAUSE exercises are a collaboration between the US Department of Homeland Security Science and Technology (S&T) Directorate and Defence Research and Development Canada Centre for Security Science.

The disaster driving the scenario for the CAUSE V exercise is that a volcanic explosion and crater collapse has occurred on Mount Baker, located 37 miles (60 kilometers) inland and less than 15 miles (25 kilometers) south of the US-Canada border.

This scenario spans several months in the second half of 2017. During that time, Mount Baker has been the site of increased volcanic and seismic activity and has emitted steam and ash. A mid-November eruption causes an initial collapse of Sherman Crater, located near the mountain's summit.

The initial collapse sends a volcanic debris flow, or lahar, down the Middle Fork of the Nooksack River to Puget Sound and northward along the Sumas River into Canada. A second eastern collapse generates multiple lahar flows down the east flank of Mount Baker, into the Baker and Skagit River system.

CAUSE V will evaluate the communication, hazard monitoring, and emergency warning systems, including the interagency coordination and public notification associated with this event. It will test response and recovery activities by local, state, provincial, and federal providers.

The experiment emphasizes cross-border communication and coordination. Observers in the United States will include the Federal Emergency Management Agency (FEMA), the FirstNet communications group, and US Northern Command.

Using NHD Flowlines to Define Lahar Travel

In the Contents pane on the left side of the interface, highlight NHD Flowlines Selected, right-click, and open its attribute table. Select individual records and study their attributes. Zoom in to check NHD flowlines in and near the communities of Everson and Nooksack. There is a very low drainage divide between the Nooksack River and Johnson Creek. The CAUSE V model will deflect part of the lahar flow out of the Nooksack drainage into the Johnson Creek/Sumas River drainage, and the flow will continue across the border between the United States and Canada and flow toward the Fraser River.

Next, close the attribute table and turn off NHD Flowlines Selected. Turn on NHD Flowlines All. In the Contents pane, expand the legend for NHD Flowlines All and open its attribute table. These polylines are raw NHD Flowlines, clipped along the Nooksack corridor. This dataset was filtered prior to the CAUSE V event to create the network dataset that will be used in this model.

Close the attribute table and turn off the NHD Flowlines All layer. Turn on the NHD Flowlines Lahar 01 layer and open its attribute table. Notice that this prepared dataset includes the same polyline data as NHD Flowlines Selected. The difference is that its attribute table supports time and distance network modeling. Sort the KPH (kilometers per hour) field in descending order.

Selecting High Velocity Flowlines

On the ribbon, click the Table tab then Selection by Attributes.

In the Select Layer by Attributes Geoprocessing pane, make sure Layer Name or Table View is set to NHD Flowline Lahar 01 and Selection type is set to New selection. Click the Add Clause button to bring up the expression creator. Create an expression choosing KPH for Field, then is Equal to, and select 120 as Value.

Click Run to select all records in which KPH is Equal to 120.

This selection includes the highest velocity flowlines located high on Mount Baker that begin at Lahar 01 Origin. In imperial units, 120 KPH is approximately 75 miles per hour (MPH) or nearly 110 feet per second.

Click the Map tab and use the Lahar 01 Origin 1:50,000 bookmark to zoom in and identify any flowline segment immediately below Lahar 01 Origin. Verify that all units are metric and that the velocity is 120 KPH. Notice the very short travel times.

Use the bookmark for Everson Nooksack 1:100,000 to zoom in and observe the constructed flowline vectors connecting the Nooksack River with Johnson Creek and Sumas River. These segments allow the lahar to travel over the Everson divide and continue north toward the Fraser River. Close the attribute table, save the project, and let's begin modeling.

Empirical Lahar Travel Estimates

The model velocities that will be used to determine lahar timing are derived from studies of lahars on the North and South Forks of the Toutle River that were created by eruption of Mount Saint Helens on May 18, 1980. Dr. T. C. Pierson, a research hydrologist at the US Geological Survey's Cascades Volcano Observatory, studied the Toutle River debris flows and developed distance-based velocities for a typical Cascade volcano lahar. His findings were published in a 1998 paper called *An empirical method for estimating travel times for wet volcanic mass flows*. Pierson's findings are summarized in Table 1, which lists estimated velocities based on distances below the origin. These values were used to set velocities for selected stream segments in this tutorial.

Kilometers Traveled	Average Velocity, KPH
5	120
10	32
15	32
20	31
25	31
30	30
35	29
40	28
45	26
50	23
55	20
60	17
65	15
70	13
75	11
80	9
85	8
90	7
95	6
100	5

Table 1: Lahar travel times (based on work by Dr. T. C. Pierson in 1998)

Loading a Prepared Lahar Network Dataset

To streamline this tutorial, a metric network dataset using selected NHD flowlines was prepared and included in the sample dataset. It was edited to include the Everson crossing. Stream vectors extend from Lahar 01 Origin at Puget Sound in the west to the Fraser River in Canada. ArcGIS Network Analyst was used to determine the flow distances to assign the velocities shown in Table 1. Modeling another debris flow would require constructing a separate network dataset.

To load the prepared network dataset, on the Map ribbon, click the Add Data button and navigate to CAUSE_V_Lahar\GDBFiles\UTM83Z10\Lahar_01.gdb\Lahar_Travel.gdb.

Click Lahar_Travel.gdb and click Lahar_Travel_ND to add it.

After the network dataset loads, move this layer to just below the NHD Flowlines All layer in the Contents pane. Save the project.

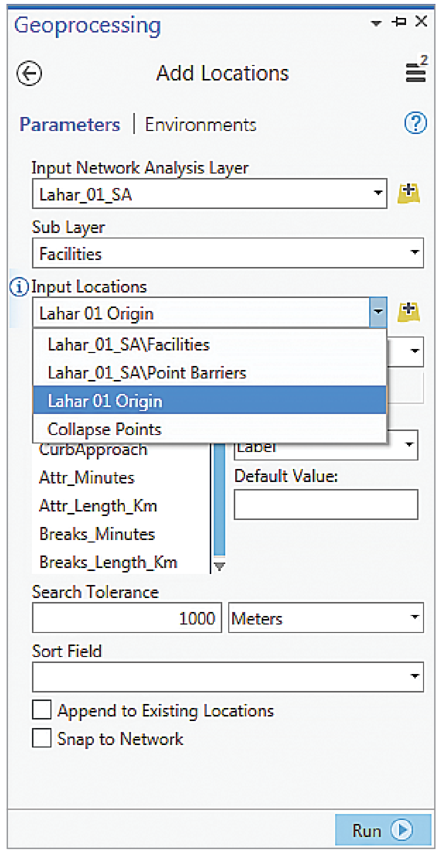
Creating a Service Area Analysis Layer

Click Analysis on the ribbon and click Tools. In the Geoprocessing pane, click Toolboxes, expand Network Analyst Tools, expand Analysis tools, and locate Make Service Area Analysis Layer.

In the Make Service Area Analysis Layer pane, specify Lahar_Travel_ND as the Network Data Source. Name the Layer Lahar_01_SA, skip Travel Mode, and set Travel Direction to Away from facilities.

Still in the pane, under Cutoffs, accept the first three completed (5, 10, 15), type 20 in the first empty cell, and press Enter or Tab to open another cell. Continue typing values in subsequent cells under Cutoffs using the values in the Elapsed Time column of Table 2. Carefully enter these values, as they will be used in a definition query expression later in this tutorial.

Skip Time of Day and expand Output Geometry. Set Output Type to Lines and set Geometry at Overlaps to Split. Polygons do not work well here, so flowlines must be split using the cutoff values just entered.



Use Add Locations to add the Lahar 01 Origin point.

Expand Accumulate Attributes, and check both Length_Km and Minutes.

Click Run. The Service Area Analysis Layer is created and loaded into the Contents pane. Save the project when finished.

