

ArcUser

The Magazine for Esri Software Users

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ArcUser

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Mapping the Past— and the Future

If the spring 2026 issue of *ArcUser* seems nostalgic, that's no coincidence—it's the publication's final issue. Monica Pratt founded *ArcUser* in 1998 to keep Esri's user base informed about product updates, best practices, and the exemplary work of the GIS community. Since then, that community has evolved, and we're evolving with it.

The media landscape is radically different from what it was at the publication's inception nearly 30 years ago. Because of this, we want to ensure that the information you need to do your best work lives alongside the most inspiring and compelling GIS stories from across the globe. Therefore, Esri's *ArcNews* publication will take on an expanded role, incorporating aspects of *ArcUser* to maintain a focus on GIS developers, managers, and experienced professionals. Subscribers to *ArcUser* will soon begin receiving *ArcNews*, which will be reimagined as part of the transition to a single publication.

In the meantime, the final issue of *ArcUser* is the perfect opportunity to revisit old hits. "GNSS Accuracy Unlocked" and "Make Maps People Want to Look At" are new versions of two of the most popular articles published in previous issues. In them, familiar concepts get necessary updates for 2026.

It's also a good time to examine how geography can illuminate our past. "A Cartographer's Quest to Map US History" covers the importance of GIS to Ken Burns's *The American Revolution*. "GIS Protects the Past from Wildfire," shows how geographic data safeguards archaeological sites. The issue's cover story, "Maps Are Memory," details efforts to digitally preserve the vanishing architecture of West Africa.

But mapping isn't just about where we came from. It's about where we go next. In this issue, you'll find many stories about the transformative power of geospatial AI as well as how the ubiquity of these tools can change your work, as in "GIS Governance in the AI Era." "Keeping Utah Moving with a Solid Geospatial Foundation" provides a road map for geospatial excellence, while "What Does It Take to Build a Career in the Drone Industry?" offers cogent advice for taking on one of the most forward-looking applications for GIS expertise.

The issue's final story, "The First Responder Who Aided Alaskan Villages She's Never Visited," aligns the past and future. This profile of an Alaskan government employee, who helped residents return home after being displaced by a typhoon, exemplifies the power of GIS to help. Because that's what GIS is—the use of geographic data to make our lives better. Sometimes that means cleaning our streets, letting people know what's being built in their neighborhoods, or giving us a better understanding of ourselves. Sometimes it means bringing us home.

Thanks for reading, and see you in *ArcNews*.



Ben Van Voorhis
ArcUser Editor

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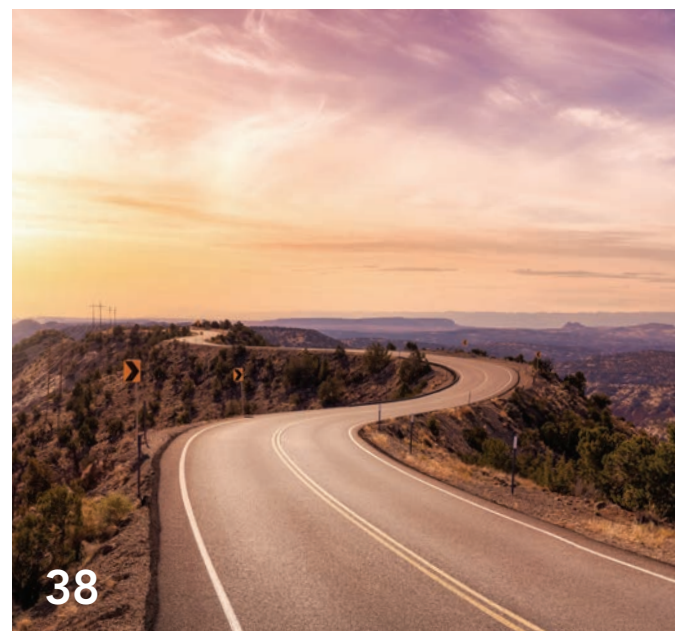
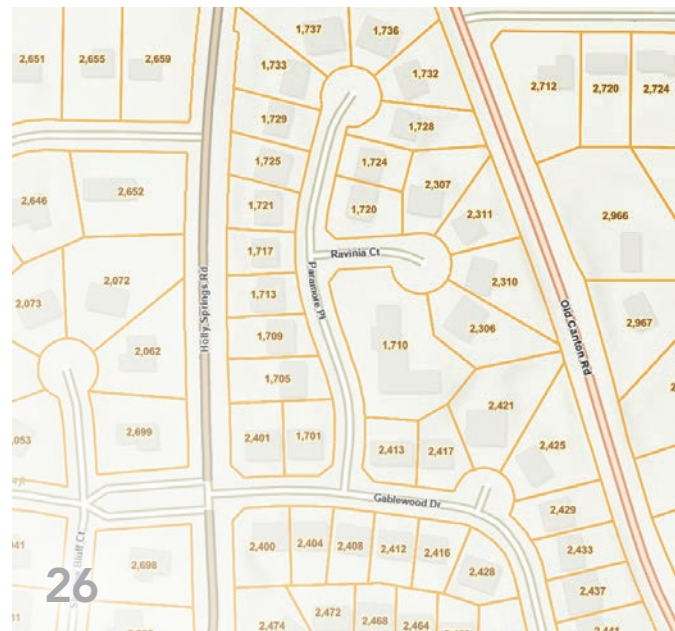
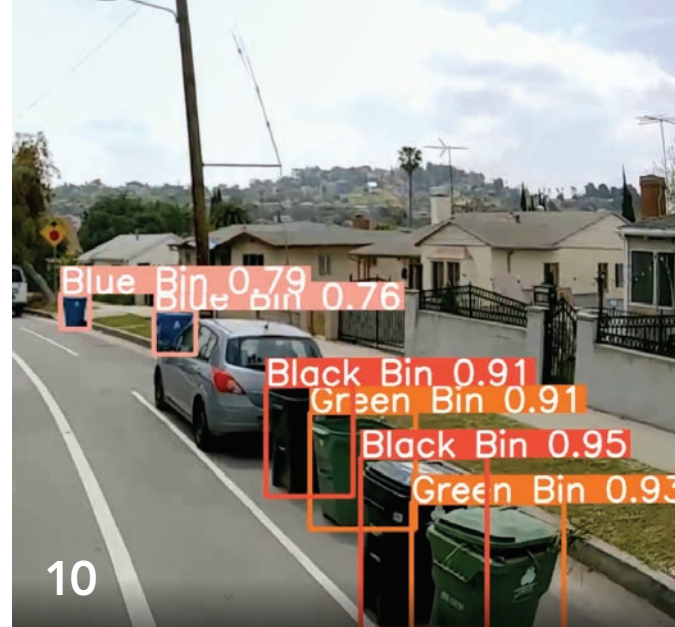
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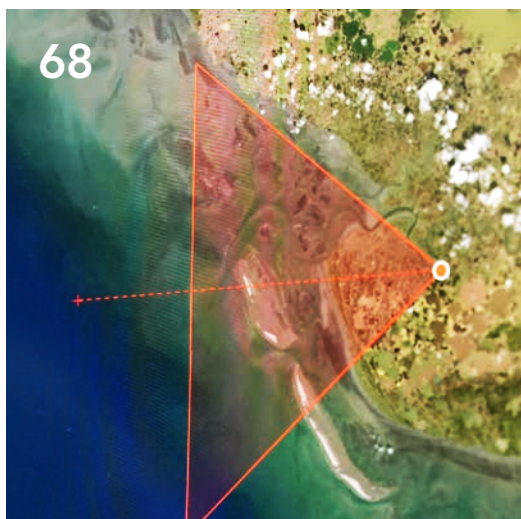
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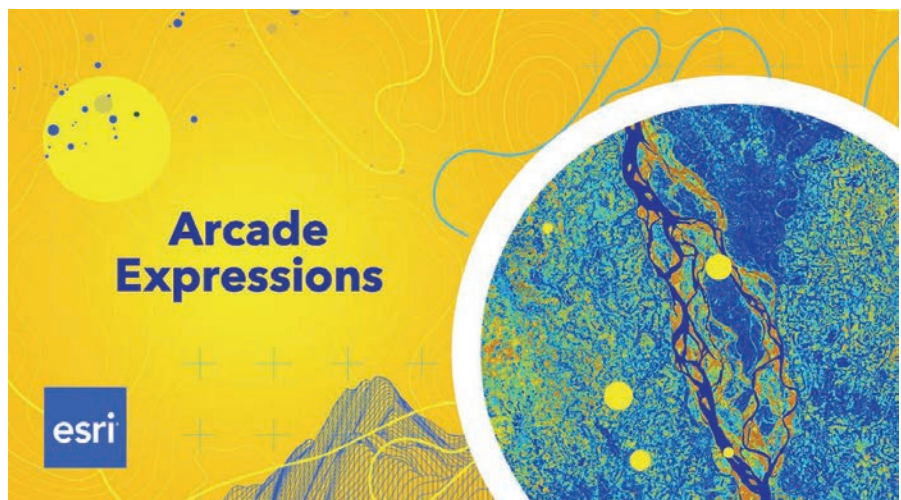
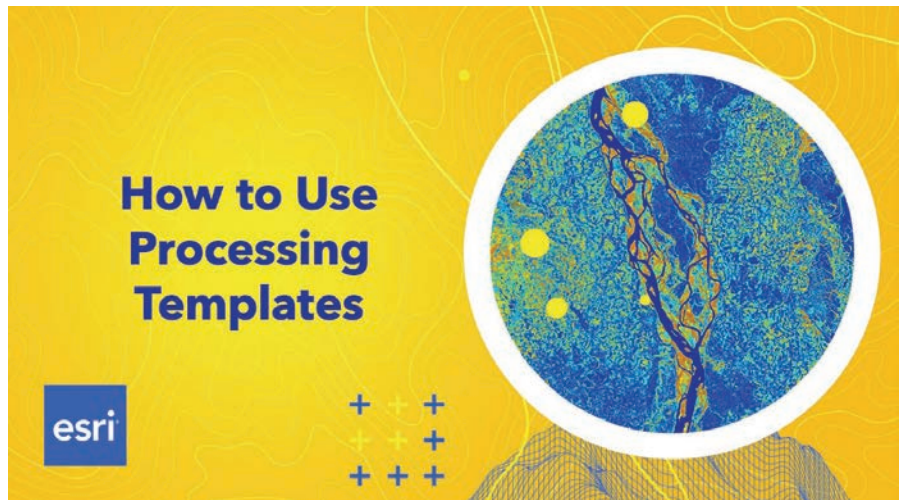
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Briefly Noted

→ ArcGIS Pro on the Go

When you only have a few minutes but need to refresh your memory on how to do things in ArcGIS Pro—like search for color schemes or add a layer to your legend—check out ArcGIS Pro Shorts. These videos are about a minute long and help users quickly learn tips, workflows, and best practices for ArcGIS Pro. Each short is made by a product expert and focuses on one skill. The videos demonstrate useful and sometimes lesser-known tools, introduce new features added to ArcGIS Pro, and help users who are moving from ArcMap.

To begin exploring, head to links.esri.com/ArcGISProShorts and click the Playlists tab.



→ Each ArcGIS Pro Shorts video is about a minute long and helps users quickly learn tips, workflows, and best practices.

→ ISO Certification Reinforces Esri’s Commitment to Data Security

Esri received a certification from the International Organization for Standardization (ISO) known as ISO/IEC 27001:2022. This certification provides a globally recognized framework for establishing, implementing, maintaining, and continually improving an information security management system. Esri’s certification demonstrates that its system preserves the confidentiality, integrity, and availability of the platforms, services, and applications used to process, transmit, and store customer assets—and that ArcGIS Online and ArcGIS Location Platform infrastructures have been evaluated and audited by a third party.

“As enterprises simultaneously navigate escalating cyber threats and complex data residency regulations, our certification provides critical assurance that we maintain the rigorous security standards required today,” said Michael Young, chief information security officer for products at Esri. “And especially on the heels of analyst firm Forrester’s *Predictions 2025* report that cybercrime costs would reach \$12 trillion, earning this certification reflects Esri’s proactive response to an increasingly complex global security environment.”

Learn more about Esri’s commitment to security, privacy, and transparency at the ArcGIS Trust Center at trust.arcgis.com/en/.

→ A New Real-Time Terrestrial Mapping Workflow with Pix4D

Esri and Pix4D—a Switzerland-based photogrammetry software company that specializes in mobile reality capture and site digitization—have launched a new terrestrial mapping workflow that allows field teams to capture and process asset data and manage it within ArcGIS.

Field teams use the PIX4Dcatch app with real-time kinematic (RTK) devices to scan trenches and infrastructure. The generated high-precision georeferenced records can now be published to Esri’s ArcGIS Online. Scans become 3D models and point clouds, viewable as a 3D layer. Existing data can also be visualized in augmented reality for instant as-designed versus as-built verification before closing trenches.

“We are focused on turning hidden infrastructure into functional data,” said Andrey Kleymenov, CEO of Pix4D. “By connecting PIX4Dcatch with a compatible RTK device to the Esri ecosystem, we are enabling a terrestrial-scanning workflow that allows teams to update a master geodatabase with professional accuracy.”

“We are happy to work with Pix4D to offer infrastructure-focused organizations a seamless, direct path from the field into a geodatabase,” added Thomas Fair, director of Esri Partner Network. “This new integration with ArcGIS will provide users with high-fidelity documentation of subsurface assets.”

You can download the PIX4Dcatch app and start publishing 3D data to ArcGIS Online today.

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Bring Out Your Bugs

By Christie Roland

If you have filled out a customer survey for Esri, thank you. These surveys are invaluable when it comes to improving ArcGIS software.

Every year, Esri product managers review countless responses to better understand how we are doing and where we can improve.

Often, we see candid reflections on what's working, like how ArcGIS is helping you and your teammates work faster or solve meaningful problems.

However, tools don't always work as expected. A tool you've relied on can misbehave without warning, slowing down a workflow and throwing off your momentum.

Those moments can be frustrating. But by the time feedback shows up in an end-of-year survey, Esri product managers have often missed the best window to act on it quickly.

If a tool or function within ArcGIS begins acting weird or glitchy, don't save it for a survey confessional. Let Esri Technical Support know about it now.

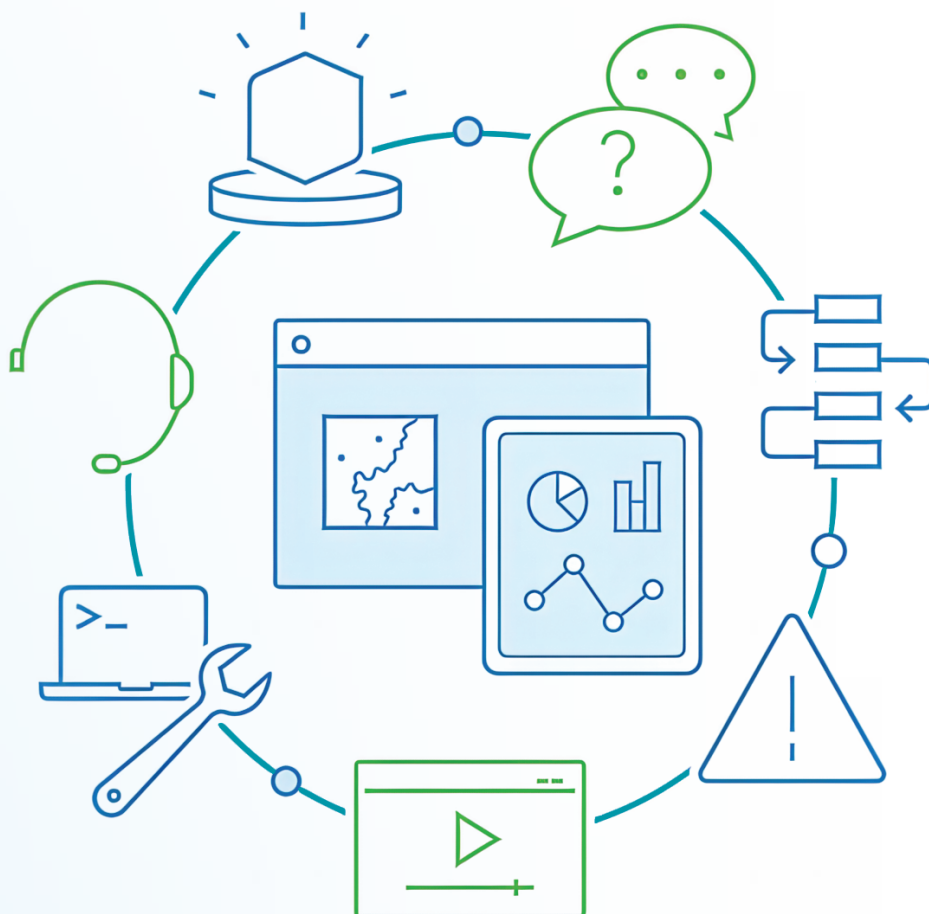
When issues are reported early, they can be validated, investigated, and sometimes even fixed or patched long before

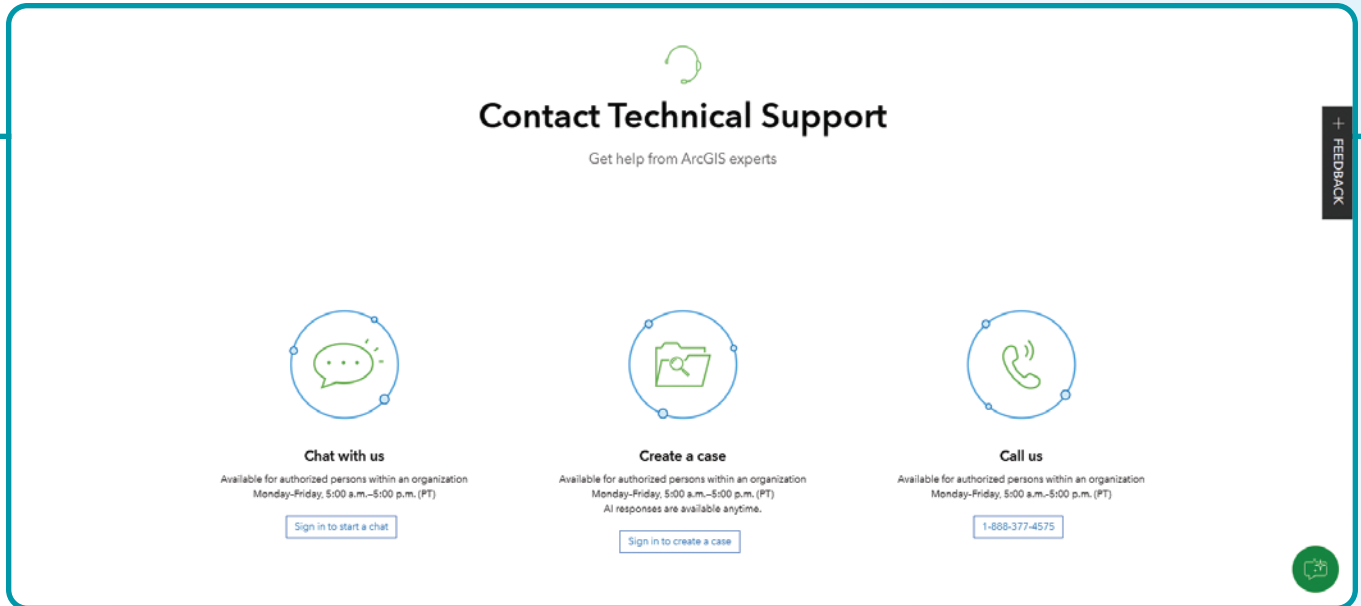
the next survey season. And believe it or not, one small moment of frustration can be the spark that shapes the road map for ArcGIS products.