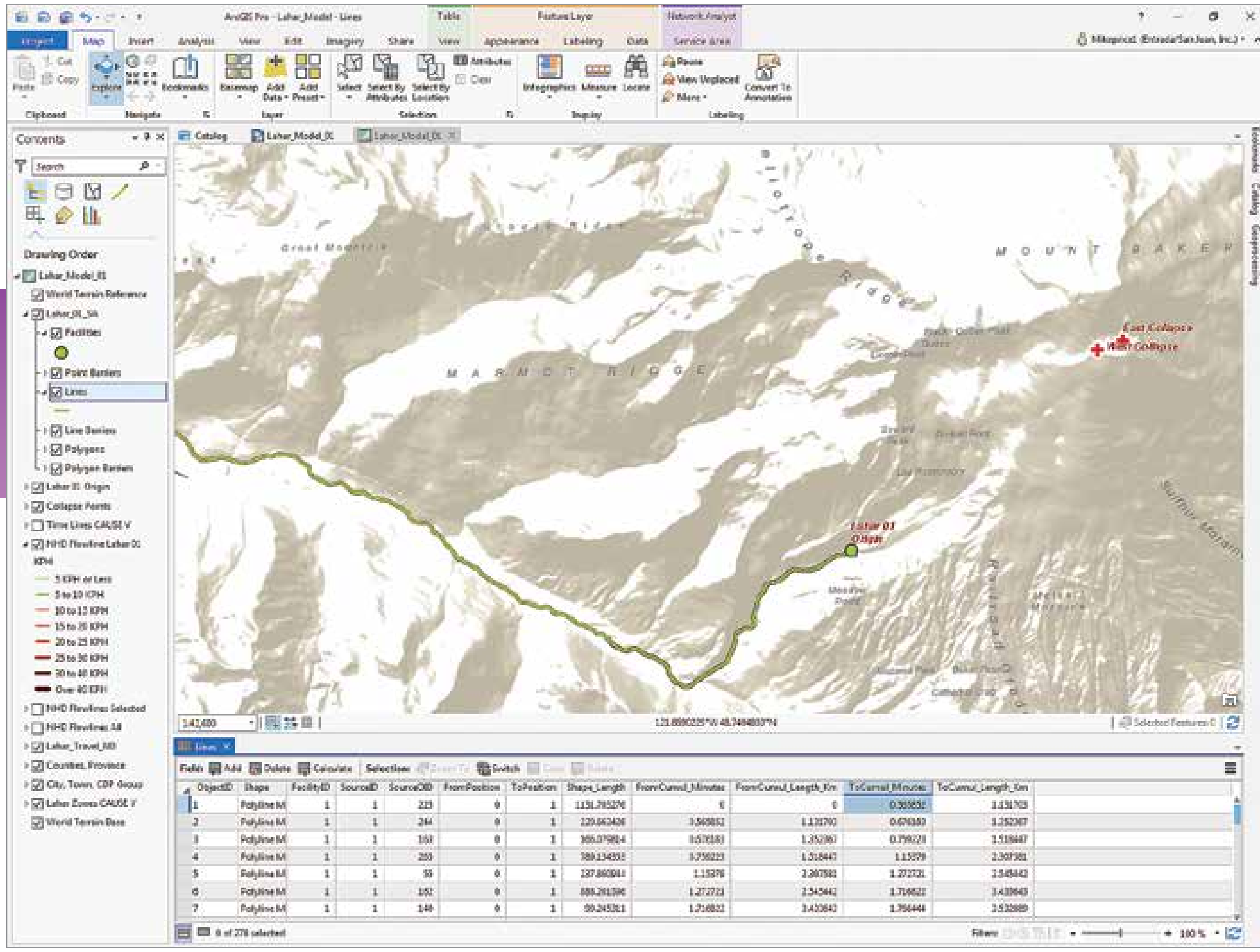
Adding a Lahar Facilities Origin and Creating a Lahar Line Set

In the Contents pane, select the Lahar_01_SA to invoke the Network Analyst Service Area tab.

Click the Network Analyst Service Area tab on the ribbon and click Import Facilities.

In the Geoprocessing Add Locations pane, set Input Network Analysis Layer to Lahar_01_SA, set Input Locations to Lahar 01 Origin. Set Search Tolerance to 1000 Meters, leave Append to Existing Locations and Snap to Network unchecked, and leave other fields unchanged.

Click Run to add the Lahar 01 Origin point. A single point for Facilities loads over



After clicking Run on the Service Area ribbon, open the Lines attribute table, which should have 278 records, and explore the ToCumul_ Minutes field.

Lahar 01 Origin. Save the project again.

After the Facility point loads, locate and click Run on the Service Area ribbon and watch the network analysis execute.

When it is finished, return to the Lahar_01_SA group in the Contents pane. Right-click Lines and open its attribute table, which should have 278 records. Inspect the Lines attribute table and explore the ToCumul_Minutes field. This field contains the downstream time for lahar travel on each NHD segment. Sort the field in ascending order and scroll through the values. You should see the time breaks as values of 5, 10, 15. If you do not see them all, rerun the solver, specifying Split for all Table 2 intervals.

Once the Lines layer values are validated, export Lines to a permanent polyline feature class. In the Lahar_01_SA group, right-click Lines, choose Data > Export Features. In the Copy Features Geoprocessing pane, set Input Features to Lines and save the polyline feature class in CAUSE_V_Lahar\GDBFiles\UTM83Z10\Lahar_01.gdb\Lahar_Travel.gdb as Lahar_01_SA_Lines.

Save the project again.

Calculating Endpoint Coordinates and Time Point Set

Now to assign endpoint coordinates to all exported Line vectors. Open the Geoprocessing pane and type geometry in the Find Tools box. This should return the Add Geometry Attributes at or near the top of the search list. Alternatively, locate the Add Geometry Attributes tool in the Features toolset, which is in the Data Management Toolbox.

In the Geoprocessing Add Geometry Attributes pane, specify Lahar_01_SA_Lines as Input Features and select Line start, midpoint, and end coordinates for Geometry Properties. Specify Meters as Length Unit and Square Meters as Area Unit.

It is very important to set the Coordinate System to North American Datum 1983, Universal Transverse Mercator Zone 10N (NAD_1983_UTM_Zone_10N). Click the globe icon and in the Coordinate System pane, choose Projected > UTM > NAD 1983 > UTM Zone 10N.

When all fields and the coordinate system have been set, click Run.

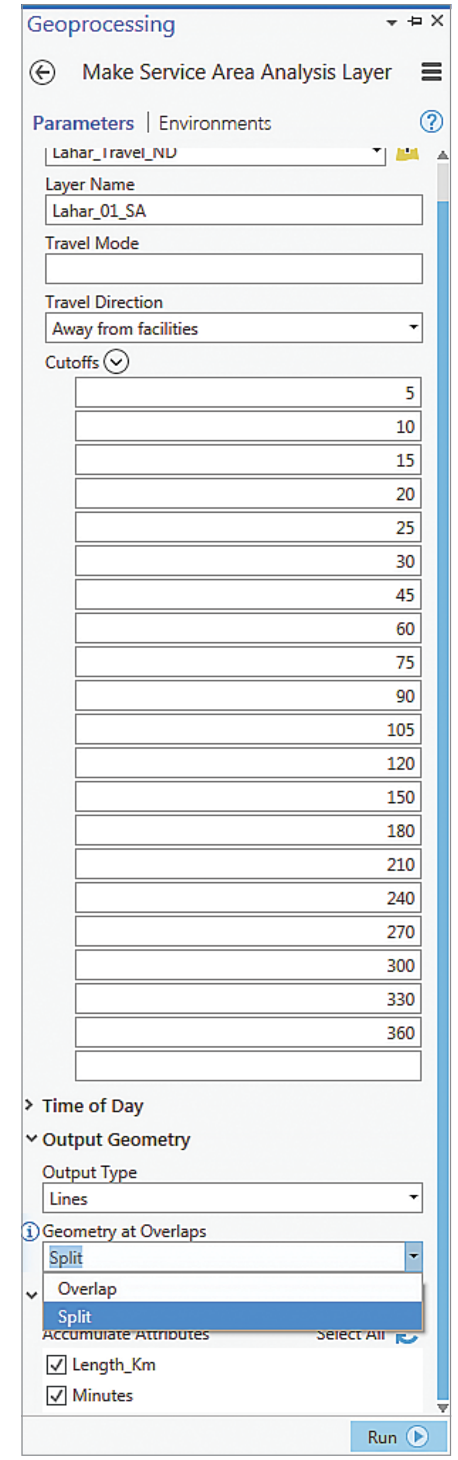
When the processing is finished, scroll across the updated table and locate the END_X and END_Y fields. These fields contain UTM coordinates for vector downstream endpoints. By creating an *x,y* point set of selected endpoints, the desired time points can be posted on the map, but first, all vectors must be filtered to obtain the values listed in Table 2.

Click the Map tab on the ribbon and click Select By Attributes. Specify Lahar_01_SA_Lines as the Layer Name, set Selection type to New selection, and open the Expression window, which could be used to create the expression by clicking 5 for the first value, and clicking Add and continuing the process to create a similar expression for the rest of the 21 elapsed time intervals listed in Table 2.

Instead of doing all that work, load the prepared expression included in the sample dataset, which will perform this task. On the bottom line of the Select Layer by Attribute pane below the Expression text box, locate the folder icon and click it. Navigate to CAUSE_V_Lahar\Utility and load Interval_Times_Definition_Query.exp. Once the expression is loaded, inspect it, and click Run.

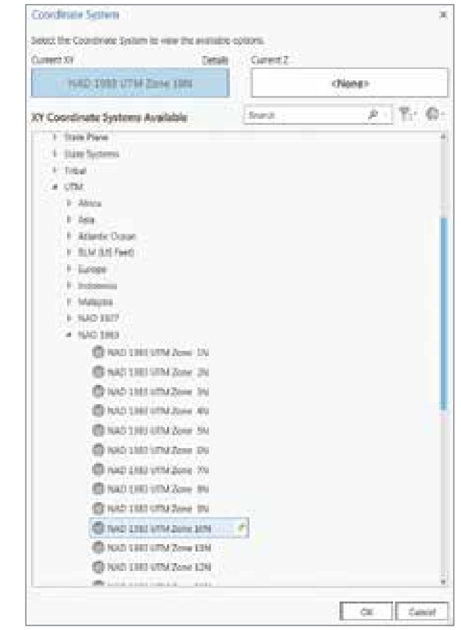
Travel Time Interval (In Minutes)	Elapsed Time	Interval Duration
Start	0	0
0–5	5	5
5–10	10	5
10–15	15	5
15–20	20	5
20–25	25	5
25–30	30	5
30–45	45	15
45–60	60	15
60–75	75	15
75–90	90	15
90–105	105	15
105–120	120	15
120–150	150	30
150–180	180	30
180–210	210	30
210–240	240	30
240–270	270	30
270–300	300	30
300–330	330	30
330–360	360	30

Table 2: Lahar travel time intervals

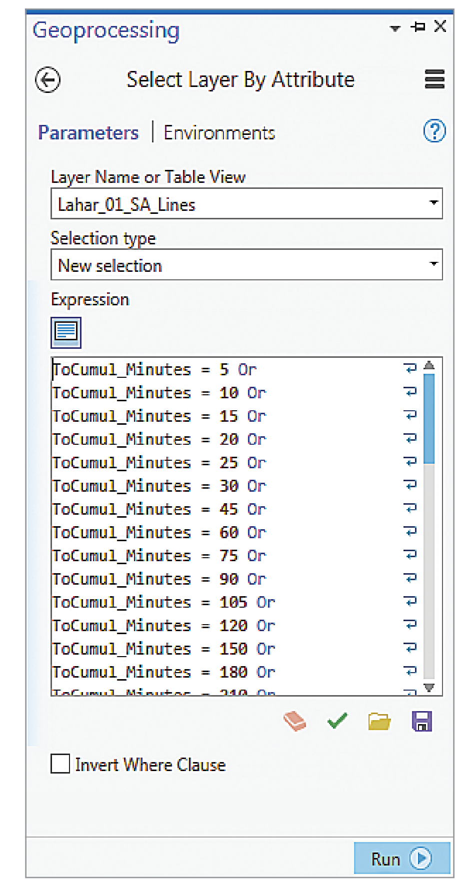


Continue adding values in the cells under Cutoffs using the values in the Elapsed Time column of Table 2. Carefully enter these values because they will be used in a definition query expression.

Use the prebuilt Interval_Times_Definition_Query.exp to save time when using the Select Layer By Attribute pane.



It is very important to set the Coordinate System to North American Datum 1983, Universal Transverse Mercator Zone 10N (NAD_1983_UTM_Zone_10N) when adding geometry attributes to Lahar_01_SA_Lines.



This query selects the 34 records that represent the desired time intervals. Return to the Geoprocessing search field and type copy rows to locate the Copy Row tools.

In the Copy Rows Geoprocessing pane, set Input Rows to Lahar_01_SA\Lines and Output Table to Lahar_01_SA_Lines_XY and save it in CAUSE_V_Lahar\GDBFiles\UTM83Z10\Lahar_01.gdb\Lahar_Travel.gdb. Zoom to the map display using the Nooksack R 1:250,000 bookmark.

Click Add Data and navigate to the Lahar_01_SA_Lines_XY table and add it to the map.

Make Event Layer

Right-click on the Lahar_01_SA_Lines_XY table in the Contents pane and choose Display XY from the context menu. In the Geoprocessing Make XY Event Layer pane, set the X Field to END_X and the Y Field to END_Y. Accept the default name of Lahar_01_SA_Lines_XY_Layer. Use the Counties, Province feature class to define the spatial reference. Click Run.

After the Event Layer loads in the Contents pane, check the locations of all points and save the project. To create a permanent layer, right-click the Lahar_01_SA_Lines_XY_Layer and select Data > Export Features. Save the new feature class in Lahar_01.gdb and name it Lahar_01_Time_Points. Be very careful to use this name: Lahar_01_Time_Points.

Do not load the new feature class in the map and use a layer file that will symbolize the data. Return to the Map ribbon, click Add Data, navigate to CAUSE_V_Lahar\GDBFiles\UTM83Z10\, and load Lahar 01 Time Points.lyr. The points will appear along the Nooksack and Sumas Rivers as black cross symbols with the modeled travel time at each point. Save once more.

Mount Baker (Briefly)

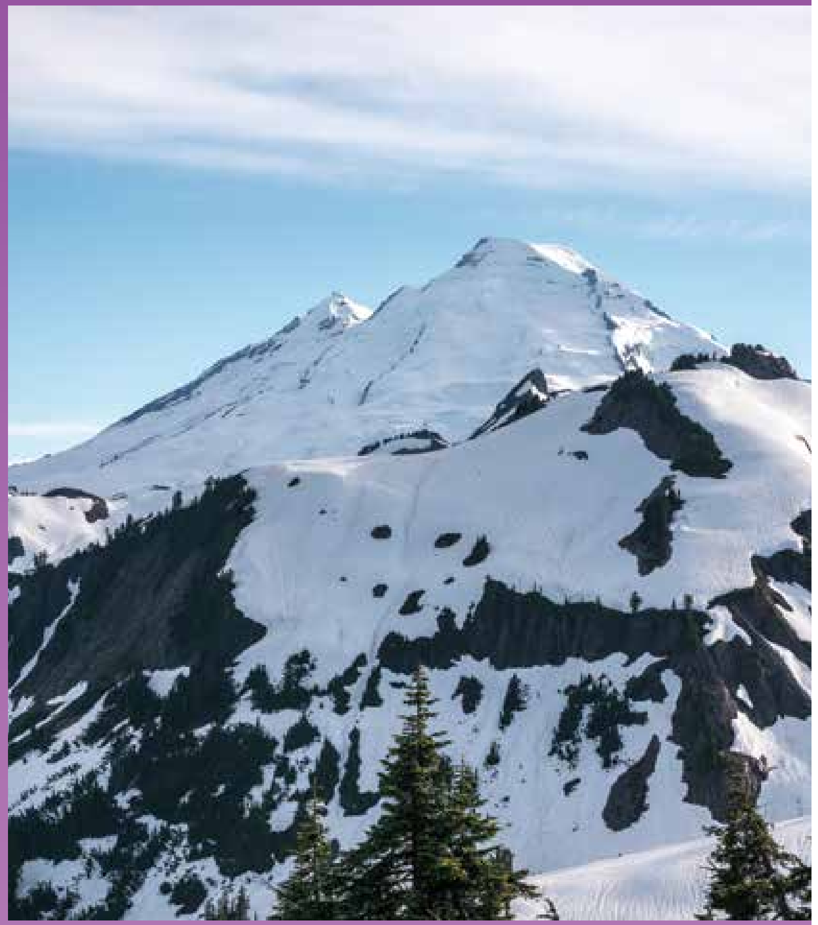
Mount Baker is a stratovolcano that is estimated to be less than 140,000 years old, although its volcanic field formed more than one million years ago. It is composed of andesite lava flows and breccias. The mountain's present form was initially developed before the Fraser Glaciation, which occurred between 25,000 and 10,000 years ago.