What to Do

If you encounter a problem while working with ArcGIS, open a technical support case. Every time something looks wrong, odd, glitchy, slow, or just plain off—even if you're not sure it's a bug—Esri Technical Support should see it.

Think of support analysts as the relay team. You bring the initial issue and context. They validate the problem, collect the information that product staff need, and direct it to the right product team.





↑ Opening a technical support case keeps you in the loop and ensures Esri Technical Support has the full picture as things evolve.

This can save you hours of do-it-yourself troubleshooting. Rather than trying to be a geoprocessing whisperer who diagnoses issues from cryptic error messages, get a support analyst to troubleshoot. They may ask follow-up questions or request testing in your environment. That back-and-forth isn't a delay, it's how we isolate what's really going on and avoid the guesswork.

Opening a technical support case also leads to clearer, more actionable fixes. When issues are worked through together and a bug is validated, product engineering staff get real data in the form of reproducible steps, environment details, and customer impact. That's what drives change in the software.

Additionally, it creates visibility and accountability. In My Esri, your organization is attached to the case and any resultant bug report, so you stay informed and can add context as needed. This keeps you in the loop and ensures Esri Technical Support has the full picture as things evolve.

How to Report a Bug

To report a bug, visit support.esri.com/en-us/contact. First, use the Technical Support chatbot to see if there's already insight on your issue. If you don't find anything similar, reach out to Technical Support directly.

To submit a case, you will need to sign in to My Esri and be an authorized caller for your organization. To become an

authorized caller, either you need administrator permissions, or you'll need to contact your administrator through the Request Permissions form in My Esri.

If you prefer to submit a case by phone, call the number on the Technical Support page and let reception know you want to submit a bug report. After asking a few questions to better understand what product you are using and the severity of the problem, they will create the case for you.

To make your case move as quickly as possible (and for the fix to be as effective as possible), include the following details in your technical support case:

- Steps for staff to reproduce the problem
- Screenshots of the issue
- Sanitized sample data
- Expected versus actual behavior
- Product name and version, if applicable
- Operating system, if applicable
- Any patterns you've noticed (for example, only happens on Mondays, with large datasets)

Once your case is submitted, Esri Technical Support staff get to work. You may hear back with questions or testing requests as a support analyst works through the details and confirms what's happening.

Behind the Scenes

Once your case is in motion, a support analyst reproduces the issue. If

confirmed, a bug is logged and your organization is attached to the bug report, meaning you can track its status in My Esri and provide additional details as needed.

This process is transparent. It's structured. And it's how fixes make it into future releases and patches.

Your Reporting Helps Everyone

When an ArcGIS product doesn't behave the way you expect, we at Esri take it seriously and truly care about your experience. Those glitches, freezes, errors, or moments that feel a little off are opportunities to improve the platform. Reporting them through Esri Technical Support gives your feedback the best chance to be seen, acted on, and prioritized.

You get answers, we get visibility. Product engineers get actionable detail. This means ArcGIS—and your experience with it—improves.

About the Author

Christie Roland is the product marketing manager for ArcGIS Pro. Before coming to Esri, she studied heritage preservation and GIS in graduate school. In her spare time, Roland enjoys exploring the outdoors, hanging out with family, and trying new recipes in the kitchen.

AI Helps Clean Up LA

By Jim Baumann

All told, the city of Los Angeles takes up about 470 square miles, including thousands of miles of streets and sidewalks, and is home to a population of almost four million people. With that much land and that many people comes a lot of trash. Los Angeles residents and businesses produce about 96,500 tons of waste daily, requiring roughly 900 heavy-duty trash trucks to keep the city clean. Despite these efforts, discarded items pile up, posing health and safety risks to residents and visitors alike.

If this sounds like a problem ripe for a GIS-based solution, Los Angeles Sanitation & Environment (LASAN) would agree. Previously known as the Los Angeles Bureau of Sanitation, LASAN started using Esri technology in the early 1980s to create printed map books for trash collection routes. Supervisors also used it to map requests for special-collection drivers to pick up bulky items like old appliances and furniture.

But LASAN's GIS has come a long way since the '80s, and has recently taken a leap into the future. CleanStat, a 2016 initiative designed to map the cleanliness of LA streets, allowed LASAN to target its resources more effectively within the city. With AI tools that integrate with LASAN's ArcGIS Enterprise environment, CleanStat has undergone an upgrade, enabling LASAN to be even more precise and efficient in the way it keeps LA's streets clean.

Clean, Cleaner, Cleanest

"CleanStat was started almost 10 years ago as a directive from the mayor to evaluate the cleanliness of Los Angeles streets and alleys," said Oscar Figueroa, chief of GIS at LASAN. "It established the city's first measurable standards for the cleanliness of Los Angeles streets."

The assessment was done every three months by five teams that drove through the city to evaluate each street segment based on four criteria. There are about 42,500 designated segments throughout the city that are evaluated based on loose litter, household items, illegal dumping,

and weeds. Homeless encampment data is captured but does not factor into the cleanliness score.

The locations of blight are shown on ArcGIS Online web maps where each street segment is rated on a scale of 1 to 3, excluding homeless encampments. These scores are then tabulated to create a citywide cleanliness score. Over the years, LASAN has increased the number of field crews for cleanliness assessments, but the process still takes from six to eight weeks to complete.

Patrick Soriano, senior systems analyst at the Los Angeles Department of City Planning, noted that the Los Angeles mayor's office and the city council directed city departments to explore the use of AI tools to enhance services for residents, given the rapid growth of these technologies. This led to LASAN's development of CleanStat 3.0.

LA's Future Is Clean—and Automated

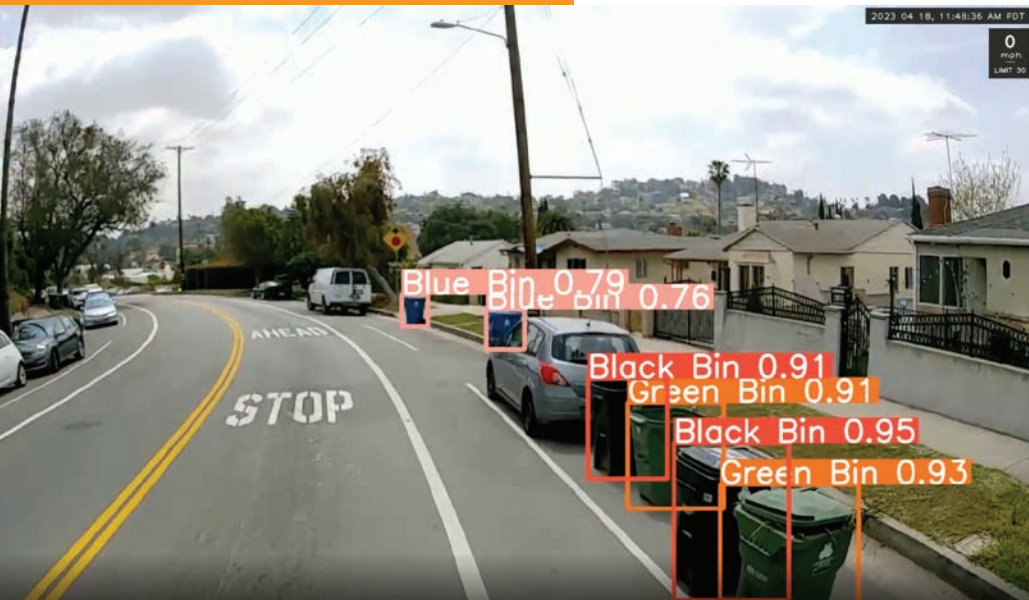
The idea is simple: The CleanStat 3.0 program automates data collection by using cameras on the city's trash collection vehicles. These cameras capture images that are then processed with a model that identifies items that need to be collected. The model, called You Only Look Once (YOLO), is based on deep learning and computer vision and used for real-time object detection and image segmentation.

A mesh Wi-Fi system in each vehicle yard automatically downloads each trash collection truck's camera footage to a dedicated

computer when the truck is within network range. This process enables weekly street cleanliness assessments and frees up field crews for other tasks.

"After the YOLO models analyze the images, the data is sent to a REST endpoint on [ArcGIS] GeoEvent Server," said Soriano. "The data is stored in our spatiotemporal big data store, then published as a feature service in our ArcGIS Enterprise portal environment. This allows

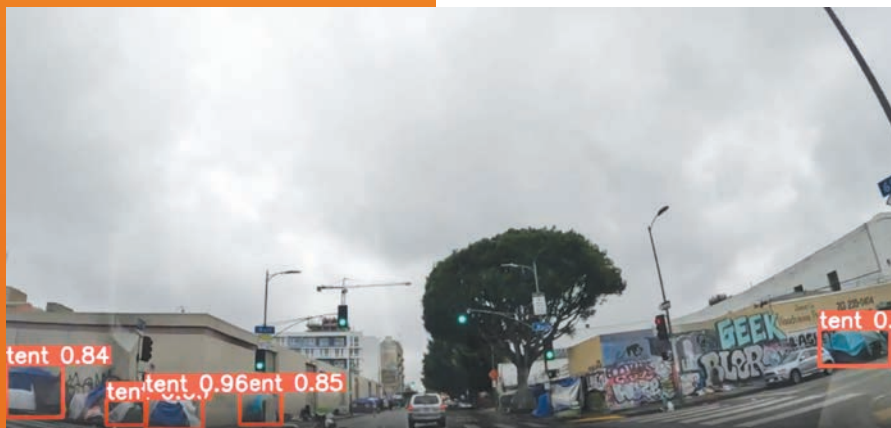




✦ The YOLO model correctly identifies LASAN's three colored bins: black for refuse, blue for recycling, and green for yard waste and organics.

✦ The YOLO model is able to identify tents of various shapes, sizes, and colors along the public right-of-way.

✦ YOLO can correctly identify objects that are outside of LASAN's interest, showing that this technology can be used for various departments.



us to create operational dashboards to provide updates on where we need to deploy resources."

The dashboards enable staff to show the locations of detected refuse and other items, such as black trash bins, construction cones, and discarded furniture. They also display the confidence level of the model's correct identification of the object. A Google Street View link verifies the object's location.

Allowing operational staff to view data on a dashboard also helps them identify refuse hot spots in the city. This includes areas that often experience illegal dumping or need regular graffiti removal. Staff can predict the type of waste services required for specific locations in the city and plan for their cleanup.

LASAN aims to use its data to help other city departments develop their own computer vision models. The data can be used to identify other things within the public right-of-way such as unpermitted construction, missing or vandalized street signs, or damaged city assets. This will help those departments provide greater efficiency for their own city services.

If LA's future looks cleaner, it might be because of the GIS and AI tools LASAN has developed to help it along.

About the Author

Jim Baumann is a longtime employee at Esri. He has written articles on GIS technology and the computer graphics industry for more than 35 years.



A CARTOGRAPHER'S QUEST TO MAP US HISTORY

By Brian Cooke and Cassandra Galindo

For more than four decades, documentarian Ken Burns has helped shape Americans' understanding of their history. His distinctive filmmaking style has brought stories ranging from the Civil War to the history of jazz to life for millions of viewers. But how does a storyteller so reliant on the photographic record tackle events that predate photography?

In developing his 12-hour miniseries *The American Revolution*, which aired in 2025, Burns and his team at Florentine Films turned to a different kind of historical document—maps. In depicting an era before cameras, maps provide a window into America in the late 1700s, showing locations in the context of conflict, change, and more.

For Esri chief cartographer Charlie Frye—a specialist in GIS engineering and information product design who has worked at Esri since 1994—helping Florentine Films with this effort was an extension of a passion project that mapped his ancestry and connected it to America's Revolutionary War.

A Personal Quest

Frye's journey began with a simple suggestion.

"My wife thought I needed a hobby because I was working too much," Frye said. "So, I started in on genealogy and I found out I had an ancestor who fought at the Battle of Breed's Hill." The battle, often called the Battle of Bunker Hill, took place near Boston, Massachusetts, in June 1775.

That ancestor was Isaac Frye, a second lieutenant who, as his descendant soon discovered, served for a longer continuous period

than any other officer in the Continental Army. This discovery sparked a quest that has spanned more than 20 years.

Frye, a geographer and information scientist, used GIS to organize his research, plotting his ancestor's movements and battles. He quickly ran into a fundamental problem—the world of 1775 was quite different from the world of today.

To fully understand Isaac's story, Frye had to envision Isaac's world. Eventually, this project grew into a massive undertaking—creating a comprehensive GIS repository for the entire American Revolution, including roads, towns, forts, and tribal territories from hundreds of historical sources. It was Frye's deep, personal, and technical expertise that eventually led him to work with Florentine Films.

Mapping a Revolution

When Burns and his team were in the production stage of *The American Revolution*, they faced the challenge of illustrating a complex, eight-year war without photographs. While there are some historical paintings and sketches—along with diaries, letters, journals, and military records—these resources often lack the geographic detail needed to show troop movements or understand the strategic landscape. Maps were the answer—but not just any maps. As Frye explained, historical maps present their own challenges for a modern audience.

"Eighteenth-century maps don't bring people into the picture," he explained. "They're generally very difficult to orient to because they're not the geography we're used to—it's not the mapping convention that we're used to."

For one thing, floods and storms have shifted the locations of waterways over the years. Coastal cities have reshaped shorelines. Many contemporary manmade features didn't yet exist. In fact, Frye said, the average person in the 18th century never even saw a map; maps were mainly available only to wealthy and powerful individuals.

For *The American Revolution*, Florentine Films wanted to create maps that felt authentic to the period but could also be immediately understandable to a 21st-century television audience. This required collaboration. Frye provided the geographic backbone—a massive geodatabase with thousands of curated features, each

↓ Florentine Films' 2025 documentary *The American Revolution* features maps created by Esri chief cartographer Charlie Frye.



with a citation tracing it back to a specific historical document, including nearly 150 maps.

Frye passed this data along to design director and visual effects expert Molly Schwartz, who designed the visual style, and animator Brian Lee, who brought the maps to life. The team produced more than 90 maps for the series, many going through 10–20 drafts.

This process was managed by Florentine Films coproducer Mike Welt, who made sure that each map aligned with the film’s narrative. Welt and Schwartz scrutinized every detail, from town name spellings to wilderness trail locations.

“There was a crossover point where the maps became part of the storytelling,” Welt said. “We worked hard to show an accurate 1775 continent beyond the 13 colonies—and when people who have otherwise been erased in most of our histories appear on the map, they become present and they matter. It reframes the story for viewers.”

Frye also went through every map at least three times to make sure every place was correct. This process allowed the filmmakers to depict everything from the grand sweep of the Great Wagon Road (which ran from Pennsylvania to southern

colonies) to the brutal details of the Battle of Breed’s Hill with unprecedented accuracy.