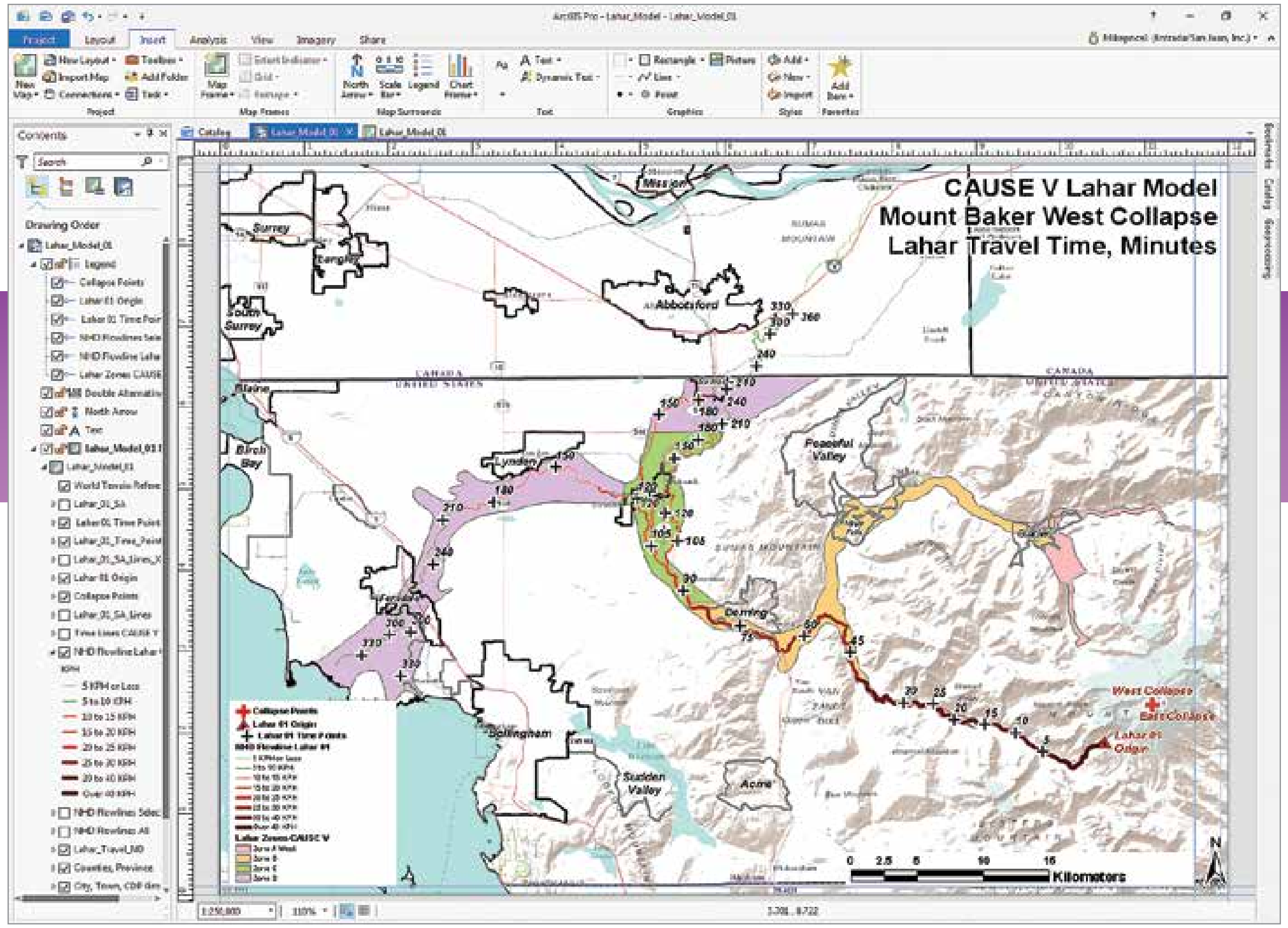
At 3,286 m (10, 781 ft), Mount Baker is the third-highest mountain in Washington State. After Mount St. Helens, it is the second most active thermal site in the Cascade Range. It is also the second most glaciated summit, following Mount Rainier. A major eruption occurred approximately 6,700 years ago, which included a flank collapse that formed significant lahars in the Nooksack and Baker Rivers drainages, accompanied by widespread ash and tephra fall.

In March 1975, Sherman Crater, a crater located immediately south of the main summit, exhibited signs of renewed volcanic activity caused by magma intruding into the volcano. The increased activity included ash and steam releases; minor seismic activity; melting ice; and small, localized lahars. The mountain was closely monitored by the Cascades Volcano Observatory, as increased activity could threaten infrastructure and communities in the Nooksack and Skagit basins.

In the following months, activity did not increase significantly. Over the following two years, activity declined and heat escape stabilized at a rate higher than in early 1975. It appears that magma intrusion decreased and that penetrating magma cooled to form a deep-seated dike.

The Cascades Volcano Observatory continues to monitor Mount Baker, providing extensive baseline data for a rather typical Cascade volcanic event.





Load Lahar 01 Time Points.lyr to easily symbolize the points as black cross symbols with the modeled travel time at each point that appears along the Nooksack and Sumas Rivers.

Update CAUSE V Lahar Model Layout

Finally, go to the Catalog pane, expand Layouts, and open Lahar_Model_01 to view the layout. Review the progress of the lahar over time as it descends the Middle Fork of the Nooksack River to the confluence with the North Fork at approximately 60 minutes. The flow continues on to the Everson/Nooksack area where it separates into two lobes at approximately 120 minutes. Follow each lobe as it continues on down the Nooksack toward Puget Sound or north into Canada along Johnson Creek and the Sumas River. Notice that as velocity decreases and deposition occurs along debris flow margins, it may take more than 300 minutes, or five hours, for lahar debris to reach Puget Sound and nearly six hours for debris to reach the Trans Canada Highway 1, east of Abbotsford, British Columbia.

Summary

The data presented and modeled in this exercise is completely hypothetical and is not intended to represent an actual event. Lahar travel times are approximately modeled using empirical observations and analyses of a recent actual explosion in the central Cascades.

Acknowledgments

The author thanks the agencies and staff that design and support CAUSE V, including Cascades Volcano Observatory; Whatcom County, Washington; Washington Emergency Management; and all other supporting agencies and organizations. Special thanks to Dr. T. C. Pierson and Cynthia Gardner at the Cascades Volcano Observatory.

Going with the Flow to Map Routes

By Rhonda Houser, University of Kansas Libraries

Who hasn't found themselves engrossed in the route maps at the back of flight magazines and asked themselves, "How do they make those maps?" Readers who have a few years of GIS experience can read through this article to find out how. This article will be most relevant to readers wanting to know how GIS can illustrate movement from one location to another when those origins or destinations are shared, such as flights arriving to and departing from an airline hub.

One splendid spring day in Lawrence, Kansas, GIS specialist Rhonda Houser was working as a colleague (her boss) was busy planning a big conference. For conference attendees, Houser had created a map of favorite local destinations. This was a straightforward process in ArcGIS Online that had a satisfactory result. Her colleague also asked if Houser could make a map showing where attendees had traveled from to attend the conference.

Houser found a helpful post on the *ArcGIS Blog* from September 6, 2011, "Creating radial flow maps with ArcGIS," by Mamata Akella. It described how radial flow maps can show the movement of goods or people, using lines to depict transportation and communication routes and relationships. A radial flow map can show multiple origins converging on a single destination (or vice versa). Best of all, she learned that ArcGIS has a tool that generates radial flow data from geographic coordinates.

Her colleague had provided a spreadsheet of attendee data that included the country, state (if the attendee resided in the United States), city, and ZIP code. Registrants were also coming from more than 100 places in Africa, Japan, Australia, and the Philippines.

Houser used Microsoft Excel to clean and format the data. She didn't touch the ZIP code data because mapping this geography is tricky. She summarized all records for each city into a single row and added a column for the number of attendees per city. She structured the data this way so the tool would create a line for each city instead of each attendee. She also added the four columns required to hold the geographic coordinates for origins and destinations.

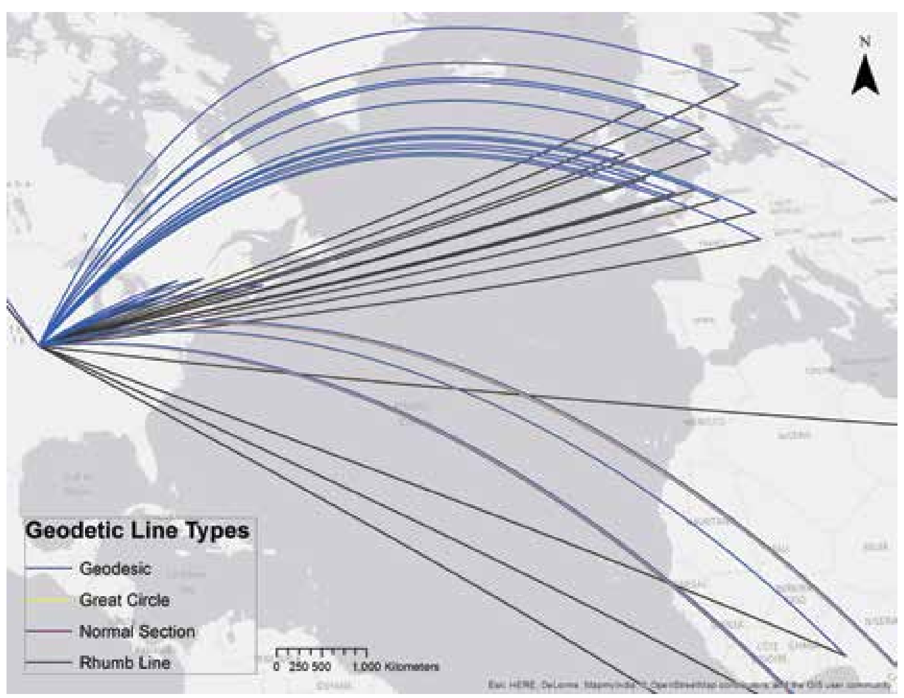
GeoNames (www.geonames.org) seemed like a comprehensive and authoritative source for latitude and longitude (*x,y*) data for the cities. *[GeoNames is an online geographic database that provides place names for all countries. Available under a creative commons attribution license, place-name data can be downloaded at no charge.]*

Cleaning data is naturally messy. GeoNames data is available based on city population, so the coordinates Houser needed were scattered throughout a few large, delimited text files.

Dealing with duplicate city names was another challenge. Guess how many Springfields there are in the United States? GeoNames city data seemed to include unique identifiers, though the attendee data did not. Preparing the data for a giant join was going to be a lot of work. Instead, Houser found an easier method. She entered coordinates for each city, using Google Maps to fill in a few gaps.

For local attendees, she assigned coordinates roughly equivalent to the city center. Although discernible only at a very large scale, this line intensified the overall density of the lines leading to the University of Kansas campus at other scales. A few x,y values that stubbornly refused to be formatted as decimal numbers conformed after some prodding.

A comparison of geodetic lines for generating radial flow data



Unless the map is set to a projected coordinate system with a custom central meridian, radial flow data in ArcGIS does not draw with the destination at the center of the map.

Success in GIS requires outlandish displays of problem solving, driven by an array of tactics and a relentless determination to solve, fix, or finish. Creativity is often the result rather than the intent when resources are scarce or ideal resources are not present. What seems creative is also a reflection of the particular combination of tools, expertise, and time available in each unique environment.

Houser used the XY To Line tool in ArcGIS Desktop 10.5 to generate a line dataset from the spreadsheet data. *[The XY To Line tool uses origin and destination values as inputs from a table and creates a new linear feature class that represents the path connecting these two points.]* The output shapefile included default vector data fields and starting and ending coordinates but not the rest of the spreadsheet data. To join that data, she needed a field containing unique identifying values. She joined the rest of the spreadsheet data based on the starting longitude value field—and it worked.

Houser wanted graceful, arched lines that appeared to leap off the map into the air and rocket down to their destination. The XY To Line tool options for line type have fun names like rhumb line, geodesic, great circle, and normal section. After reading their definitions, the names seemed less whimsical but were still interesting. Except for the rhumb line type, which produced straight lines, the other line type options produced similar results.

The geodesic line type, the default choice, is the most accurate for representing the shortest distance between two points on the earth's surface, and the lines are visually appealing. As the objective was a map balancing a clean and appealing appearance with geographic accuracy, the geodesic line type was the winner.

The *ArcGIS Blog* post described how to center the data by setting the prime meridian of the map projection to match the local longitude. If the default coordinate system of World Geodetic System 1984 (GCS WGS84) with a custom central meridian was used, the flowlines seemed to crawl off the map. Instead of lines flowing from

Data spatial reference	Map spatial reference	Data centers correctly?
GCS WGS84 or GCS WGS84 with custom central meridian	Clear	No
GCS WGS84 or GCS WGS84 with custom central meridian	GCSWGS84	No
GCS WGS84 or GCS WGS84 with custom central meridian	Sphere Winkel Tripel NGS	No
GCS WGS84 or GCS WGS84 with custom central meridian	GCS WGS84 with custom central meridian	No
GCS WGS84 with custom central meridian	Sphere Winkel Tripel NGS with custom central meridian	No
GCSWGS84	Sphere Winkel Tripel NGS with custom central meridian	Yes

Table 1: Test results for data and map spatial reference combinations

The map showing just the cities of origin for all conference attendee data

The map of attendees from outside the United States showing the cities of origin. The thickness of the flowlines is based on the number of attendees from that city.

the map edge inward to Kansas at the center, the data resembled a spider crouched on one side of the map with its legs broken off on the other side.

To make radial flow data draw with the destination at the center of the map, the map's spatial reference needs to be set to a projected coordinate system with a custom central meridian.

Now for a moment of geospatial gratitude for the utility of the ArcGIS Geoprocessing Results window, since most people don't take copious notes on every step and setting during geoprocessing operations, Houser used the log saved in the map project, along with her notes, to determine which tool settings generated optimal radial datasets.

Houser experimented with spatial references for the data and map, shown in Table 1. The only combination that correctly centered the data in ArcGIS Desktop or ArcGIS Online was the data in GCS WGS84, with the map in a projected coordinate system with a custom central meridian.

The file was too large to upload to ArcGIS Online, so Houser divided the data into attendees within the United States and attendees from outside the United States. This worked conceptually and geographically and provided more map viewing options.

Working with her colleague, Houser chose a contrasting basemap and data symbolization combination that highlighted attendee data at all scales. Mapping line thickness by number of attendees was somewhat effective at a global scale and improved with each successive zoom. This worked reasonably well with the US data alone (at national or larger scale) and worked better when showing attendees from outside the United States (at any scale). To highlight the attendees' places of origin, Houser created a point shapefile of cities. She symbolized them in a way that differentiated them from cities shown on the basemap.

Houser spent a solid four to five hours building this map. This was a relatively small map project that used a tiny dataset, but a new project has already arisen that could use these techniques to illustrate immigration stories.

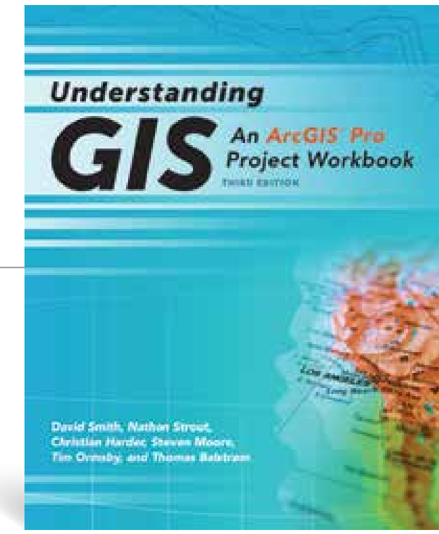
When applying these methods to similar data, keep in mind that generating a simple map is often a complex process that involves formatting data, troubleshooting, streamlining methods, and clarifying messages. This process takes time, skill, and persistence. It can take hours to prepare even a small dataset so it can be turned into dots or lines on a map. However, it's usually worth it—especially if someone thanks you or publicly recognizes the hard work and expertise that is essential for creating that simple map.