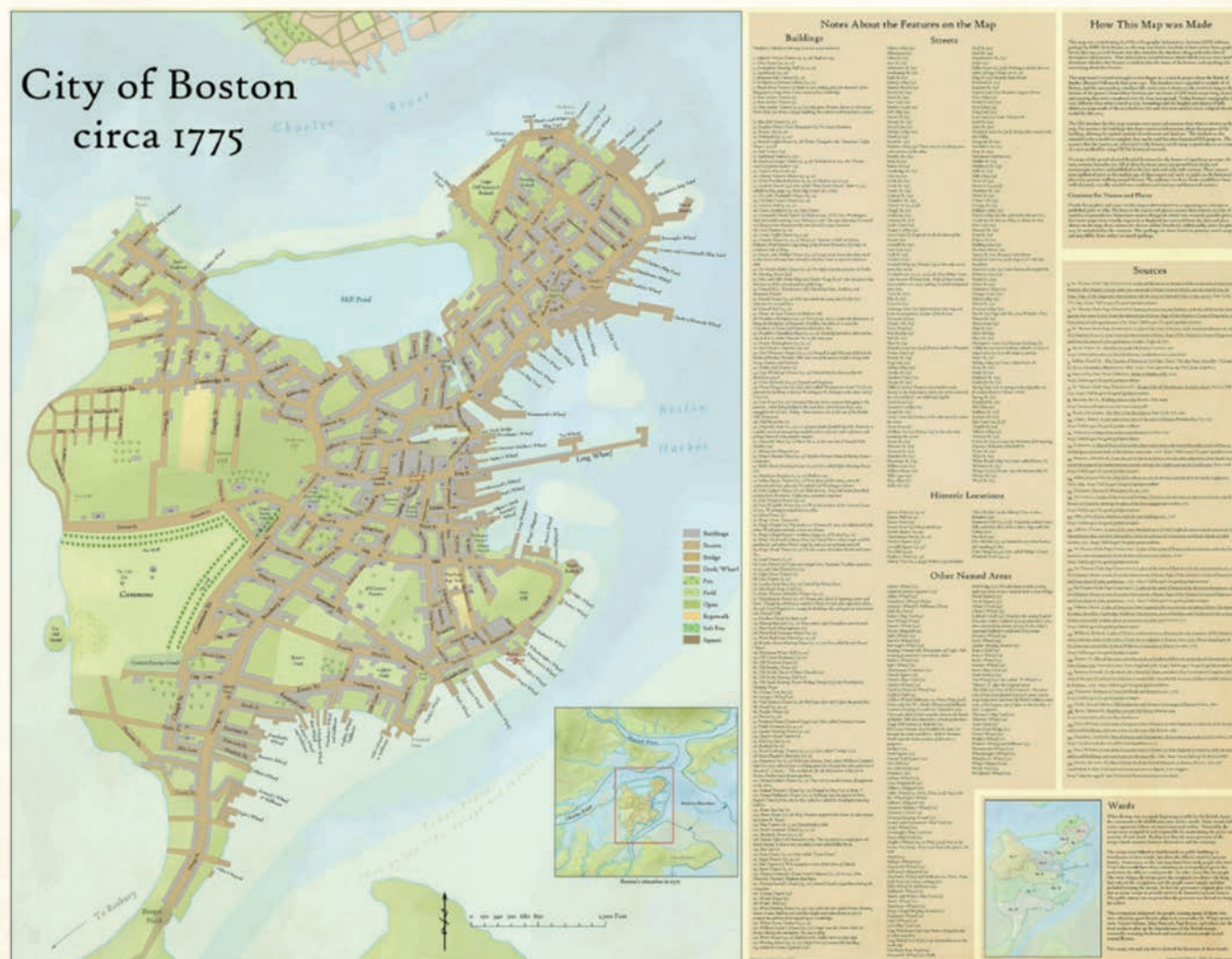
Uncovering Hidden Histories

The project did more than just illustrate known events—it revealed forgotten histories and challenged long-held assumptions. One of the most significant outcomes was a set of maps depicting the locations of North America’s Indigenous tribes in 1607 (just before European colonization began) and in 1775, and another at the outset of the Revolutionary War.

“This was a map showing something I’d never seen before,” Frye said, explaining that he compiled it using the Smithsonian Institution’s *Handbook of North American Indians*.

“The purpose was to show that the vast majority of North America was populated by more than five million people” prior to European settlement, Frye said, a contradiction of the deep-seated myth that Europeans colonized an empty or sparsely populated continent. “I don’t know if today’s school textbooks show this, but mine and my generation’s textbooks did not.”

↓ One of the several maps Frye created for *The American Revolution*.





↑ Many of the maps that Frye created for the documentary show troop locations and movements for key events such as the Battle of Long Island in 1776.

By locating these people on maps, the project provides a powerful visual counternarrative. Specifically, by depicting North America before and after more than a century of wars, disease, and colonial policy, the maps show the devastating impact on Indigenous populations.

Sharing a Vision

Frye's work on the documentary is just part of his mapping journey. He was recently awarded a Heller Fellowship at the University of Colorado Colorado Springs. The fellowship, cosponsored by the university's department of geography and environmental studies, has given Frye a platform to share his methods and expand his vision.

Frye also plans to transform his personal repository of maps into a collaborative resource that other historians, authors, and students can use and contribute to.

"I started with ArcMap side by side with ArcCatalog to provide previews of the scanned archival maps," he said. "During the COVID-19 shutdown, I learned that the ArcGIS for Personal Use accounts included access to ArcGIS Pro, so I moved my work to ArcGIS Pro. I share everything via ArcGIS Online."

Frye's other plans include developing workshops to teach others how to build a historical GIS from the ground up.

"I'm trying to figure out how I describe that process so that somebody else can do it a lot faster, or at least without so many do-overs," he said.

From a hobby that grew out of a desire to connect with his own past, Frye's work has blossomed into a contribution to America's collective memory. His maps provide countless viewers of *The American Revolution* with a new, more intimate understanding of

the nation's founding. His fellowship promises to empower a new generation of storytellers and historians with the tools to explore their own questions about the past.

For Frye, the goal is to encourage deeper and more nuanced engagement with history, moving beyond simplified narratives to appreciate the complex realities our ancestors faced.

"I want people to get out of the habit of thinking history is something you funnel down to a sound bite," Frye said. Instead, he explained, "you should take those sound bites and unpack them and figure out what they really meant."

About the Authors

Brian Cooke is a writer and contributing editor for the Esri publications team. He helps readers stay informed about ArcGIS technology and tells compelling stories about how Esri partners and users apply Esri technology. Cooke has worked as a marketplace researcher, an enterprise technology analyst, a technical writer and editor, and an environmental science writer for clients such as the US National Park Service and the US Forest Service. In addition to a bachelor's degree in science writing from Lehigh University, he has a master's degree in natural resource stewardship and a certificate in conservation communications—both from Colorado State University.

Cassandra Galindo is a content writer at Esri. Fueled by iced coffee and a passion for prose, she shares the power of GIS through captivating case studies, the *Esri Blog*, print publications, and other media. She earned her BA in creative writing from UC Riverside and previously worked in journalism and public relations.

Smoothing Out Türkiye's Road Network

By Jim Baumann

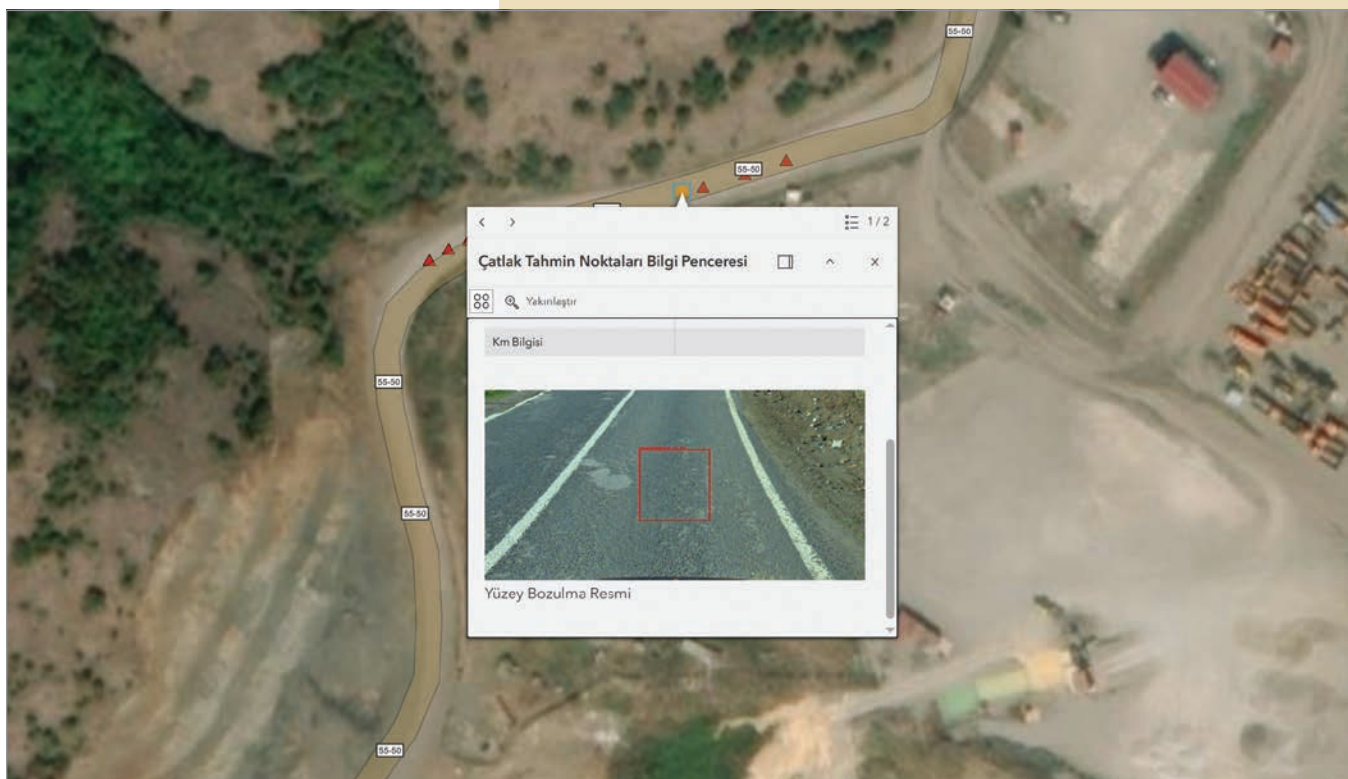
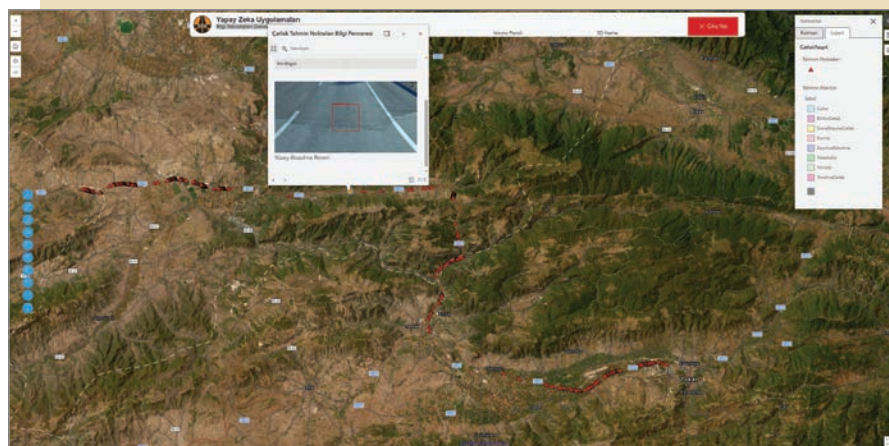
Traffic on the Trans-Caspian International Transport Route (TITR), a multi-modal transport network connecting China and Europe through Central Asia, has intensified since 2022. After Russia's invasion of Ukraine, this middle corridor became a vital pathway for cargo and freight. Parts of the route are currently under development using existing roads, railways, and port facilities. But much of this infrastructure needs to be repaired or upgraded to keep up with the increased flow of traffic.

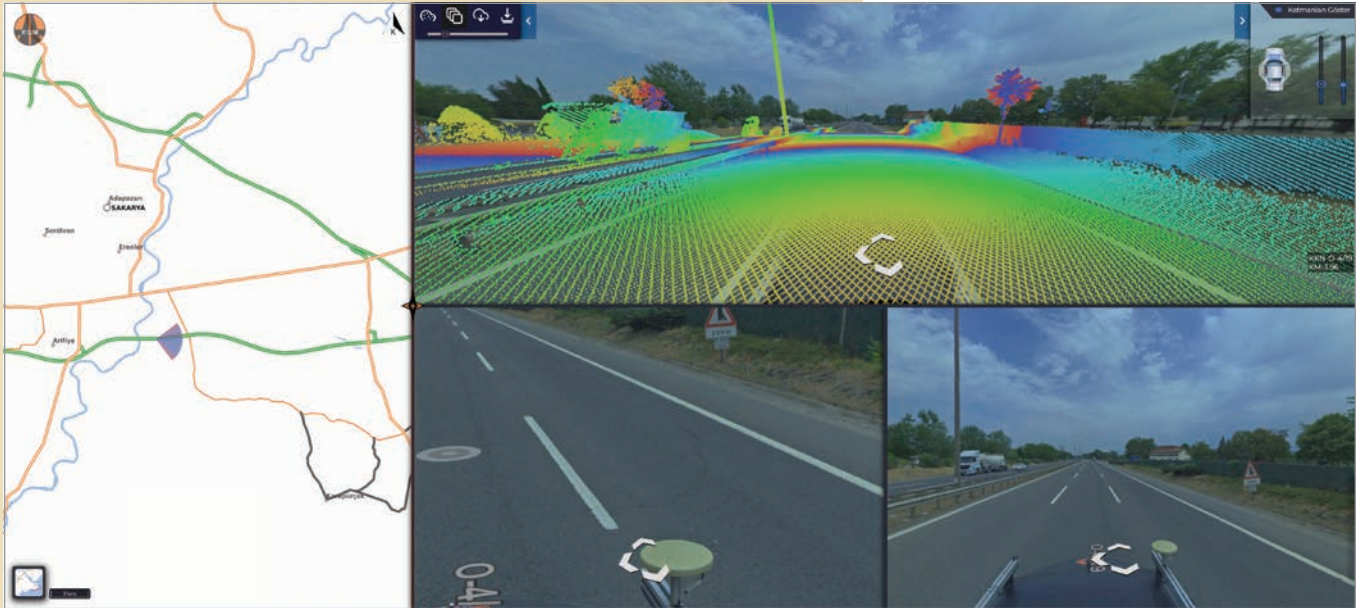
→ Fourteen different types of cracks require identification and categorization for repair in the roadway system.

↓ Some cracks contain substructures that are difficult to distinguish visually. AI and deep learning techniques provide an ideal solution.

The central part of this corridor is located in Türkiye, making the country a lynchpin for the TITR. Fortunately, Türkiye

already has over 90,000 kilometers of road, including more than 100 four-lane national highways that will serve the middle corridor.





- ↑ Nearly 2.5 million panoramic images and five terabytes of lidar data were collected and geotagged in a four-month period.
- ← Each image is stored simultaneously with its coordinates so that crews can easily find the cracked pavement in need of repair.



works with this complex data to provide continuous, consistent, and much faster analysis of those cracks, all without human intervention."

The KGM created a custom vehicle with specialized equipment to collect the data necessary to train models in the identification of pavement cracks and specify necessary repairs. This included lidar imagery of highway surface conditions and panoramic views of the roads. Nearly 2.5 million panoramic images and the related five terabytes of lidar data were collected and geotagged during a four-month period in 2024. Each image was stored simultaneously with its coordinates so that crews could easily find the cracked pavement in need of repair.

The KGM team used ArcGIS Pro for data processing and visualization, with the ArcGIS Image Analyst extension for advanced imagery processing and analysis. ArcGIS Notebooks was used for rapid modeling and prototyping, while ArcGIS Enterprise allows crack detection data to be published as a service.

Additionally, ArcGIS API for Python automated data preparation for deep learning workflows by applying transformations and augmentations to training data.

Other major roadways include province highways and secondary motorways, comprising an extensive roadway system that is planned, designed, constructed, and maintained by the General Directorate of Highways (KGM).

As the TITR is built out across multiple continents, it has been an opportune time for the KGM to improve on its road maintenance process. The agency has relied on ArcGIS technology for more than 15 years, but the KGM is now employing AI tools that interface with software such as ArcGIS Pro and ArcGIS API for Python to maintain and repair its vast road network.

AI and Automation

"Because of the high volume of traffic on our roadways, both domestic and international, maintenance is an expensive and ongoing process for the KGM," said Özgenç Uslu,

director of the KGM's GIS department. "This is compounded by the country's geographic location between Europe and the Middle East, which increases the volume of goods being transported using heavy commercial vehicles."

Fourteen different types of cracks require identification and categorization for repair in the roadway system. In many cases, these varied cracks contain substructures that are difficult to distinguish visually, making manual inspection both time-consuming and prone to human error.

As a result, AI and deep learning techniques provide an ideal solution to detect subtle highway deterioration that cannot be easily identified by visual inspection.

"Artificial intelligence is able to accurately classify each type of crack by processing large amounts of data during the training process," said Uslu. "Deep learning

The team also used Python and ArcPy to automate processes, as well as the deep learning libraries of fast.ai and PyTorch, plus Labellmg for image labeling. PostgreSQL and PostGIS allowed the KGM to store panoramic image coordinates as well as lidar data, and LAStools and PDAL were used for point cloud processing.

“With the Single Shot Detector algorithm, model training was performed using the deep learning capabilities of ArcGIS Pro,” said Uslu. “The model was optimized to accurately detect cracks. On the completion of its training, it identified cracks on the panoramic images and saved these data with their coordinates. The cracks were then analyzed with lidar data to determine their depth. The resulting data were used to assess the severity of the cracks.”

Expanding the Network

Improving Türkiye’s roads with AI didn’t begin and end with crack identification, however. The KGM recently completed three other projects using ArcGIS and AI.

→ The speed limit map analyzes road and pavement data for a nationwide highway analysis.

↓ Deep learning models detect curve points and their start and end positions in the roadway network.

A speed limit map analyzed road type, pavement data, toll plaza locations, and residential area boundaries for a nationwide highway analysis. This was used to create a speed limit prediction model.

The KGM also used AI and a lidar-generated point cloud to sort road terrain into three categories according to slope for land structure classification. Processed terrain data was published as a GIS feature layer.

For a traffic safety study, deep learning models were trained to detect curve points and their start and end positions in the roadway network. The radii were then calculated using the existing road centerline.