For more information, contact Rhonda Houser, GIS and mapping specialist at the University of Kansas Libraries, at rhouser@ku.edu or 785-864-1238.

About the Author

Rhonda Houser has worked in GIS for local and state government and higher education over the last 17 years and still loves it. She thrives (or survives) on the ever-changing nature of the field, its problem solving (both big and small), and the variety of skills it requires. Houser enjoys working with tea-stained maps that have stories to tell and finds the landscape represented by geospatial data—whether satellite imagery or geology data—to be beautiful. She holds a bachelor's degree in environmental studies from the University of Kansas and a master's degree in environmental science from Virginia Commonwealth University. In 2014, she obtained certification as a Geographic Information Systems Professional (GISP).

Teaching ArcGIS Pro Using a Project-Centric Approach



Understanding GIS: An ArcGIS Pro Project Workbook, Third Edition, is a textbook that introduces college-level or graduate students in GIS-related disciplines to the speed, efficiency, and 2D/3D capabilities of ArcGIS Pro by working through a single project. It can also be used by GIS professionals who are transitioning from ArcGIS Desktop or who want to expand their proficiency and understanding of ArcGIS Pro, as well as professionals in other fields who want cross-training in GIS.

Readers work through nine lessons and 35 exercises in sequence as they use ArcGIS Pro to find the best location for a new park along the Los Angeles River in Southern California. Each exercise offers step-by-step instructions and graphics that confirm exercise results.

In addition to helping readers become proficient with ArcGIS Pro, the book has the larger goal of teaching a geographic approach to problem solving. Conceptual information is supplied as needed for each exercise in the body of the text, in callout boxes, or in sidebars.

Readers will explore the use of the advanced 2D and 3D visualization and analytical capabilities of ArcGIS Pro. In addition, they will work with Esri ArcGIS Online and Esri Story Maps apps.

By the end of the last exercise, readers will have completed all the important phases of a GIS analysis project including planning, building a data model, and performing spatial analysis. They will also incorporate the results of their analysis in an Esri Story Map Journal app that will present the best locations for a Los Angeles River park.

All project data needed to complete the exercises is downloadable from the book's resource web page. This is real data, and it includes United States Census data and data provided by the City of Los Angeles. The book provides access to ArcGIS Desktop software, which includes ArcGIS Pro.

The book's authors are David Smith, spatial instruction manager for the Center for Spatial Studies; Nathan Strout, director of spatial technology for the Center for Spatial Studies; and Steven Moore, director of the Center for Spatial Studies—all staff members at the University of Redlands in California. Additional authors include Thomas Balstrøm, associate professor of geoinformatics at the Department of Geosciences and Natural Resources Management, University of Copenhagen, Denmark; Christian Harder, a technology writer and information designer at Esri; and Tim Ormsby, a technical writer at Esri.

Esri Press, 2017, 362 pp., ISBN: 9781589484832, (print) or ISBN: 9781589484955 (e-book).

Cliff swallows nexting on the Moreno Valley College campus. Photo used courtesy of Daniel Pierce.

Research-Based Learning Is Enhanced by ArcGIS

By Dr. Joanna Werner-Fraczek

Joanna Werner-Fraczek and Diana Marsh, associate professors at a community college located in Moreno Valley, California, have developed a multidisciplinary, multiyear research-based learning project that studies the cliff swallows that migrate to the area each year. Students participating in the project use ArcGIS to record and analyze the data they obtain.

The Flying with the Swallows (FWS) project, offers college students an opportunity to conduct scientific research while taking science, technology, engineering, and mathematics (STEM) courses.

Every year, cliff swallows (*Petrochelidon pyrrhonota*) migrate from Central or South America to Moreno Valley College (MVC) in Southern California, which is part of the Riverside Community College District. These swallows build nests around campus, use the nearby lake as a water source, and gather mud for their nests from the surrounding hills.

All swallows are protected under the Migratory Bird Treaty Act of 1918. During swallow nesting season, declared by the California Department of Fish and Wildlife to extend from February 15 to September 1, nests are protected as well.

In 2015, the FWS project was awarded a grant by the National Science Foundation (NSF). This was the first NSF grant given to MVC in natural sciences. The program was also selected by the Community College Undergraduate Research Initiative (CCURI) as one of the 26 community colleges nationwide to develop and implement research-based learning.

Research experiences are one of the most effective paths for attracting students and retaining them in science and engineering programs and for preparing them for careers in these fields, according to a consensus studies report, *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities,* edited by James Gentile, Kerry Brenner, and Amy Stephes, that was published by the National Academies Press in 2017.

Currently, FWS is integrating research-based curricula and activities into biology and chemistry courses. The project builds scientific engagement and research by broadening student participation in activities that are related to real-life applicable subjects of study. Students study various aspects of swallow life in a suburban area.

Biology students conduct the MVC ecosystem survey and investigate the swallows' diet. Chemistry students focus on developing methods for measuring the water and soil content of materials used by swallows to build their nests to monitor the pollutants present. Since cliff swallows are insectivores that feed on insects flying in swarms, these studies also emphasize that swallows are a keystone species for insect population regulation.

The intellectual merit of the FWS project has been significantly enhanced by students' access to ArcGIS Online. The project makes use of the ArcGIS Online subscription that was donated to MVC by Esri. ArcGIS Online allows students to create multilayer maps that tell the story of *where* and conduct analyses of likely factors, such as rainfall or temperatures, to address *why* questions.

Through MVC's relationship with Esri, 24 biology students; biology, geography and computer science faculty members; and the MVC STEM coordinator have been trained by Esri employees to develop such maps. With Esri's assistance, students are creating editable maps and collecting pertinent data in the field with smartphones in a crowdsourcing environment.

Adopt a Window and Who Lives Here? are ongoing initiatives for the ecosystem survey aspect of the project. Each student taking a biology course is assigned a window on the campus where nests are present. Their observations are recorded on the *Swallow Nest Observations—MVC* map hosted on ArcGIS Online. Samples of feathers, droppings, fallen nests, and other materials, are also collected from each assigned area for future analysis.

Who Lives Here? activities involve camera trapping around the campus and recording data on the *Fauna MVC* ArcGIS Online map. The best images of animals are collected and presented on the college website.

Recently the third tracking project, Six Leg Flyers, has been started. This project monitors insect populations on the campus, using insect traps. The samples collected are identified by using the iNaturalist app or the insectidentification.org or bugguide.net websites and confirmed by DNA barcoding, a modern molecular technique that uses a short genetic sequence from a standard part of the genome to identify species. All observations are recorded on the *Insects MVC* ArcGIS Online map.

This research led to the establishment of a new collaboration with Citrus College in the Pasadena area. The colleges collect and compare insect populations in two

Students collecting insects at the Moreno Valley College campus. Photo used courtesy of Daniel Pierce

Nesting sites of cliff swallows on the Moreno Valley College campus for 2016

Moreno Valley College students at the national poster conference (from left to right, Juana Pelaez Sanchez, Carolina Sanchez, Rebecca Bednorz, Dr. Joanna Werner-Fraczek, James Corbitt, Josue Franco, and Luis Cuevas). Photo courtesy of the Riverside Community College District

Southern California locations.

In May and June 2017, studies made of the stomach contents of nestlings that died after falling out of nests indicate that the majority of the insects consumed were termites, flies, and mosquitoes. With the maps that support the consistency of these findings, community members will be able to make an informed decision as to whether, despite dirtying windows, swallows are beneficial in helping diminish pest insect populations.

(The author and Marsh, who created the FWS project, want to erect alternative structures at MVC for swallow nests to move the birds away from the buildings. Funds must be obtained for building structures, so they are looking for potential funding sources.)

As more data is collected, other research opportunities will arise such as exploring the diversity of fauna over time, using swallows as indicator organisms for pollutants, studying the biomagnifications of pollutants throughout the swallows' food web, and any health hazards these birds may pose to humans when coexisting in the community.

Results of the FWS research are disseminated on national, state, and local levels. Students travel to state and national conferences and publish their research papers. The Annual Swallow Day has been held at MVC for the last three years. At this event, students present their research in poster sessions or individual oral presentations. External experts in the field are invited to deliver a science seminar. The surrounding community is also invited to the conference.

At the 2017 Swallow Day, Spanish students presented Latin music that celebrated swallows. Plans for the 2018 Swallow Day will include anthropology students emphasizing the presence of swallows in Native American culture. The Adopt a Window initiative will be expanded to the local community, creating a citizen science project that would enlist Moreno Valley citizens to monitor the city's cliff swallow populations.

There is also a desire to join with a sister college at a location where cliff swallows migrate to in the winter months. Although the literature is vague on this topic, cliff swallows from Southern California most likely migrate to Argentina or Uruguay. Starting in spring 2018, the Riverside Community College District is opening a new study abroad site in Buenos Aires, Argentina. The author sees this as an opportunity to establish a sister college relationship in Argentina. Since tracking devices will be essential to this project, she is searching for funding opportunities.

Linking ArcGIS with STEM-related studies provides students with examples of how what they learn is interconnected and integrated. It is essential to indicate that community college students often come from low-income families and underrepresented minorities and might have no other opportunity to be exposed to the world-class GIS software.

Thanks to the use of ArcGIS, the FWS transforms undergraduate science courses by enriching research areas of interest to the community at large and providing clear practical applications. ArcGIS creates a platform for professional and personal growth to the community college students and faculty.

Additional study brings up more questions about the swallows, and this is what makes the author's job very exciting. As Aristotle said, "What we have to learn to do, we learn by doing."

Esri has provided the tool to do that.

For more information on FWS, contact Werner-Fraczek at joanna.werner-fraczek@mvc.edu.

Acknowledgments

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About the Author

Joanna Werner-Fraczek is an associate professor of biology at Moreno Valley College, California, who implements research-based learning objectives into her teaching. She received her doctorate in genetics and molecular biology from the University of Wisconsin, Madison, and her master's degrees from the University of Gdansk in Poland and the University of Wisconsin in Madison.

Who is watching who? Bobcat overlooking the valley of Moreno Valley College. Photo courtesy of the Riverside Community College District

Presence of animals in the surroundings of Moreno Valley College as revealed by camera trapping in fall 2015

Learning That's Out of This World

Students Explore Lunar Ice Mining with GIS

By Karen Abruzzo, Delina Levine, and Pragati Muthukumar, Commack High School

The ingredients for a great science adventure were all there in the fall of 2016 for three high school sophomores from Commack High School in Long Island, New York. Curiosity and desire—combined with support from a NASA organization, dedicated mentors, and their school district—along with access to mapping and analytics in the ArcGIS platform helped Karen Abruzzo, Delina Levine, and Pragati Muthukumar begin their space research journey.

Richard Kurtz, their teacher, introduced them to ExMASS (Exploration of the Moon and Asteroids by Secondary Students). This contest, sponsored by the Lunar and Planetary Institute (LPI), allowed the students to cultivate and combine their interests in GIS and astronomy, especially as related to the moon and asteroids. All three students have had a lifelong passion for space, so they immediately signed up to begin a project.

In this rigorous competition, student teams from 10 high schools from around the United States develop research projects that involve the moon and asteroids. The competition begins with six weeks of preliminary work related to basic lunar and asteroid science, followed by student presentations about initial findings to Andrew Shaner, the ExMASS organizer.

ExMASS arranged for the teams to be assisted by mentors, typically from research institutes. The teams spend six months working on group-developed and group-driven research projects. At the end of this period, each team creates a research poster that is evaluated by experts in the field.

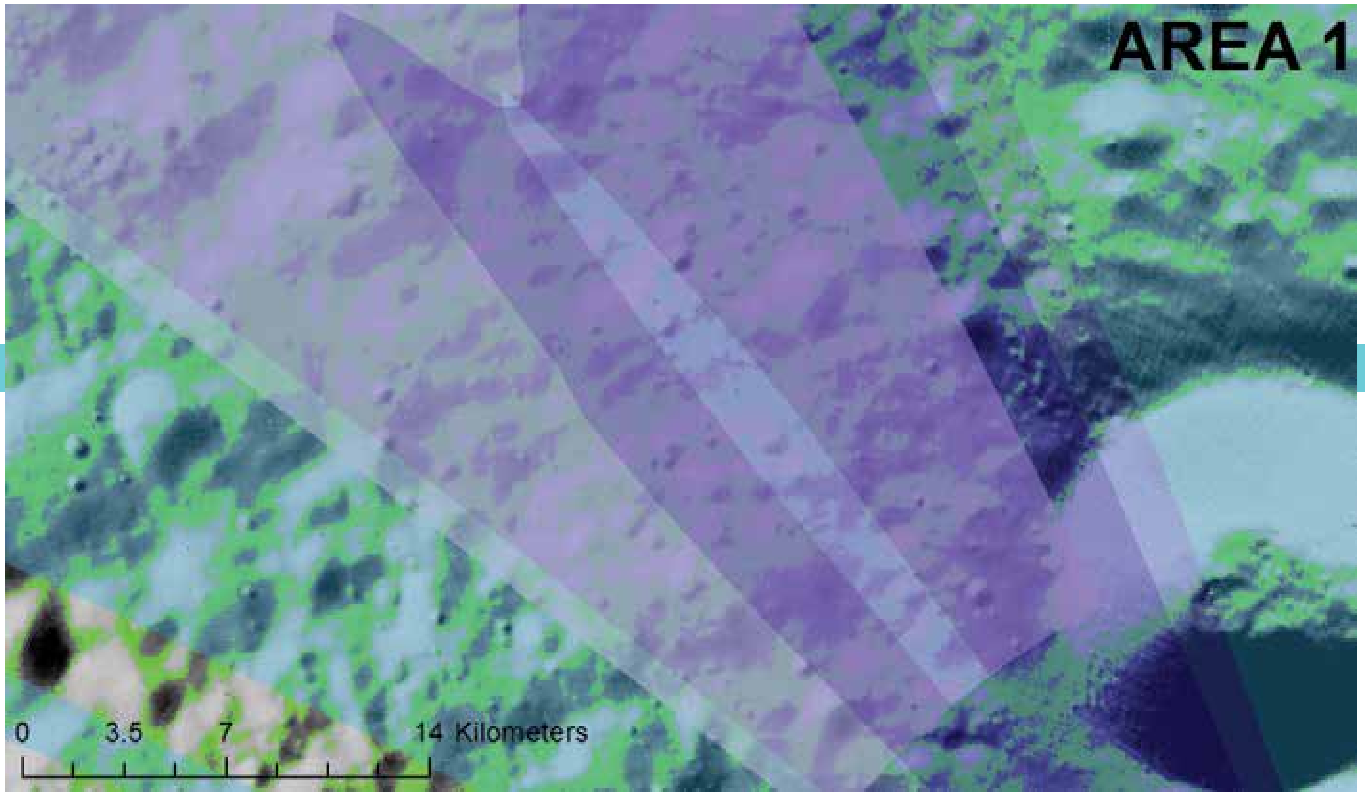
The four teams with the highest-scoring posters were given the opportunity to present to expert judges via video conference. The team with the best presentation was awarded the opportunity to attend a conference at NASA Ames Research Center in California.

The Commack High School research team developed a project that applied the use of ArcGIS to map possible locations of lunar ice mining using topographic, elemental, and economic data with assistance from their dedicated mentors, Dr. Tabb C. Prissel of the Department of Earth and Planetary Sciences at Rutgers University and Dr. Jennifer Whitten from the Center for Earth and Planetary Studies at the Smithsonian National Air and Space Museum.

The students used GIS to layer this data so that the finished map would show the lunar topography, slope values, and elemental abundance of both hydrogen and oxygen in an area. They also considered economic feasibility, as they needed to ensure that lunar ice mining would be practical.