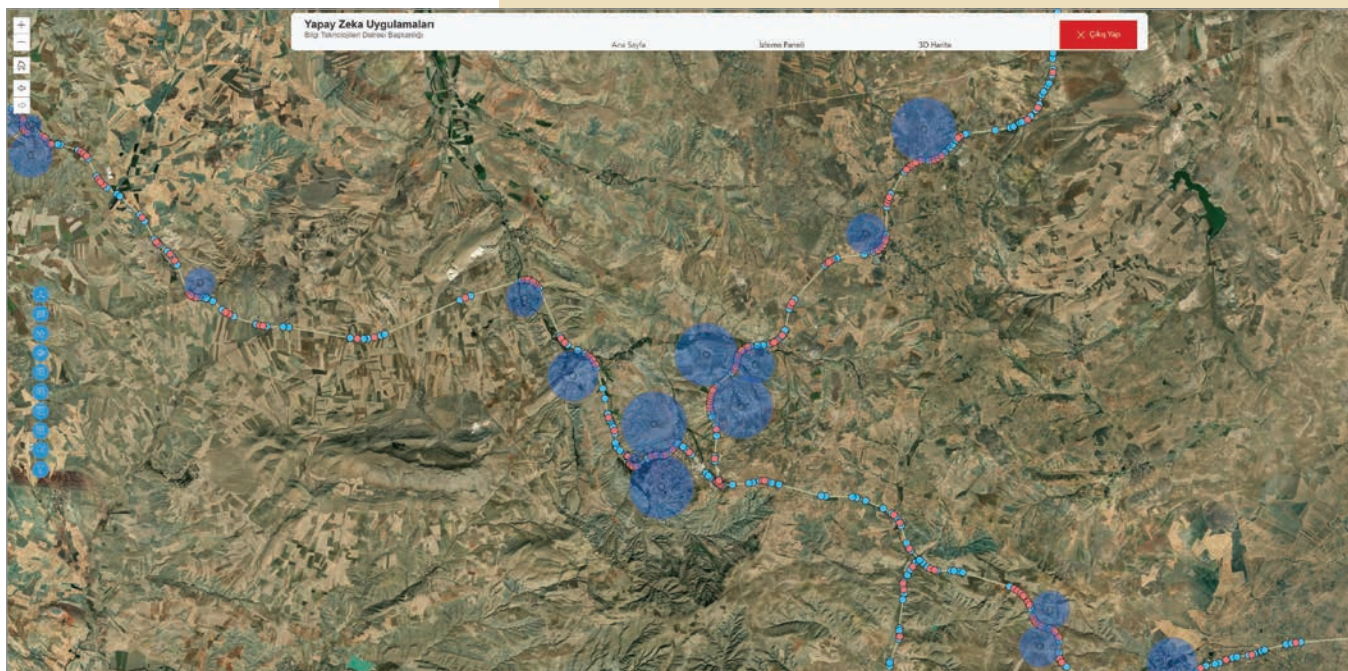
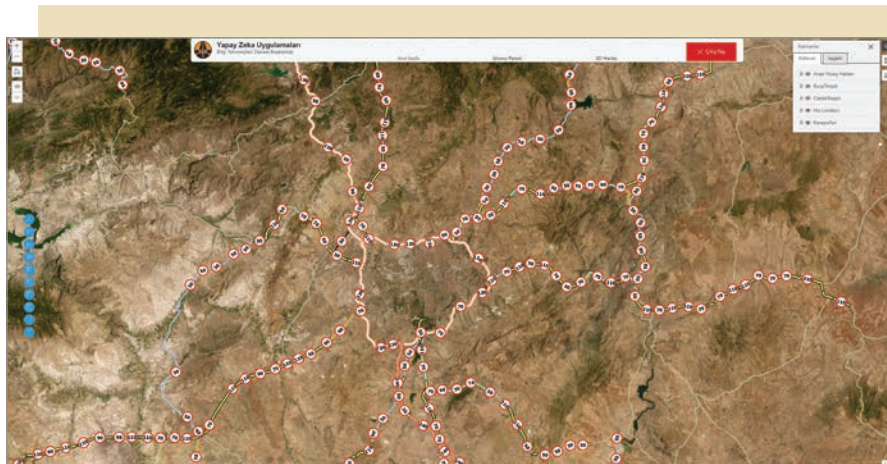
“In the future, we plan to use artificial intelligence algorithms to detect and

classify the deformations and distortions of our bridges using high-resolution images captured with a drone,” said Uslu.

The possibilities for AI-augmented GIS projects are myriad—and crucial—when it comes to Türkiye’s road network. And with the heavy traffic coming through, the KGM is more determined than ever to ensure that its roads are well-maintained and well-equipped to handle the load.

About the Author

Jim Baumann is a longtime employee at Esri. He has written articles on GIS technology and the computer graphics industry for more than 35 years.



Tracking Plans and Places in Kenton County

By Louis Hill and Cole Waymeyer

How many housing units did we build last year in our county?

Where were they built?

How many were built the year before that?

How many lots do we have available for development?

As communities across the United States grapple with a lack of available and affordable housing, being able to answer these questions is vital for county governments. But in Kenton County, Kentucky, answers were difficult to come by. Tackling these questions required plans from the engineering department, zone change approvals from the planning department, and final building permits from the building inspection department. Then, the GIS department needed to map that information. Multiple data silos, five internal departments, four permitting sources. The development and permitting process worked well, but the reporting side was agonizingly slow.

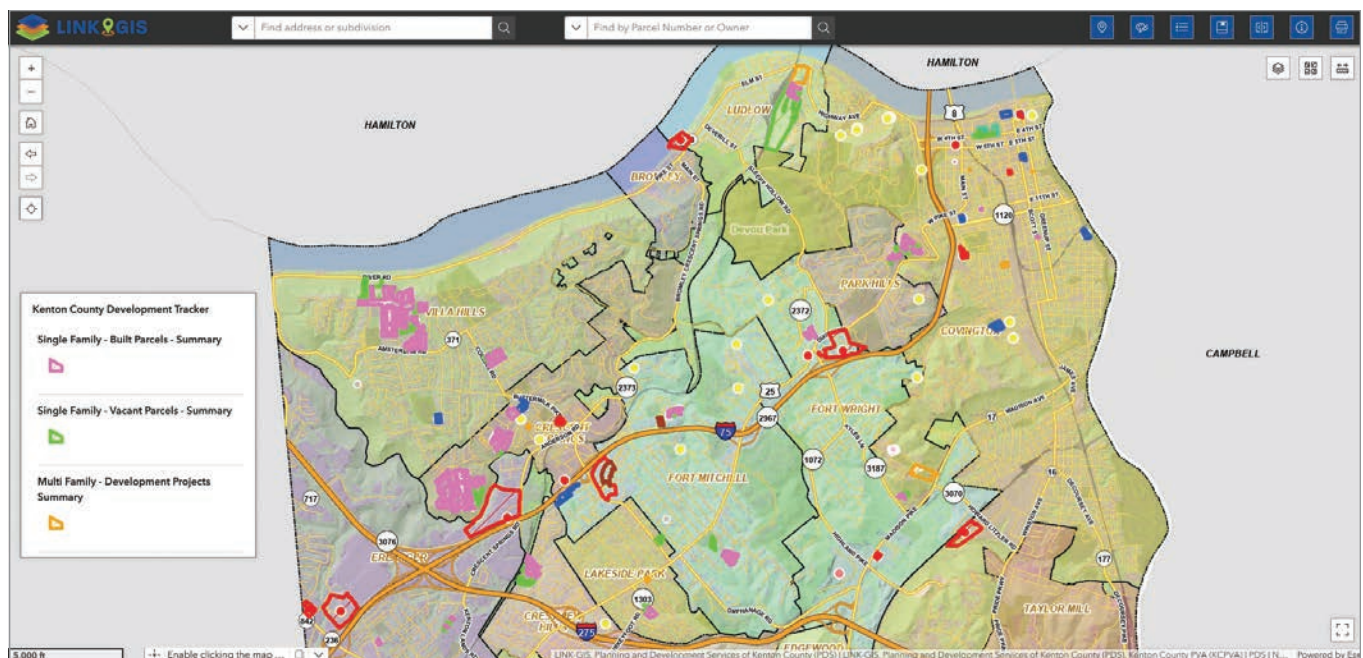
Located directly across the Ohio River from downtown Cincinnati, Kenton County has attracted a strong portfolio of development

projects, large and small. While beneficial for the local economy, frequent development activity has added complexity to the already complex task of managing development and permitting for the county and its 19 cities.

Within Planning and Development Services of Kenton County (PDS), individual departments used their own tools, workflows, and software platforms to manage their respective parts of the development process effectively. What was lacking was a comprehensive way for PDS leadership, elected officials, and the public to view the entire development activity picture in the county on demand.

Beginning in fall 2024, PDS staff set out to change this. The goal was to develop a tracking system centered on the location of developments across the county. The backbone of this tracking

↓ The Kenton County Development Tracker shows residential, commercial, industrial, mixed-use, and civic development activity across the county.



Sub_Number	Name	Planned_Lots	Planned_Units	Acres	LU_Catagor	CurrentDev
PP-578	Wildrose Estates	10	10	2.971043	Single	YES
PP-552	City View Station	54	259	49.631995	Single	YES
PP-552	City View Station Apartm...	1	273	9.59	Multi	YES
PP-25-0001	Everett Ridge	256	256	87.833732	Single	YES
PP-24-007	Kilbeggan Farms	72	72	59.814434	Single	YES
PP-24-0009	Heartland Pointe	57	57	18.016184	Single	YES
PP-24-0006	Rising Ridge Estates	4	4	25.698	Single	YES
PP24-0002	Harris Pike Retail Center	2	12	14.799	Commercial	YES
PP-23-0010	Tullamore Estates	81	81	59.145252	Single	YES
PP2109-001	Reserve at Meadowood	175	175	50.978772	Single	YES
PP1910-000	Stonewater	201	201	101.85886	Single	YES
P567	Willow Green	26	26	11.662476	Single	YES
P484	The Meadow at Grand Ga...	64	64	49.453263	Single	YES

← The attribute table for the plats feature class forms the foundation that the Development Tracker uses to calculate lots, development capacity, and development type.

system would rely on GIS to address the questions that spreadsheets and permit reports can't answer. The result was the Kenton County Development Tracker, an ArcGIS Experience Builder app that leverages ArcGIS Online, ArcGIS Server, ArcGIS Enterprise, and extensive Python automation to provide a near real-time view into development activity throughout Kenton County. By mapping development plats, new subdivisions, and building permit data, PDS has developed a tool that makes this data the most accessible to the public it has ever been.

From Data to Display

The development process begins with two types of data—plats and permits. For the Development Tracker, plats represent the land area of the development project. A plat can be a subdivision of land or a planning commission action (land rezoning) if a subdivision of land is not required. Within these plats, final building permits (certificates of occupancy) are tracked for each individual home, apartment, or suite.

Through Python automation and the use of geoprocessing tools, the data within each development is aggregated and the tracker displays a summary of the development area that shows units built, units planned, lots built, lots vacant, units built last year, units built so far this year, and percentage of full build-out. The end result is a one-click solution that makes it easy to see development progress and relevant information for a particular project.

However, developments are constantly evolving, and each project has unique features that must be accounted for. Sometimes a developer includes a pocket park as a recreation feature on a parcel within the subdivision, a parcel is reserved for a monument sign, or a building already exists on the parcel of land that is being further developed. Each of these situations can negatively impact the ability of the automation to recognize the status of a development or the individual parcels within a development. To solve this problem, certain parcels are excluded from being summarized in the automation process.

For example, the Pinnacles of Fort Mitchell is a recent development with a mix of townhomes and single-family detached housing. The plat submitted to PDS showed 50 total lots in the development.

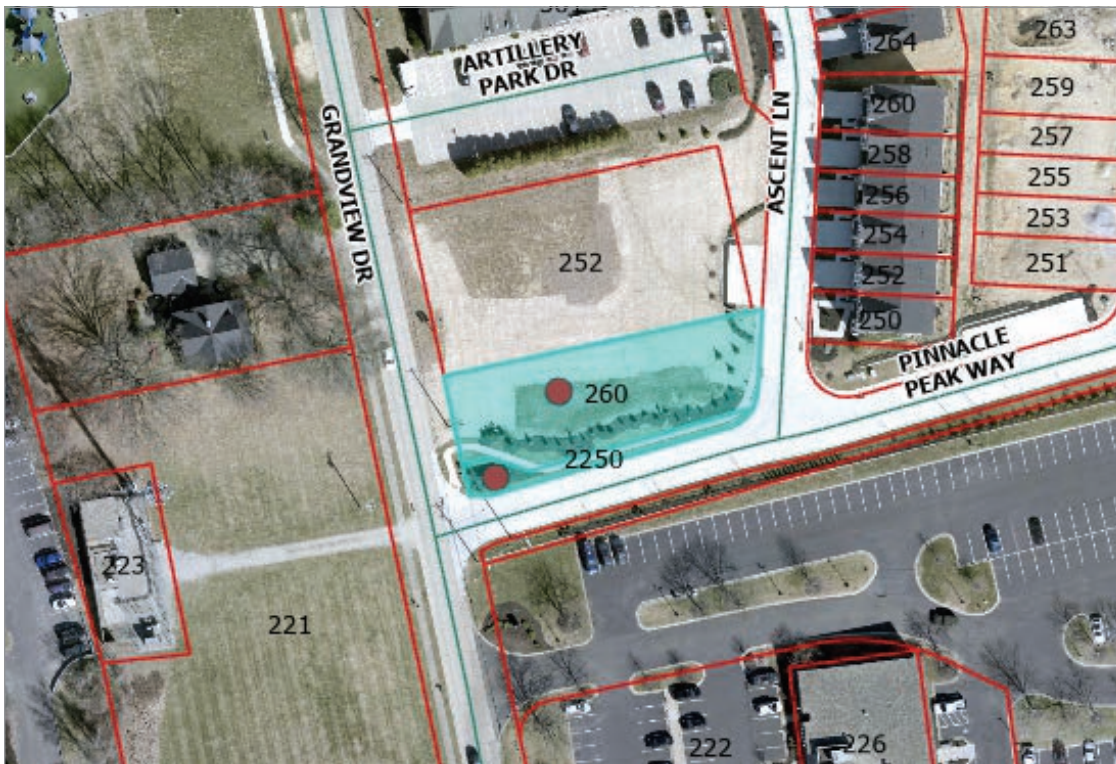
However, two of those lots were nonbuildable lots (reserved for a monument sign and an homeowner-association-owned property with entrance landscaping) and were flagged as such in the GIS. The total planned lots was automatically revised down, allowing the total build-out to be calculated based on 48 lots and 48 units. This is important because the Development Tracker reports the percentage of planned lots built as a metric for the entire development. Without this adjustment, full build-out would appear to be incomplete, rendering an inaccurate picture of the development by incorrectly showing lots available for future building activity.

Moreover, not all projects fit cleanly into predetermined categories. For example, some cities use a request for proposal (RFP) or request for qualifications (RFQ) process to unlock development opportunities. In most cases, RFP/RFQ projects lack the specific details that development tracking is geared toward—for example, total planned lots and total planned residential units. The Development Tracker takes these future opportunities into account by including them as a separate map layer, allowing a comprehensive look at the entire development picture—vacant, built, planned, and future—and placing future development opportunities into the context of active developments, all within a single map.

Behind the Automation

Extensive automation is crucial in keeping the data that feeds the applications current. The Development Tracker relies on a number of feature classes that are edited daily through Spatial Database Engine (SDE) and SQL Server in a versioned editing environment. From there, ArcPy scripting and geoprocessing run on the SQL database feature classes to create new analysis-derived feature classes that are specific to development activity in Kenton County. The newly created data is then transferred from the internal network to an external Amazon Web Services (AWS) cloud environment, via Simple Storage Service (S3) buckets. Using ArcPy and Windows Task Scheduler, the data processing and data transfer are automated to run on a set schedule, with the most important tasks running nightly.

Once the data has been transferred to AWS, ArcPy automation updates the geodatabase that serves as the source data



↑ Developments are constantly evolving, and each project has unique features that must be accounted for.

← Filtering out nonbuildable lots from all stages of analysis is a crucial component for having accurate results. This image shows that two lots will not contain future housing development and are intended for the development's amenities and monument sign.

for the ArcGIS Enterprise map services, including the updated Development Activity layers. ArcGIS Pro is used to set the feature class symbology and labels, then the projects are shared out as map services in the hosted ArcGIS Enterprise environment.

Once established, the map services are added to an ArcGIS Online web map by their URL REST endpoints. The web map is used to create pop-ups from the map service layers. This includes the use of ArcGIS Arcade expressions to run calculations and to select and count point data, which is also shown in the configured

pop-ups. The web map is then loaded into an Experience Builder application. Experience Builder is used to configure navigation tools, add widgets, and determine the functionality and appearance of the app. Finally, the app files are downloaded from Experience Builder and copied to the website host server, where the application is served out for public consumption.

To maintain the most current inventory of active and future projects along with any other unreported developments, PDS has also developed an application called CivicScope. This app uses

ArcGIS Dashboards, ArcGIS Survey123, ArcGIS Instant Apps, and Microsoft Power Automate to allow local officials from all 20 jurisdictions in the county to report missing or incorrect development information to PDS for review. CivicScope is a credentialed application that allows authorized users to submit updates to known and future development activities with a high level of authoritative confidence. This solution allows PDS to close the feedback loop on development processes throughout the county.

A Suite of Solutions

With the tracking process, automation, and reporting mechanisms in place, the focus turned to how PDS could take this geographic data and turn it into actionable information for PDS leadership, elected officials, and the public.

Enter the PDS Development Hub, a site created with ArcGIS Hub to do just that. The site is a one-stop destination for all development-related information in Kenton County. It includes the Kenton County Development Tracker, the Active Subdivision Dashboard, dashboards tracking nonresidential economic development projects, and reports from local agencies, all working together to paint an accurate and near real-time view of development across the county.

The automation involved in the Development Hub follows the same early steps as the Development Tracker. The site contains map viewers that are fed by the same map services as the Development Tracker, and also combines data from the ArcGIS Online environment to power additional housing dashboards and key performance indicator dashboards hosted on the Development Hub site.

Each of these solutions—the Kenton County Development Tracker, the PDS Development Hub site, and CivicScope—is a

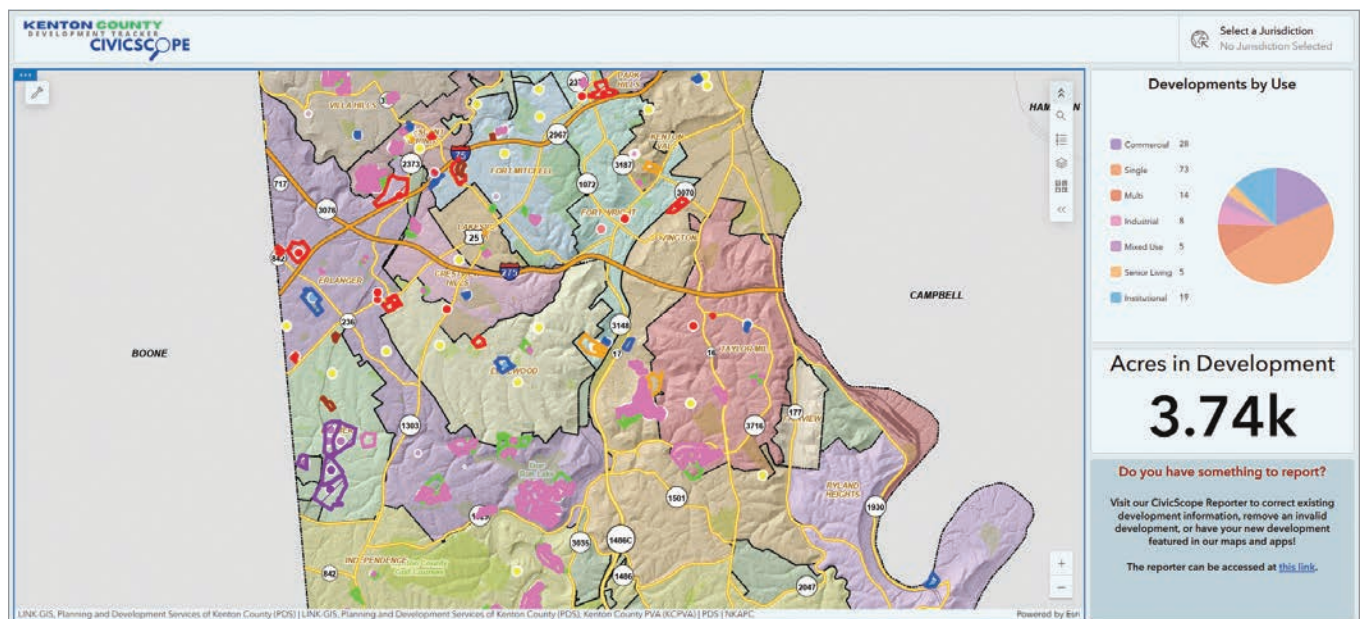
powerful stand-alone tool. But the pieces work together to form a comprehensive suite of solutions that prioritizes public accessibility and data transparency. By implementing a more robust suite of solutions, PDS has used GIS to inform and engage its leadership, stakeholders, and the communities in Kenton County.

About the Authors

Louis Hill, AICP, GISP, is the director of GIS administration at PDS. He leads a team of six full-time GIS professionals who manage the LINK-GIS consortium's three-county mapping and application development ecosystem. He holds an undergraduate degree in urban planning and development and a graduate degree in information and communication sciences from Ball State University. Hill served as the president of the Kentucky Association of Mapping Professionals from 2017 to 2018 and was previously appointed by the governor for a term on Kentucky's Geographic Information Advisory Council. He currently teaches GIS and geospatial AI at Thomas More University as an adjunct faculty member. For more information, contact Hill at lhill@pdskc.org.

Cole Waymeyer, GISP-E, is a geospatial solutions analyst based in northern Kentucky. In his current role, he leverages GIS to support public sector decision-making and strengthen community engagement. He collaborates regularly with leaders across the public and private sectors, as well as local GIS users, to develop custom geospatial solutions including interactive applications and traditional maps. He currently teaches GIS and geospatial AI at Xavier University as an adjunct faculty member. For more information, contact Waymeyer at cwaymeyer@pdskc.org.

↓ The CivicScope dashboard allows credentialed users to report missing or incorrect development information for inclusion in Kenton County Development Tracker.



Johns Hopkins University Elevates Drone Education

By Brian Cooke

At Johns Hopkins University in Baltimore, Maryland, GIS education gets about as hands-on as you could imagine.

Take the students who investigated Chesapeake Bay shoreline erosion. They initially suspected that sea level rise was the primary cause. Careful analysis revealed a more complex story.

"The students found that shoreline erosion is happening because underground saltwater intrusion is reaching plant roots that help hold soil together," said Jim Blanchard, a lecturer at Johns Hopkins University. "When this kills the vegetation, you get erosion. This is useful to know, because although you can't hold back the rising water, you can plant salt-tolerant vegetation."

He offered another example: "One student, a law enforcement officer in a major city, implemented drone mapping using thermal sensors to detect human activity on rooftops." By establishing baseline activity patterns adjusted for weather conditions, the officer could identify anomalies warranting investigation during public gatherings or in areas with criminal activity.

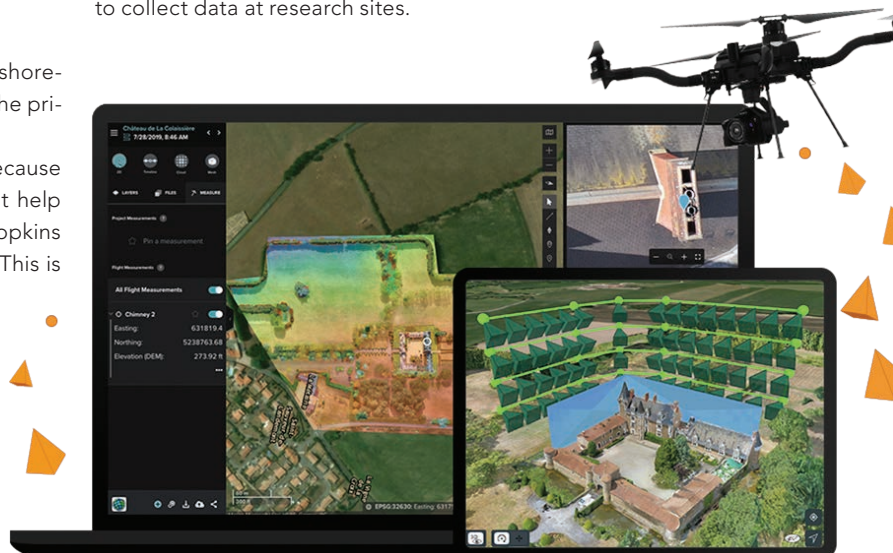
These students are part of Drones in Geospatial Decision Making, an eight-week course Blanchard has taught since 2019. He brings more than 40 years of aviation and remote sensing expertise to the curriculum. After becoming a commercial pilot at age 20, he worked at Embry-Riddle Aeronautical University, then advised military leaders on aviation systems for a decade following the September 11 attacks.

In this class, students in the university's environmental science and GIS programs go beyond basic flight training to master a skill that sets them apart in the job market—the ability to transform drone-collected data into actionable geospatial knowledge. The students use drone technology alongside Site Scan for ArcGIS, ArcGIS Drone2Map, and ArcGIS Pro to move beyond surface observations and identify underlying mechanisms. These are the kinds of hands-on analytical skills designed to set students up for success.

Beyond Basic Certification

Many universities across the United States offer Federal Aviation Administration (FAA) Part 107 drone pilot certification as part of their geospatial education. At Johns Hopkins, earning that certificate is just the beginning. Through the repeated data collection missions of Blanchard's course, students learn to detect environmental changes over time with precision that satellites can't match. The result is a competitive advantage that has helped graduates land positions such as state drone coordinators and infrastructure assessment specialists.

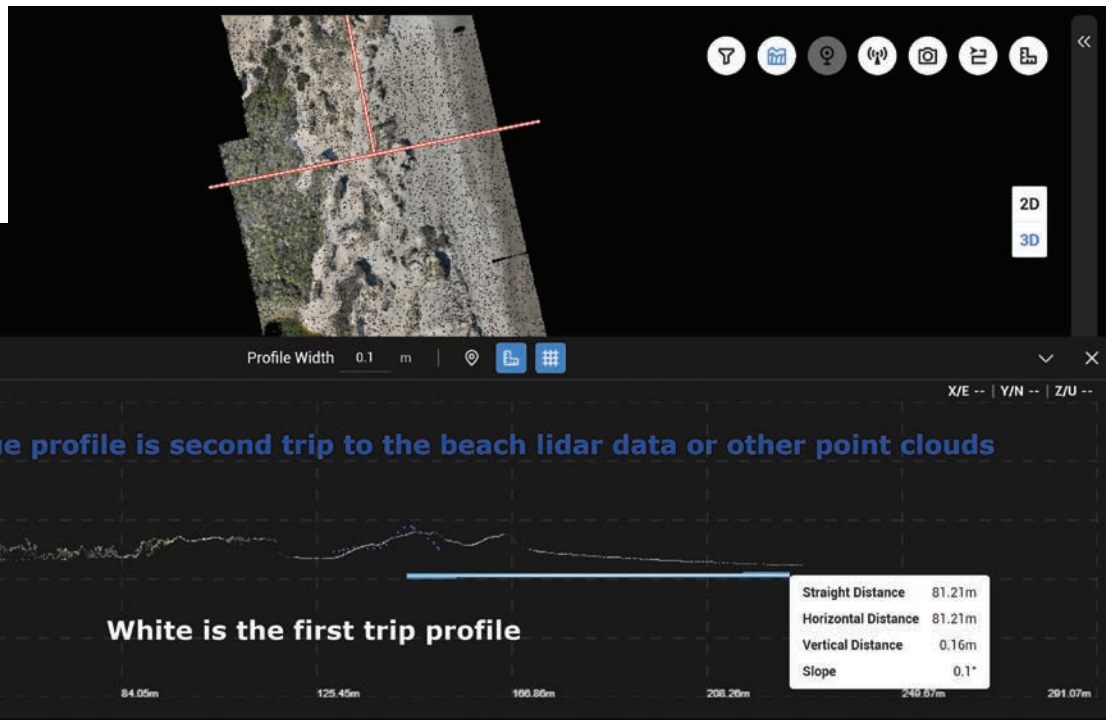
So far, about 140 individuals have completed the course, with up to 16 people in each class. Students complete three distinct modules that determine their final mark. The first is based on getting their drone pilot certificate from the FAA. The second focuses on sensor selection (lidar, thermal, and multispectral) for environmental science problems and advanced visualization techniques that support time-series analysis. The third is based on an intensive, four-day field laboratory where students operate drones in teams to collect data at research sites.





← For a Chesapeake Bay shoreline erosion project, students discovered that saltwater intrusion kills vegetation, leading to erosion.

→ Johns Hopkins GIS students used a dynamic transect method in Site Scan for ArcGIS to assess dune crown movement before and after a storm.



“It’s all about turning data into information, which humans then can turn into knowledge.”

The program’s emphasis on temporal analysis—teaching students to collect data repeatedly at the same locations over time—distinguishes it from other university drone courses.

“I don’t know of any other program that teaches you how to go out and fly repeatedly and compare the data over time, utilizing a high-resolution dataset like you get from one of these aircraft drones,” Blanchard said.

This approach enables temporal and spatial saturation. While Landsat satellites pass over locations every 16 days, students flying drones weekly can triple the sampling frequency with higher resolutions, helping identify cause and effect relationships with greater confidence. Even basic consumer drones can capture imagery with detail surpassing that of the best satellite sensors. This enables micromapping—studying environmental features in such fine detail that subtle change indicators become visible.

“Correlation to true causes can be discovered using frequent data collection and well-conceived analysis,” Blanchard said.

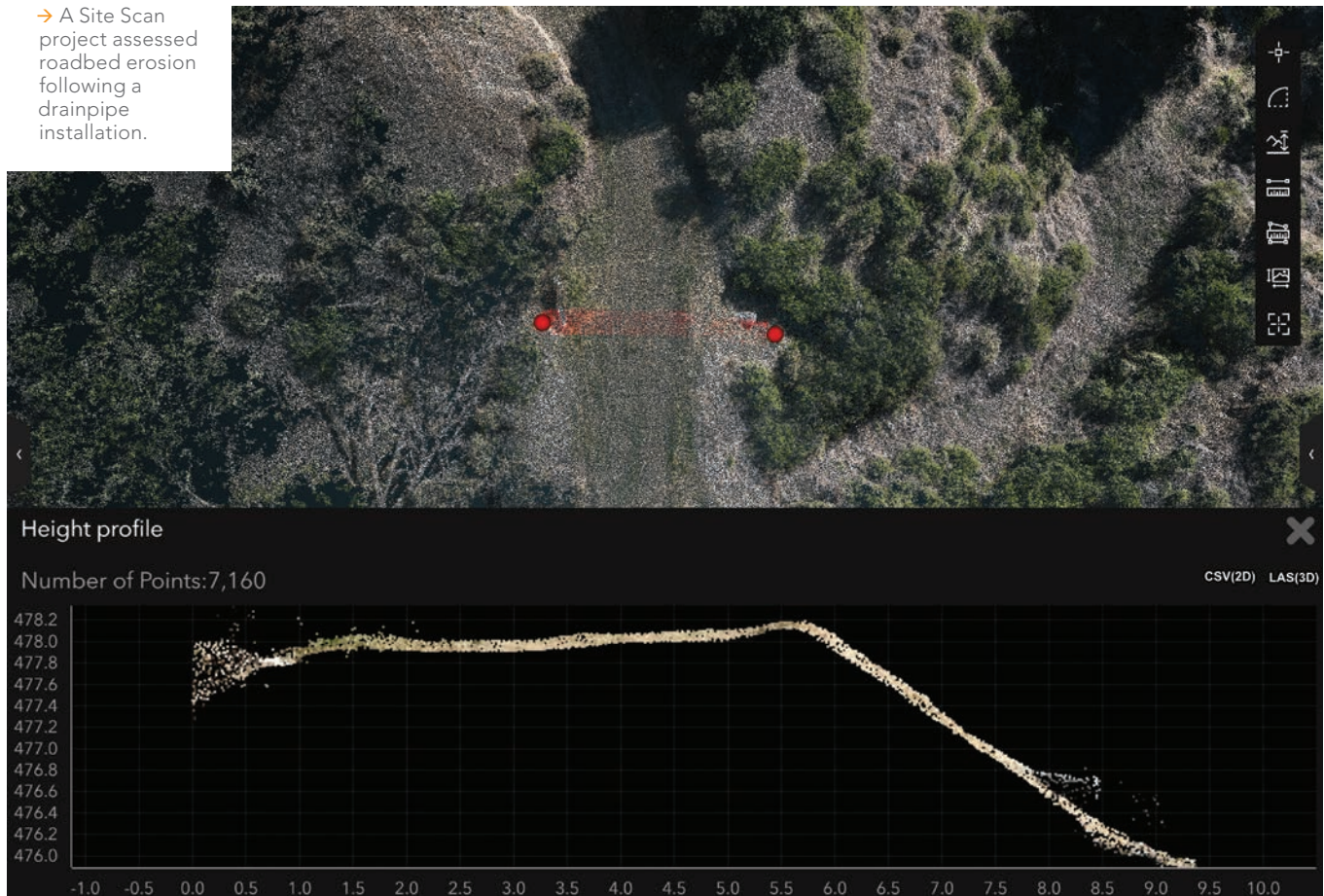
Students begin each project by formulating a hypothesis and identifying variables. Then they determine which sensors can measure them effectively. This approach ensures students understand not just how to fly drones but also why they are collecting specific data and what it means.

Building a Competitive Edge

Rather than mandating specific software, Blanchard provides students with three options: Site Scan for ArcGIS, ArcGIS Drone2Map, or advanced tools in ArcGIS Pro. Site Scan for ArcGIS—a cloud-based platform that processes drone imagery without requiring powerful local computing resources—enables students who are limited by hardware capabilities to participate.

“We use Site Scan because it basically enables the lowest level of computer skills of students in my program, and that way nobody’s left out of the process of learning how to interpret the results,” Blanchard said, noting that about half his students use Site Scan. Its elevation profile and point cloud volumetric tools proved essential for coastal dune projects, allowing precise measurements without disturbing sensitive environments.

→ A Site Scan project assessed roadbed erosion following a drainpipe installation.





The program emphasizes communication skills, as students must articulate scientific conclusions clearly during online meetings and in final assignments.

“Without the ability to verbalize the complex points of their work, they won’t be able to get feedback from me during the course meetings on Zoom,” Blanchard said.

This extends to field operations, where students work in teams using crew resource management—collaborative protocols that professional pilots use for safe, effective operations.

During the four-day field portion, students progress from supervised training to autonomous team operations. Days one and two cover basic flight skills and mission planning. By day three, students operate unsupervised in teams, collecting data for research projects. Students then present their final projects with ArcGIS StoryMaps. The stories later become portfolio pieces students can share with potential employers. Project topics have included shoreline erosion, stormwater management, and invasive species assessments.

“Our students have an advantage because they have a story map that they can link to in their job application. If they’re applying for a flight job or a GIS job that’s focused on turning data into actionable information, they’re going to be able to provide an example of their work,” Blanchard said.

One former student became a special assistant to a state governor, coordinating drone adoption across state agencies. Another was hired to map roads leading to bridges, using high-precision vertical measurements to detect early structural change indicators.

For Blanchard, the goal extends far beyond teaching students to operate drones.

“I teach that the flying isn’t the reason you get certified,” Blanchard said. “It’s all about turning data into information, which humans then can turn into knowledge. That’s the strategic pathway. Having a drone pilot certificate is just the stepping stone.”

This reliance on analytical thinking guides the program’s emphasis on scientific methodology. Students learn that understanding what maps reveal, collecting data safely and legally, and knowing which sensors to deploy for scientific questions matter more than piloting skills alone. The competitive advantage Johns Hopkins students gain comes not from their ability to fly, but from their capacity to transform aerial observations into geospatial insight.

About the Author

Brian Cooke is a writer and contributing editor for the Esri publications team. He helps readers stay informed about ArcGIS technology and tells compelling stories about how Esri partners and users apply Esri technology. Cooke has worked as a marketplace researcher, an enterprise technology analyst, a technical writer and editor, and an environmental science writer for clients such as the US National Park Service and the US Forest Service. In addition to a bachelor’s degree in science writing from Lehigh University, he has a master’s degree in natural resource stewardship and a certificate in conservation communications—both from Colorado State University.

Get to Know Cobb County's GIS Chatbot

By Jim Baumann

While greater demand requires greater capacity, the opposite is also true—greater capacity creates greater demand. This is particularly true for the information services department of Cobb County, Georgia, where the use of GIS has grown exponentially for the past 26 years. It is now an essential part of the county's operations, supporting a wide range of departments and services.

"The use of ArcGIS technology is applied in virtually all of the services provided by Cobb County," said Chunguang Zhang, information business analyst in the county's GIS Core Group, which is part of the information services department. "We utilize GIS in many ways—from desktop-based editing of parcels, roads, highways, and water utility networks to managing real-time public safety and emergency event data. Today, Cobb County makes extensive use of both enterprise GIS and ArcGIS Online in the daily operations of county government."

Applications range from parcel and land records management to public safety and emergency response to elections and voter services. If you can name it, Cobb County uses GIS to make sure it's done well.