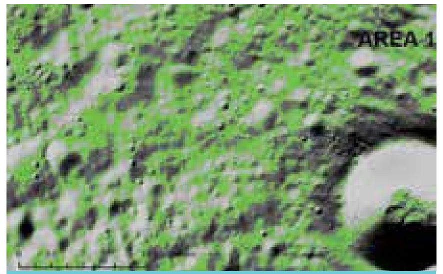
The students made two assumptions. The first assumption was that the areas where the highest concentrations of hydrogen and oxygen overlapped would be more likely to contain water ice. The second assumption was that areas with the lowest slope value and the highest abundance of each element would be the most economically feasible to mine, making those areas attractive potential mining locations.

Members of the winning Commack High School research team shown in front of the Vertical Motion Simulator during their tour of NASA Ames Research Center (from left to right: Karen Abruzzo, Pragati Muthukumar, and Delina Levine).

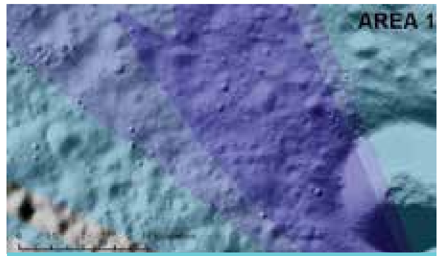


This is a map of Area 1 at the lunar South Pole produced using ArcGIS showing hydrogen abundance, oxygen abundance, hillshade, and slope layers.

Hillshade



Slope



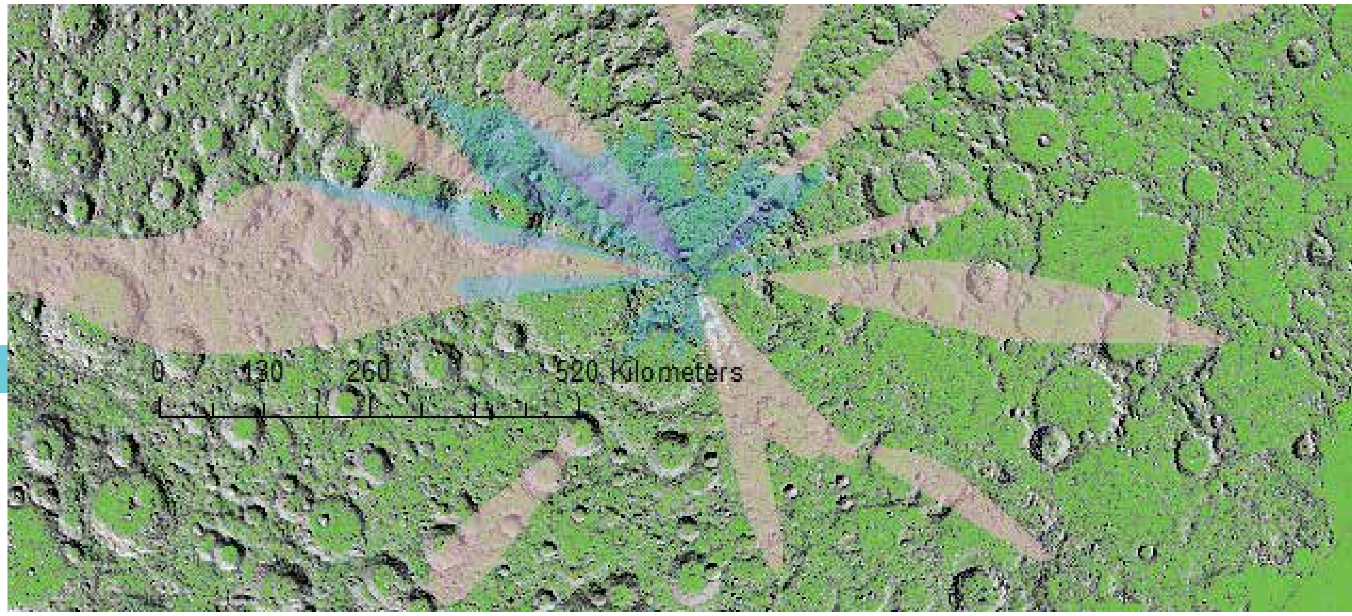
Hydrogen

Oxygen

The students worked with public domain data: topography data from the Lunar Orbiter Laser Altimeter (LOLA) and elemental data from the *Lunar Prospector* (LP). The students began with a basemap of LOLA topography data to which they added a hillshade layer that filled in gaps in the original LOLA data and provided a grayscale 3D representation of the surface that improved the lunar surface image resolution. The students then added a slope layer and highlighted areas with a slope of less than 6 degrees. These areas would be level enough for a spacecraft to land on and remain stable. The next step was to import the LP coordinate elemental data and highlight areas of highest oxygen and hydrogen abundance to locate potential mining sites.

The students researched rockets built by the United States, including those of upcoming SpaceX projects, to evaluate the cost of fuel, payload capacity, and the cost of the entire mission. They compared various rockets to determine which would be the best for a lunar mining mission and determined a spacecraft with low fuel cost, high payload, and low cost per mission would be the best candidate for a lunar mining mission.

Although this type of research may seem a bit farfetched, the students noted that the implications are quite promising for the future. If water ice were to be mined and then decomposed into liquid oxygen and liquid hydrogen, two important components of rocket fuel could be obtained. Creating a launch point on the moon is under serious consideration in the space industry, so having a fuel source on the moon would lower both fuel and energy costs. Also, scientists are



ArcGIS image of the lunar North Pole, with all data layers shown. High levels of oxygen (pink and white) and hydrogen (blue and purple) can be seen in various areas at the North Pole.

seriously considering a potential lunar base, and water ice could be used as a coolant or converted into breathable oxygen.

The team's project was awarded first place in recognition of the authors' research efforts and results. To reward this achievement, the students attended the NASA Exploration Science Forum held in July 2017 with Dr. Alison Offerman-Celentano, Commack's director of science. The forum was hosted by the Solar System Exploration Research Virtual Institute (SSERVI).

As the only high school students at the forum, they were excited for the opportunity to present their work to professionals in the field. During the forum, they were able to listen to engaging presentations and learn about the latest lunar and planetary research.

From Left to right: Dr. Alison Offerman-Celentano, Commack's director of science; Delina Levine; Karen Abruzzo; Pragati Muthukumar; and Richard Kurtz, the team's mentor and their Commack High School teacher

The students found a panel discussing water on the moon to be one of the most interesting presentations. In their experience, the idea of researching water on the moon was usually regarded as farfetched. However, this panel confirmed that their research was not only relevant but a hot topic in the lunar and planetary field.

They also participated in a student poster session in which they shared their research with other scientists. Through engaging in conversations with fellow researchers making connections, they glimpsed what their futures might be like as science researchers.

Although the three students had fun doing the project, it was not without its challenges. Through working tutorials on the Esri website and YouTube, they learned on their own how to use ArcGIS. Learning a complex program under a time constraint was definitely a test of their abilities.

The limited time was also a challenge, as these high school researchers frequently found that there was simply too much they wanted to do and not enough time to get it done. However, they found the entire experience to be invaluable and certainly unforgettable.

The project gave them the opportunity to experience research that was impactful outside of the classroom. They spent the vast majority of their spare time working on

From left to right: Dr. Alison Offerman-Celentano, Delina Levine, retired astronaut Harrison "Jack" Schmitt, Pragati Muthukumar, and Karen Abruzzo shown in front of their poster

this research project. Even after numerous failures and setbacks, they were motivated and eager to see where the project would take them. This is a skill that will definitely benefit them in the future. These high school students realize that the opportunity to do real-world research, get advice from experts, and use the ArcGIS platform was unique. They can honestly say that they had a fantastic time researching lunar ice mining, and they have learned that you never know where your research will take you.

For more information on using GIS for STEM, contact Kurtz at RKurtz@commack.k12.ny.us or 631-786-7426.

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About the Authors

Karen Abruzzo, Delina Levine, and Pragati Muthukumar are now eleventh-grade students at Commack High School. They began conducting research in ninth grade and have loved it ever since. Abruzzo is interested in electrical engineering and computer science and wants to work in the field of astronomy as an engineer. She is a member of the Astronomical Society of Long Island and enjoys reading whenever she has time. Levine enjoys physics and hopes to be an astrophysicist in the future. In her free time, she loves studying music and is an excellent piano player. Muthukumar finds chemistry and biology extremely interesting in addition to space. She is also a music lover, and she sings and plays viola and piano. All three students are extremely grateful to have had this opportunity and are excited to see what the future holds.

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