"There are five members in our group and we support countywide GIS operations," said Zhang. "We oversee more than 30 GIS databases, maintain three production ArcGIS Enterprise portals, and run

numerous internal and external GIS applications. In addition, we ensure the smooth integration of our ArcGIS platform with critical county systems like the UMAX water billing system and Accela business process. We also handle daily GIS-related requests from residents, such as GIS data sales inquiries, emails, and phone calls."

The sheer volume of these tasks caused Zhang to wonder if he could develop a GIS chatbot specifically for Cobb County to handle both public and internal inquiries in real time.

What Makes This Chatbot Different

While large language models (LLMs) like OpenAI's ChatGPT and Google Gemini retain extensive information, they are generalized models. They lack deep domain expertise, which is critical in government applications.

For example, LLMs sometimes provide incorrect or misleading information (hallucinations). In government, misinformation can have significant consequences. LLMs also lack domain-specific knowledge because they are trained using publicly available data that does not include proprietary or recently updated information. In GIS, domain knowledge is vital for accurate responses. Additionally, LLMs often do not reliably remember past interactions,

leading to inconsistent user experiences. The probabilistic nature of current LLMs means that asking the same question multiple times can yield different responses, which is undesirable in a government setting where consistency is crucial.

"To overcome these challenges, we implemented a solution using Retrieval-Augmented Generation [RAG]," said Zhang. "This powerful framework enhances LLMs by integrating them with private data stored in a vector database. Instead of relying solely on the model's pretrained knowledge, RAG retrieves relevant, up-to-date information from our proprietary GIS dataset and provides it as context for the model. This approach significantly improves response quality and reliability."

In developing the GIS chatbot, Zhang compiled years of resident inquiries and staff responses from GIS-related emails for training purposes. To ensure the consistency of the chatbot's response, he leveraged ChatGPT to generate three similar variations of each question while keeping exactly the same answer. This ensured uniform and accurate responses every time.

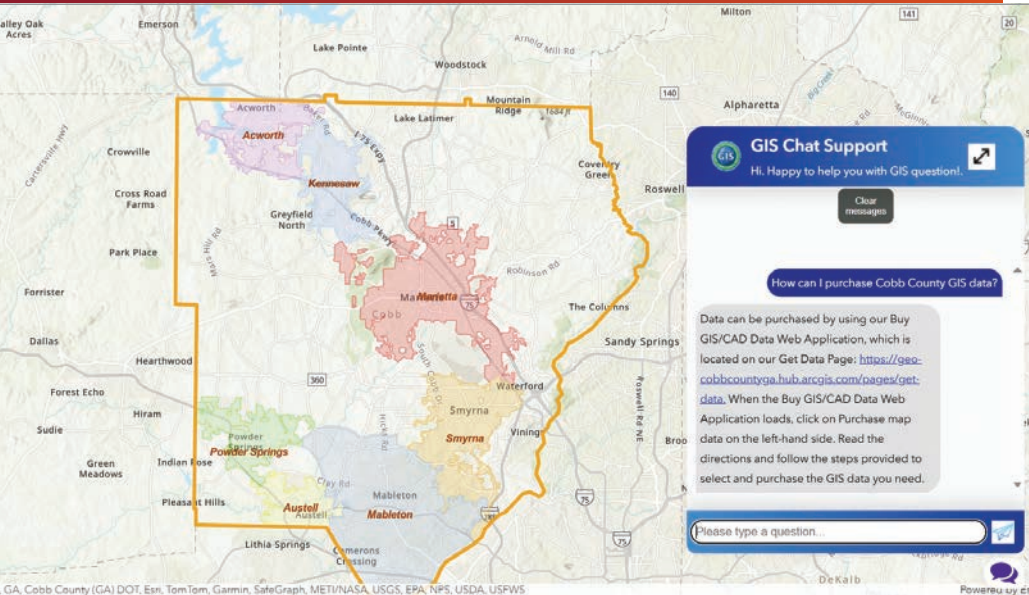
Software used for the GIS chatbot's development and operation included ArcGIS Enterprise, ArcGIS basemaps, ArcGIS Maps SDK for JavaScript, and ArcGIS API for Python. Other technologies used are LangChain open-source libraries and the ChatGPT API.

The Future of AI in Cobb County

By integrating RAG for relevant and up-to-date knowledge retrieval and function calling for real-time GIS operations, Cobb County has built a GIS chatbot that overcomes the limitations of generic LLMs. The project leverages AI to improve public services and optimize GIS workflows.

The GIS chatbot answers frequent GIS-related questions and queries, which reduces the need for human interaction and support.





- The Cobb County GIS chatbot answers a general GIS question.
- The chatbot not only is trained on localized data but also can handle both public and internal inquiries in real time.
- ArcGIS Maps SDK for JavaScript helps the chatbot answer specific GIS questions.

“The GIS chatbot answers frequent GIS-related questions and queries, which reduces the need for human interaction and support,” said Zhang. “This improves response times and ensures consistency in the response. It also allows staff to quickly retrieve zoning information, parcel verification, address validation, and GIS application data.”

Moreover, the chatbot supports government transparency and operational efficiency, helping agencies within the county better serve their communities.

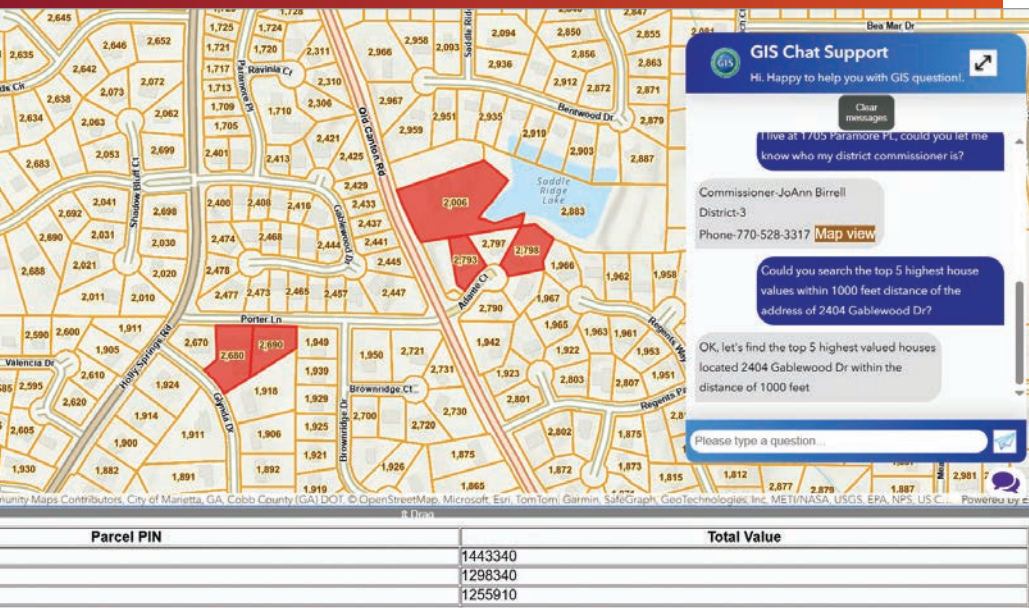
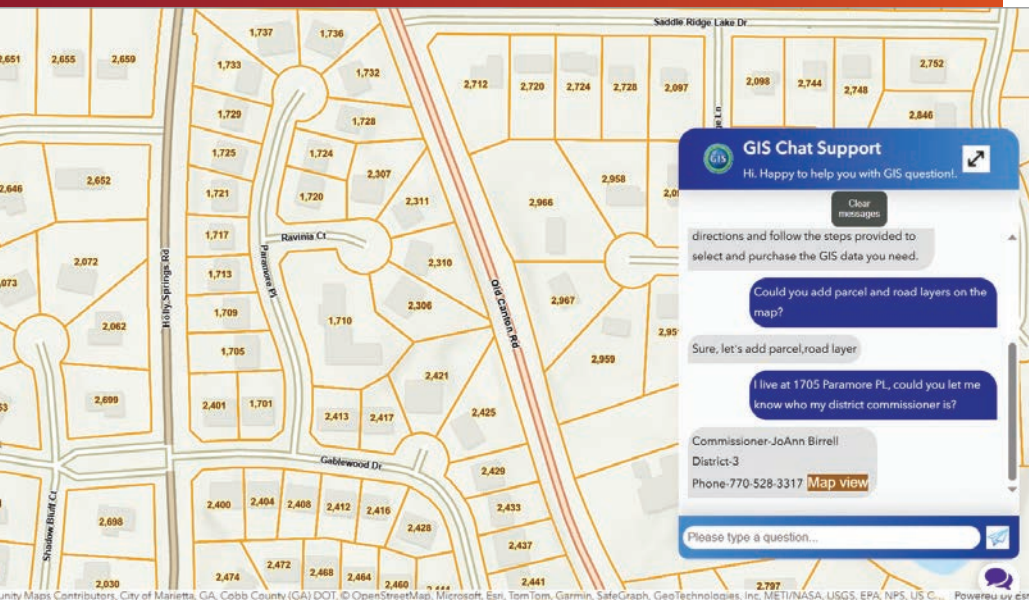
“I envision increased use of AI to improve services and optimize GIS workflows at Cobb County in the future,” said Zhang. “This includes automated feature extraction, change detection over time, and predictive modeling for infrastructure.”

In its expanded use of AI, the county aims to use ArcGIS pretrained image models to extract features such as houses, streams, and roads from the county’s annual Pictometry aerial imagery flights. The use of change detection would analyze temporal imagery to identify changes, such as new construction, deforestation, and post-disaster damage. Predictive modeling for infrastructure would use machine learning models to predict when infrastructure (like roads or water pipes) might fail based on historical patterns, current sensor data, accidents, and other road incidents.

In the meantime, Cobb County staff and residents with GIS-related questions now know where to turn to get geospatial information efficiently and effectively.

About the Author

Jim Baumann is a longtime employee at Esri. He has written articles on GIS technology and the computer graphics industry for more than 35 years.



Parcel PIN	Total Value
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ONE PUBLIC UTILITIES PLATFORM, THOUSANDS OF USERS

By Alyssa Grant

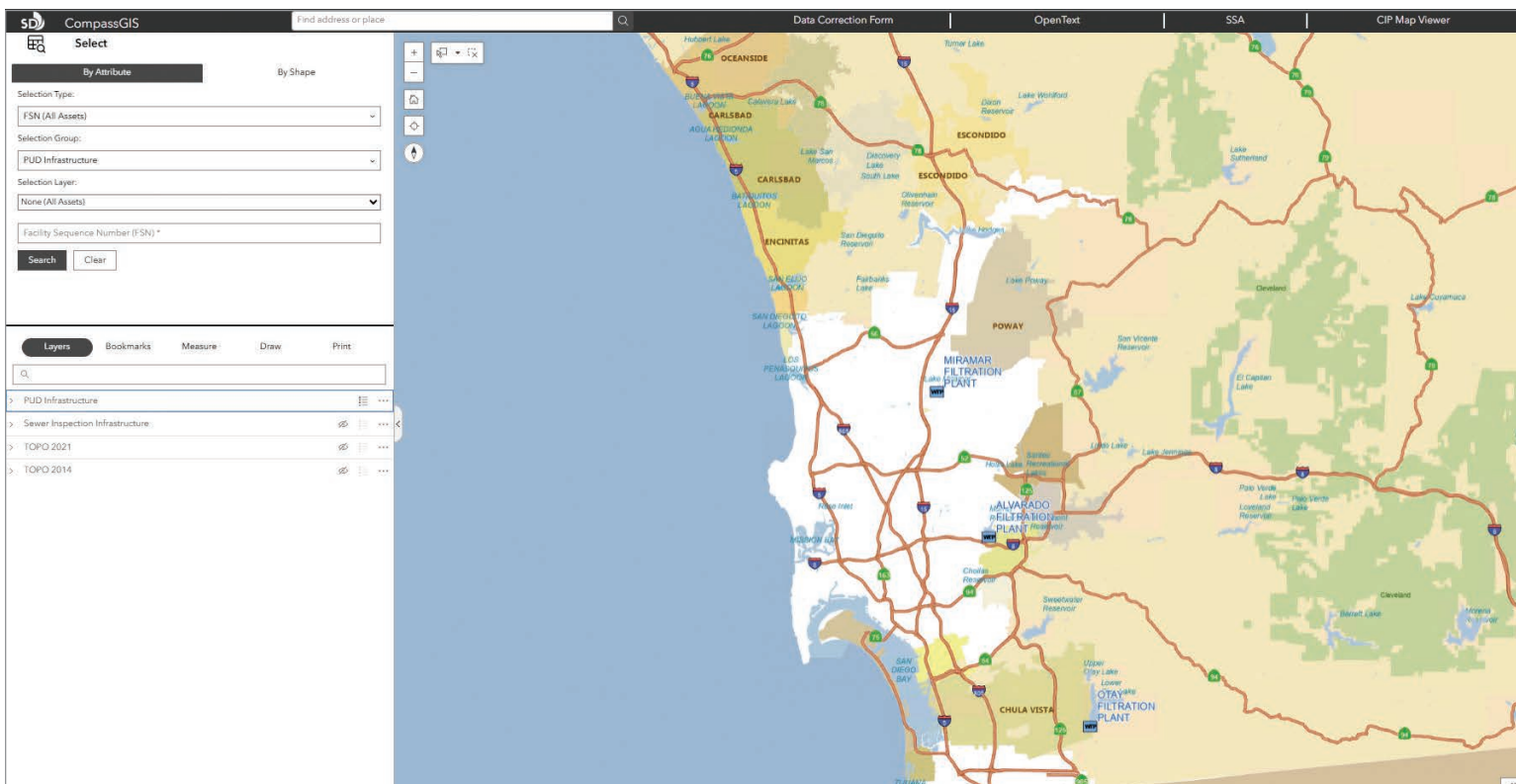
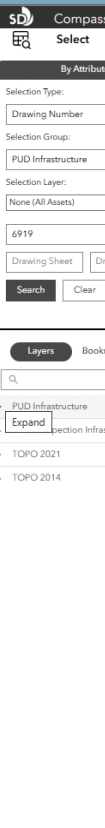
For the City of San Diego's Public Utilities Department (PUD), giving staff quick access to accurate infrastructure data is essential to keeping the United States's eighth-largest city running. Thousands of employees rely on this information daily, whether responding to a water main break, planning maintenance, or supporting critical field operations. To make this data easier to access, PUD developed CompassGIS Viewer, an application with dozens of tools that delivers critical GIS information to staff across the organization quickly and reliably, without the need for individual Esri licenses.

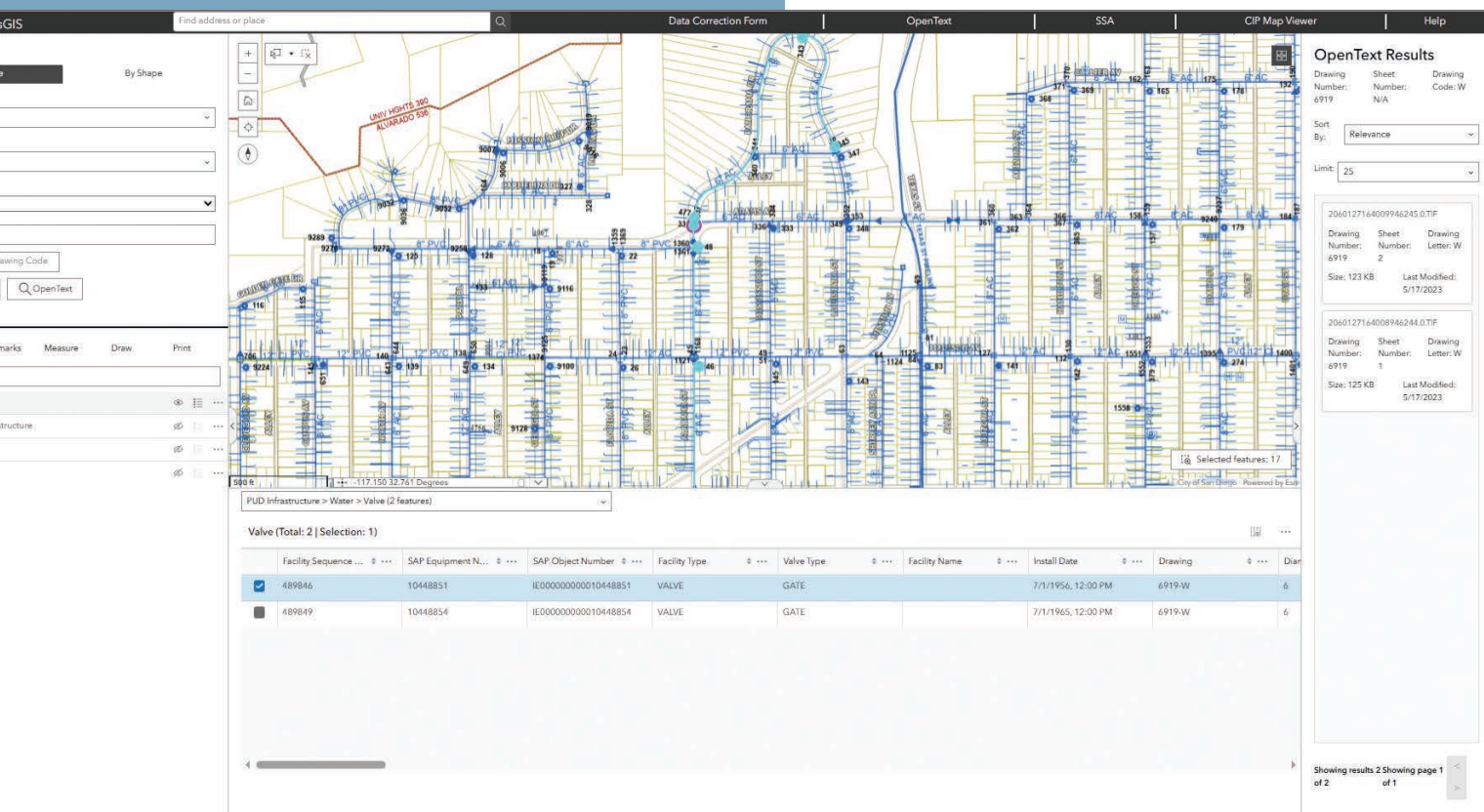
THE ORIGINAL DATA viewing application was built using ArcGIS API for JavaScript. It served its purpose for years, but the tool's aging architecture and design were beginning to create challenges and disruptions for city staff.

"It was deprecating and creating risks and vulnerabilities, as some of the code was no longer supported," said Rod Miramontez, GIS analyst at PUD. "There were times when some of the functionality wouldn't be there. For instance, a map service might go down

or a FEMA [Federal Emergency Management Agency] layer might not load. Staff would submit tickets, but it was time-consuming and reactive."

A modernized data access platform with less back-end complexity was needed. This would allow future enhancements to be delivered more quickly and improve both performance and user experience. Esri partner Quartic Solutions worked closely with PUD to make that vision a reality.





↑ Simplified, dynamic tables keep the user's view focused by only showing layers with active selections.

← The CompassGIS Viewer interface.

Over a two-year period, the Quartic team planned, built, and delivered an updated data viewing platform using ArcGIS Experience Builder, enhanced with custom widgets and integrations. ArcGIS Experience Builder was instrumental in designing the application's complex layout, including the placements and configurations of header items, application navigation, and map data handling.

EASIER ACCESS AND NEW WORKFLOWS

With CompassGIS Viewer, city staff can easily access utility data and explore infrastructure data, look up attributes, set filters, and generate custom maps with ease.

"It's a tremendous upgrade from what we had," said Miramontez.

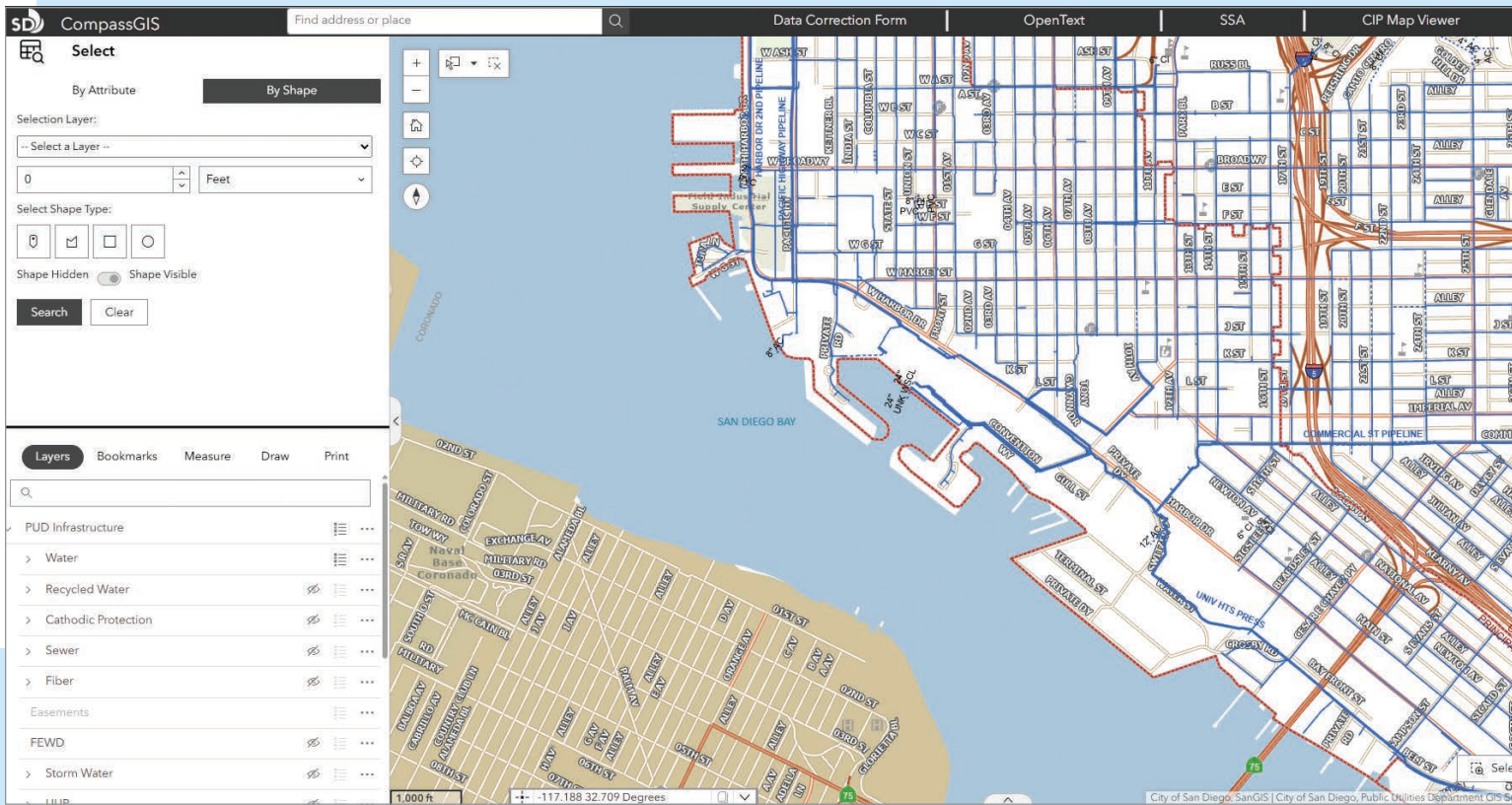
Once signed in, users can see the locations and information related to over 100 asset types such as water valves, sewer mains, and recycled water services. Additional useful layers include items like council districts, easements, capital improvement projects, and topographic lines. The department's assets are updated weekly, providing the latest infrastructure data to city users.

Behind the scenes, a new ASP.NET API delivers sewer inspection closed-circuit television videos, images, and other detailed information directly to the data viewer, making inspection data available with a single click. A custom JavaScript integration with the city's Microsoft

Power BI Report Server allows staff to generate and view sewer inspection reports on demand, straight from the map interface.

The team leveraged the flexibility of Experience Builder for supporting custom widgets to address city staff workflows and needs. Utility datasets, for instance, are huge. Smart search capabilities allow users to quickly locate assets across all layers or within a specific layer, select and highlight map features, and view results in a custom table. The Integrated Document Viewer gives users access to records like as-built drawings, inspection videos, and related documents without leaving the map via integration with unstructured data and content management software from OpenText.

Additionally, the enhanced pop-up widget provides a consolidated view of asset information by displaying key attributes alongside related OpenText documents, sewer inspection videos, images, and reports, all directly within the map. Right-click tools give users instant location context. Users can jump to Google Street View, geolocate an address, or preview the surrounding area. And simplified, dynamic tables keep the user's view focused by only showing layers with active selections. These tables also include a layer drop-down menu and direct links to OpenText documents and sewer inspection details for selected features, saving time and reducing the back-and-forth between systems.



↑ CompassGIS Viewer’s street view capabilities display key attributes directly within the map.

“One of the most important customizations was OpenText integration,” said Miramontez. “OpenText is the repository where all our records and drawings are stored, and it’s incredibly valuable to have a user interface within the data viewer that is much faster than going to the hosted website that’s designated for OpenText.”

The custom widgets leverage developer settings panes to simplify the selection of the application environment and associated integrations. For example, in the OpenText Integrated Document Viewer widget, a developer settings menu can be used to set the production URL for the OpenText API. ArcGIS Maps SDK for JavaScript is then used to obtain the CAD drawing number from a selected feature’s attributes, set the OpenText viewer widget’s visibility in the sidebar to true, and pass the drawing number to the OpenText API.

Experience Builder allowed Quartic staff to build the app layout and include the required functionality in a fraction of the time it would have taken without it. While re-creating that functionality in custom widgets with React (the underlying framework for Experience Builder) came with a steep learning curve, the ability to design and set widget parameters using the developer settings panes graphically made the process much easier. With the custom widgets’ structures, it’s now simpler to understand and document how different aspects of the application are connected.

OUT-OF-THE-BOX WIDGETS IN ACTION

Twenty out-of-the-box widgets were included in the solution. Two of the most-used widgets are the Layers widget and the Selection Tool widget.

The wastewater collection division uses the Layers widget to visualize sewer mains and underground-access points by their preventive maintenance cycles. Each asset is assigned a maintenance frequency based on a risk analysis: High-risk assets are scheduled for more frequent cleanings, while lower-risk assets are maintained less often. The widget’s gradient color ramp allows quick identification of high-risk areas, with red indicating assets needing immediate attention and green for lower-risk areas.

“Before this visualization, we relied on BusinessObjects report tables,” said Miramontez. “Planners had to manually look up each asset from the reports. This color-coded visualization has improved planning and allocation of field resources.”

The Selection Tool widget enables staff to make custom selections of infrastructure within a defined area. Users can select assets like water mains, valves, or other utilities and immediately view key attributes in a tabular format. Selections can also be exported as CSV files for reporting or operational planning. During a water main break or planned valve maintenance, staff can quickly see which services will be affected, understand the scope of the



impact, and use that information to guide response efforts and communicate clearly during the event.

“The older selection tools were limited in enabling customization for an area of interest,” said Miramontez. “The new selection tool, specifically the lasso option within it, is faster and allows users to tailor their selection of specific assets within a customized area.”

A FASTER, MORE CONNECTED WAY FOR STAFF TO WORK

CompassGIS Viewer launched in September 2025 and is already changing operations. Staff use the data viewing tool for valve maintenance, hydrant replacements, engineering planning, sewer video inspections, and emergency response coordination. The app runs on multiple servers with load balancing to improve performance.

“Previously, field crews had to manually email corrections with a PDF form and image attachments. Now, they can drop photos and details directly into the map viewer using the data correction form. It’s all automated,” said Miramontez.

Staff feedback on the modernized map viewer has been enthusiastic, thanks to its speed and intuitive interface. Training sessions take just under two hours, and most users pick it up simply by exploring. Staff who were used to the old data viewing application can find comparable capabilities in locations similar to those that previously existed, reducing the overall learning curve.

“It’s evolving into a one-stop shop for all city mapping and data needs,” said Miramontez.

ABOUT THE AUTHOR

Alyssa Grant leads marketing communications at Quartic Solutions, working closely with the firm’s GIS professionals and clients to communicate how geospatial technology improves government operations and outcomes. She develops case studies, articles, and marketing strategies that highlight the real-world impact of Quartic’s work. She holds a bachelor’s degree in English literature from the University of Northwestern–Saint Paul.

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GIS Protects the Past from Wildfire

By April Watson

It comes as no surprise that areas like California experience more wildfires by the year, but even wetland-dense places like Florida are vulnerable to increasingly large and catastrophic fires.

Many Florida ecosystems are actually wildfire dependent. Fire clears out underbrush and prepares soil for germination. However, years of fire suppression have led to excessive growth throughout the state, meaning that fires are more frequent and more damaging than these ecosystems can adapt to. This creates massive clouds of billowing smoke and other environmental hazards when wildfire strikes—often as a direct result of human activity. This risk is compounded by climate-related factors.

In 2025, the wildfire likelihood for Florida was high, with an average likelihood that is greater than that of 86 percent of US states. A recent study from First Street Foundation suggests that the risk of wildfire in Florida could double by 2052.

Plenty of research and resources have been devoted to wildfire risk and vulnerability in Florida. However, little attention has been paid to how these fires affect Florida's cultural heritage, especially its archaeological sites. Researchers at Lynn University are using a GIS-based approach to address this gap by leveraging ArcGIS to map and analyze the areas in the state that are most vulnerable to wildfire, with the aim of preserving Florida's archaeological sites—and its history.

From Data to Analysis

To create the wildfire risk map, researchers first obtained archaeological site data from the Florida Master Site File, the state's official inventory of historical and cultural resources. This data was

queried to limit it to artifact scatters, campsites, midden/mound sites (prehistoric landfills and other raised earthworks), and some historical relics such as logging chains. Structures like historical buildings would have a different set of parameters for their preservation during a fire event compared to other archaeological sites. Wildfire data came from Monitoring Trends in Burn Severity (a US federal program designed to map fires across the country), and all data was processed and analyzed in ArcGIS Pro.

To determine the areas at highest risk for large wildfires, a hot spot analysis was completed based on acres burned. Larger fires tend to burn hotter and have the potential for fire to carry along the root structures deeper into the ground. Generally, site damage is correlated with fire duration and intensity. Larger fires could also have indirect effects such as those from suppression efforts and erosion following the fire.

Researchers then compared archaeological site data with the burned areas and further selected for areas with over 23,000 acres burned and over 10 archaeological sites within the boundaries of the wildfire. These were determined as the most vulnerable areas for Florida archaeological sites.

Based on this determination, the risk map combines vulnerability based on hot spot analysis, burn acres, and site density, as well as wildfire susceptibility. Susceptibility is based on the US Department of Agriculture's wildfire hazard potential data, and archaeological sites were narrowed to those with National Register

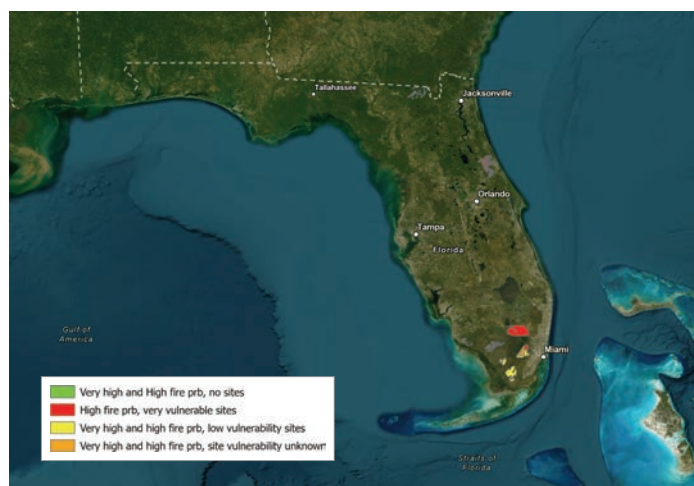
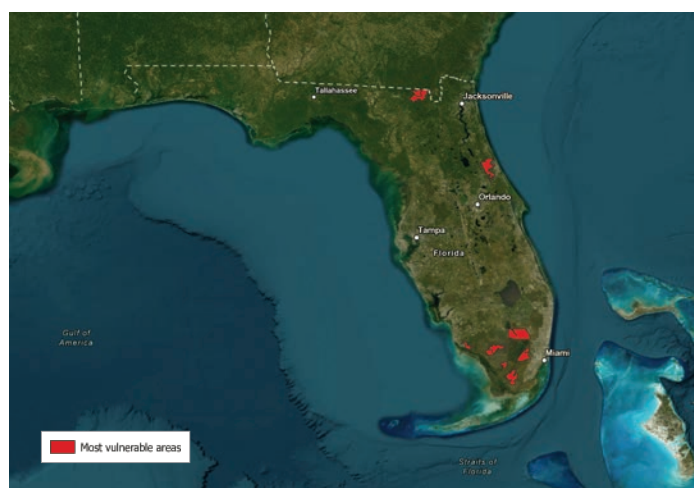
← Crystal River State Archaeological State Park is one of Florida's many midden/mound sites.

of Historic Places (NRHP) potential. NRHP eligibility is used to focus on those sites that are deemed to have the most research potential. Sites containing human remains are also considered among the most vulnerable.

The risk map revealed that 380 sites are located in the most wildfire-vulnerable areas. Of these, over 200 are precontact (dating to the period prior to European arrival) and 60 of these are identified as midden/mound sites. Many of the sites are ineligible for NRHP classification, but many more are NRHP eligible or require preservation. Nearly half of the sites do not have enough information for evaluation, meaning damage done to these sites might result in catastrophic loss of data. Most importantly, 22 of these vulnerable sites contain human remains.

Risk and Return

Even with these areas and sites identified, many other factors and unknowns impact how cultural sites are protected from fire damage. The project will be fleshed out over time to include some of these factors, such as proximity to susceptible land cover and site depth.



Studies conducted largely in New Mexico show that fire doesn't necessarily affect buried cultural materials. Even a few centimeters of soil cover can be sufficient protection. This is good news, as sites in Florida tend to be more deeply buried than those in other states—but it doesn't mean that Florida sites are not at risk of fire damage. Stumps can smolder and burn, with the potential to affect buried materials in the vicinity. Heavy duff, surface logs, and roots that smolder and burn also have the potential to expose subsurface materials to heat over time. In addition, root structures in many Florida plants are shallow due to high water table, which can carry burn into buried archaeological sites such as midden/mound sites. The southern part of the Florida peninsula also has exposed limestone in many areas, limiting the soil cover.

Fire damage might cause ceramics to change color or to spall (flake or fragment). It could also damage surface decoration. Beyond damage to the materials, fire could also affect thermoluminescence dating, which uses light emitted from an object to determine age.

In addition, organic materials tend to burn at lower temperatures than other types of artifacts. Most Florida sites contain numerous bone and shell artifacts, which could undergo changes in color or appearance. Bone might also shrink or crystallize, which affects the ability to assess it.

Another consideration in assessing wildfire impact is shell heat capacity. Most Florida midden/mound sites are composed primarily of shell materials. However, studies evaluating the thermal conductivity and heat capacity of shells haven't tested for wildfire situations, which would be a significant factor in evaluating risk for Florida sites.

Even with all these risks and factors still up in the air, the project can go a long way toward helping Florida archaeologists plan for the worst. Archaeologists working within these boundaries can implement fire-resilient site management practices such as vegetation clearing to remove excess duff, and site documentation for previously unevaluated sites. Above all, this project highlights the need for careful and continued site monitoring, especially pre- and postfire, to make sure that Florida's history is well protected.

About the Author

April Watson, PhD, is an associate professor of natural and applied sciences at Lynn University. Watson studied archaeology at Florida Atlantic University. She focused her research on the precontact period of the Caribbean and South Florida, with a particular focus on lithic and ceramic technologies and GIS modeling. She subsequently worked in cultural resources management before returning to graduate school to receive her PhD in geosciences. Watson has worked as the archaeologist for Everglades and Dry Tortugas National Parks and has collaborated with the Florida Public Archaeology Network, Palm Beach County, and the University of Miami. Her research interests include GIS, archaeology, and climate change. For more information, please contact Watson at apwatson@lynn.edu.

↗ Florida's most wildfire-vulnerable areas, depicted by combining wildfires over 23,069 acres burned and higher archaeological site density. Density was classified as over 11 sites in an area.

↙ Risk map of wildfire damage to archaeological sites in Florida. This included land cover of very high or high wildfire potential, as well as classification of sites based on NRHP potential.

GIS Governance for the AI Era

By Matthew Lewin

I wrote an article for the fall 2022 issue of *ArcUser* called “GIS Governance Distilled,” which outlined a simple GIS governance framework and offered guidance on using it to improve the oversight of GIS programs. It was built on the notion that the most effective GIS departments are diligent about building a system of rules, practices, and processes to direct their efforts.

In the few short years since that article appeared, generative AI and other AI-based technologies have upended the GIS world, introducing solutions like smart assistants and autonomous agents. These advances have created an entirely new class of governance challenges driven by the trend toward machine-led decision-making and concerns about trust and reliability.

The simplified framework from the original “GIS Governance Distilled” article (outlining structure, controls, processes, and performance across six domains) remains a solid foundation. What’s changed is the content within those components.

We need new roles or sets of responsibilities in the structure for AI oversight, new or revised controls (policies and standards) to guide AI usage and ethics, updated processes to handle the AI life cycle (from approval to audit), and new performance metrics (like measuring AI model accuracy or bias as part of program success).

So, how exactly is AI driving new governance best practices, and how can you address the shift?

Structure: New AI Oversight Functions

AI introduces culpability and decision-making dynamics into GIS programs that traditional governance structures weren’t designed to handle.

For example, when an AI-supported system provides a spatial analysis or generates a map autonomously, who is accountable if

something goes wrong? Existing governance typically assigns a person (e.g., a data owner or application owner) to be responsible for those outcomes, but with AI, algorithms are increasingly acting partly on their own. This can lead to finger-pointing unless roles are updated. New oversight roles are emerging as a solution.

General IT guidance now calls for establishing an AI review board. This is a multidisciplinary committee that reviews and guides AI use, including legal, ethical, data science, and business stakeholders. Its duties would include oversight of bias, approval of high-impact AI deployments, and monitoring for ethical compliance. This certainly applies to GIS solution deployment and would ideally include specialist GIS expertise. Alternatively, consider embedding AI expertise into existing GIS governance committees. This ensures that whenever AI is part of a decision, someone at the table understands it and owns the consequences.

Update committee charters to include AI responsibilities. For example, the GIS data subcommittee should oversee the quality and bias of AI training data, while the technology subcommittee should review AI system architecture and security.

Additionally, the role of a model owner or steward is emerging generally. IBM’s guidance on data governance for generative AI suggests designating an owner for each relevant AI model who is responsible for the model’s generation and operation. They would ensure that the model is developed and deployed in line with governance policies. For spatial machine learning models and spatial vision-language models, a model owner experienced with training spatial models should be assigned ownership and responsibility for the integrity and alignment with overall AI standards.

Controls: AI Embedded into Spatial Data Policies

Conventional GIS governance controls such as policy documents and usage guidelines often lack enforceable mechanisms for specific AI behavior and may need to be revised in the AI era.

Many organizations have rules on how internal data can be shared or published, but they may not address scenarios like an employee feeding proprietary geospatial data to a generative AI service to obtain an analysis. Such an action could inadvertently expose sensitive data to an external model. Without clear policies, staff might not realize this is prohibited.

One tactic would be to implement a responsible AI-use policy or to update existing data policies to explicitly cover AI and GIS data specifically. This could include rules about what types of data can or can't be used to train AI or be inputted into third-party AI tools; requirements that only approved, secure AI platforms be used for certain data; and guidelines on reviewing AI-generated content for sensitivity before release. It's also a good idea to embed fairness and bias-mitigation standards into model development and deployment workflows.

Similarly, security policies should cover GIS deployments that access external large language model (LLM) services or require agents to have elevated system access. Ensure that AI systems undergo security testing and that any AI with elevated system access has constraints (an agent shouldn't be granted admin rights beyond its needs, for example). Agentic AI can chain actions in unpredictable ways, so enforcing the principle of least privilege (giving AI only the minimum access needed) becomes a procedural must.

Processes: Dynamic Oversight Needed

Governance isn't just about who decides, it's also about how decisions are made and enforced day to day. AI introduces several new governance process requirements and puts pressure on existing ones.

Most GIS departments have processes for evaluating new projects or technologies—for instance, an architecture review or a project approval checklist. Historically, these might check for budget, alignment with strategy, security, etc. Now, they must also ask: Have we evaluated the AI-related risks? AI systems can carry unique risks like algorithmic bias, unpredictable behavior such as hallucinations, or regulatory compliance issues (e.g., does

using a cloud AI service violate privacy laws or data sovereignty policy?). If governance processes don't explicitly include these considerations, unintended risks could slip through. Project intake workflows should include AI risk screening, which asks whether a proposed solution uses AI, what kind of AI it uses, and whether it requires ethical or compliance review.

Monitoring for data sovereignty adherence is particularly important. AI models trained on sovereign GIS datasets may embed sensitive spatial patterns or infrastructure details into their parameters. If these models are shared or commercialized, it could result in indirect exposure of protected data even if the raw data isn't explicitly shared. This is especially problematic for sensitive land data, critical infrastructure, and defense-related geospatial assets. It's worth implementing private-by-default AI strategies. Use local or on-premises AI models for sensitive GIS data, or leverage retrieval-augmented generation (RAG) architectures that keep data within sovereign boundaries.

Also, generative AI is capable of producing new spatial content (e.g., synthetic maps, inferred land-use layers) based on sovereign data. If these outputs are used outside the originating jurisdiction or without proper governance, they may undermine local control over how spatial knowledge is represented and used. Define rules for how synthetic or inferred geospatial outputs can be used and shared, especially when derived from sovereign datasets.

Change management must account for AI model updates. If an AI model is retrained, governance should define who approves the new version and how it's tested.

Performance: AI-Specific Metrics

As AI becomes increasingly embedded in GIS programs, traditional performance governance must evolve to address new dimensions of success, accountability, and risk.

Historically, GIS program performance was measured with metrics like system uptime, data quality, and user satisfaction. However, AI introduces complex, dynamic behaviors such as autonomous decision-making, generative outputs, and model drift that require more nuanced and continuous oversight.

One major challenge is redefining what success looks like. AI-driven GIS outputs must be evaluated not only for technical accuracy but also for fairness, transparency, and ethical compliance. For example, a model with high overall accuracy may still produce

biased results that disproportionately affect certain communities. Governance must incorporate fairness audits, bias detection, and stakeholder trust metrics to ensure equitable outcomes. Augment your existing GIS performance indicators with AI-focused ones. Consider metrics for accuracy, bias, user trust, and AI uptime. Implement continuous monitoring. Don't treat AI evaluation as a one-off. Many AI platforms can monitor whether input data is shifting or whether outputs start differing from expected patterns. Subscribe to these alerts.

AI-based decisions must also be explainable and traceable, especially when used in planning, public services, or regulatory contexts. Governance frameworks should track how often AI outputs are overridden by human reviewers, whether explanations are available, and how well ethical principles are embedded into workflows. Integrate AI performance into regular governance reporting. For example, in quarterly reports to your GIS steering committee, include a section like this: "AI in our operations—here's what it did, here's how it performed, here are any issues and how we addressed them." This keeps AI's contributions and challenges visible at the executive level, which is important for accountability.

On the technical side, performance monitoring also becomes more complex. AI models can degrade over time due to data drift or changing conditions. GIS governance must implement continuous validation and model-retraining protocols. Dashboards should report on model accuracy and compliance status, similar to how system health is tracked today. Some of this means it's important to invest in monitoring infrastructure, such as audit logs and centralized dashboards, which provide visibility into AI behavior.

In addition to numbers, gather qualitative feedback. Have an open channel for users to report concerns or odd behaviors from AI tools. Track how many suggestions for improvement come in related to AI. This can be a performance indicator of its own (if too many people report that the AI isn't helpful, that's a problem to solve).

Integrating AI into Your GIS Strategy

I'd be remiss if I didn't mention strategy. Many GIS strategic plans did not originally account for AI, or treated it only as a distant innovation topic. Now that generative and agentic AI are becoming mainstream (with GIS software incorporating AI capabilities and users expecting them), not having a clear AI direction is a governance gap.

Organizations may end up with ad hoc AI experiments (some departments forging ahead, others holding back) that don't align with long-term objectives. Governance at the strategic level should ensure that there is a cohesive AI game plan: either as part of the GIS strategy or as a stand-alone AI strategy that interlocks with it.

Your strategy should answer these questions:

- Where will we apply AI in our geospatial program?
- What goals do those AI use cases serve?
- What is our risk appetite with AI?
- What investments in skills and technology are needed?

For example, if a city's GIS strategy included improving residents' engagement, the plan might now include deploying a generative AI assistant to answer spatial queries from residents. However it's handled, managers should act proactively to update their existing GIS strategies and ensure that AI efforts are spent productively.

The introduction of generative and agentic AI into geospatial programs brings tremendous opportunities (faster analysis, innovative services, automation of tedious work) but also significant governance headaches around accountability, data management, and risk.

Perhaps the most important mindset shift is recognizing that governance itself must be agile and innovative. Just as GIS technology is innovating, governance practices can't remain static. Managers should treat the governance framework as a living tool and iterate on it as AI use cases grow. This might mean pilot-testing an AI governance addendum in your GIS department's governance charter, then refining it. It's better to start with some guidelines and committees for AI now (even if not perfect) than to leave AI completely ungoverned in a rapidly evolving environment. With the right adaptations, you'll be in a better position to navigate the AI era confidently and achieve your GIS program's goals in a dramatically changing technology landscape.

About the Author

Matthew Lewin is the director of management consulting for Esri Canada. His efforts are focused on helping management teams optimize and transform their businesses 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. His interests lie at the intersection of business and technology and he thrives on helping organizations bridge the gap between the two to achieve their most challenging GIS ambitions.



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Keeping Utah Moving with a Solid Geospatial Foundation

By Brian Cooke

In 2011, the Utah Department of Transportation (UDOT) began developing a comprehensive inventory of its roadway assets to address the serious transportation challenges presented by the landscape. With Utah's high mountain passes and deep valleys, the state's rapidly growing population is concentrated in a confined area. Winters bring heavy snow to major highways, while summer heat stresses infrastructure. Traveling along state roads, UDOT vehicles equipped with lidar and photogrammetry equipment captured everything from signs and barriers to rumble strips and striping.

When UDOT's planning division sought a way to share this unprecedented collection of data across the organization, ArcGIS Online was the solution, enabling users to create maps and manage their own data. What started as a platform called UPlan for sharing roadway assets eventually became the foundation for an enterprise-wide geospatial program.

What distinguishes UDOT's program is not any single technology deployment, but rather a deliberate, holistic approach to the business of GIS—transforming scattered data and static maps into an integrated digital foundation that keeps people in Utah moving safely and efficiently through challenging terrain and often harsh weather conditions.

Moreover, UDOT exemplifies the five components of Esri's Path to Geospatial Excellence framework: aligning business strategy with organizational goals, establishing robust governance frameworks, architecting flexible systems, driving broad engagement, and building organizational capacity through training and career development. This makes the department a textbook example for other agencies or organizations that aim to go down the same road.

Business: Aligning Technology with Organizational Strategy

Building a strong geospatial foundation requires alignment with organizational mission and vision. For UDOT, this meant establishing a geospatial strategy with specific business goals and objectives that ensured that GIS would support core departmental functions tied to the linear referencing system that anchors a wide variety of projects and more than 500,000 assets.

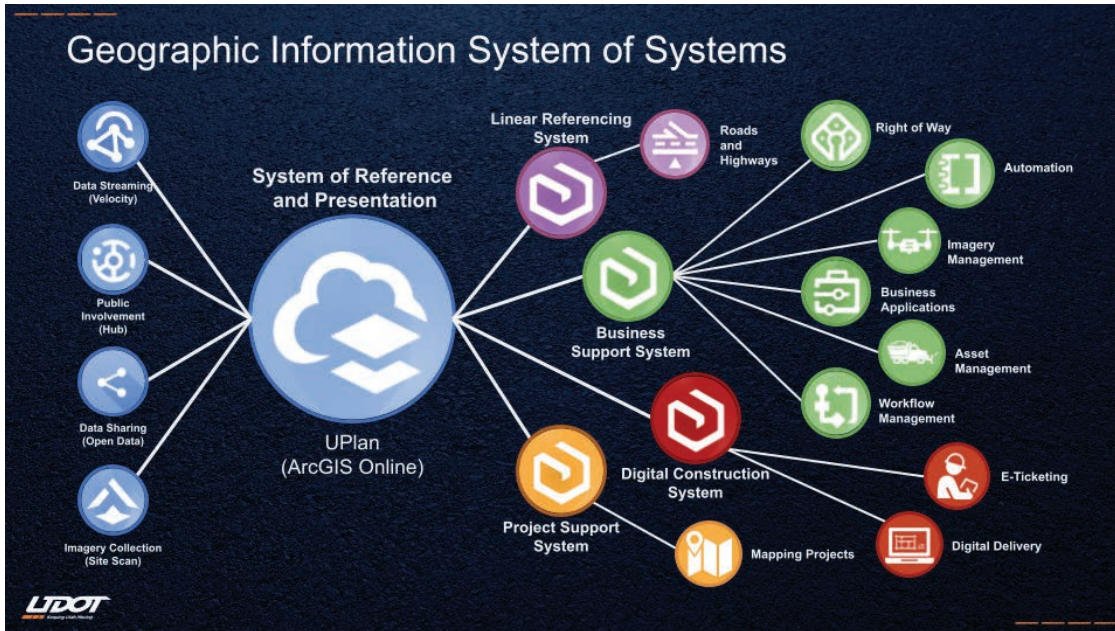
"By having this live picture, we're better able to get people where they're going safely," said Corey Unger, GIS program manager at UDOT. The department's strategic direction emphasizes innovation and collaboration, with geospatial technology providing the spatial context needed to optimize processes and support data-driven decisions across planning, design, construction, and maintenance operations. This directly contributes to the organization's overall success.

Governance: Establishing Frameworks for Quality and Trust

Early success with ArcGIS Online brought unexpected challenges as it freed users to create maps and manage their own data.

"It started to become a victim of its own success," Unger explained. ArcGIS Online became so popular at UDOT that it evolved into what he described as a chaotic mess. "It became a dumping ground where we had copies and copies of data and a lot of it was old and out-of-date," he recalled.

UDOT's response was to establish a formal approach to decision-making consisting of policies and procedures that



← Demonstrating the Systems component of Esri's Path to Geospatial Excellence, the Utah Department of Transportation uses four ArcGIS Enterprise environments supported by ArcGIS Online.

↓ GIS technology helps the Utah Department of Transportation meet the challenges of Utah's rugged topography.

enabled positive change. The UDOT Central GIS Group implemented robust governance frameworks with administrators across each system along with coordinators who could share content at certain levels, addressing leadership, authority, decision-making, and accountability. To ensure that public-facing content met quality standards, UDOT implemented a formal review process tied to department policy.

"Anything that's shared publicly needs to fit certain standards," Unger explained. Governance requirements now specify that content must meet metadata standards, have configured pop-ups, and follow proper theming guidelines before administrators approve it for public sharing. This has dramatically increased content quality and reinforced senior leadership's trust in the geospatial program through effective governance and holistic business alignment.

Systems: Building a Flexible, Well-Positioned Architecture

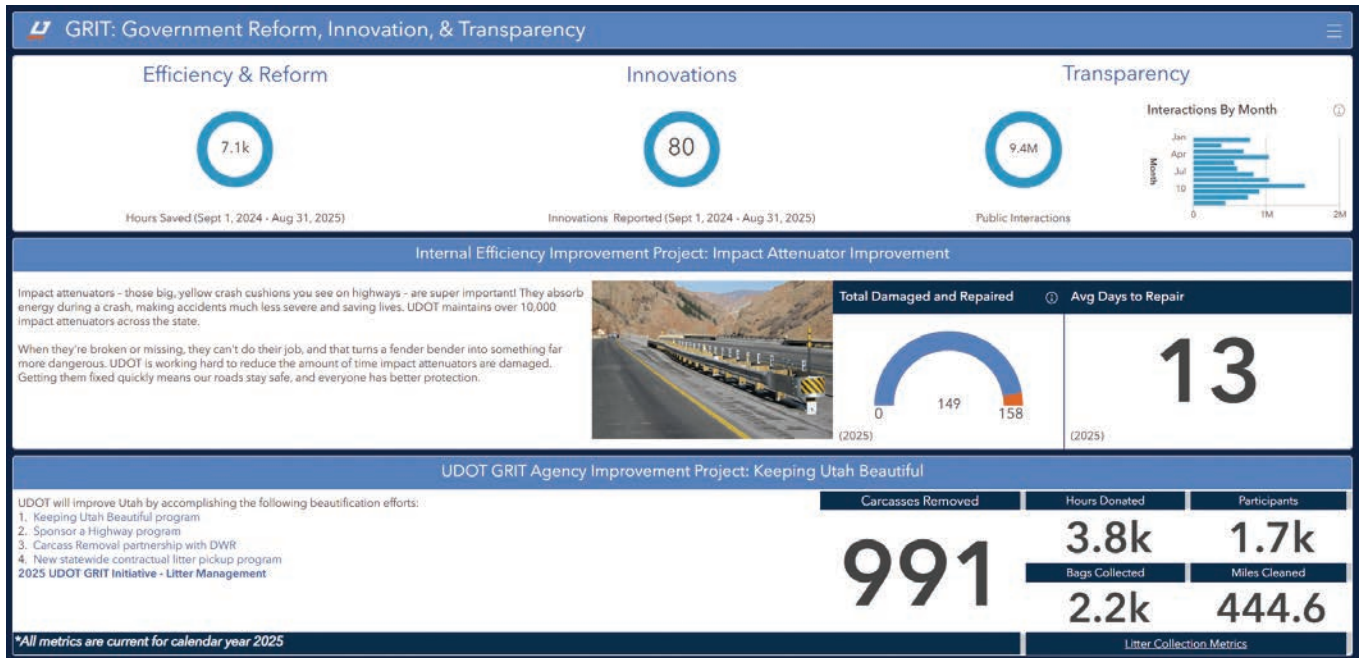
UDOT's GIS technology evolved from a single server to what Unger calls a "system of systems," which consists of four distinct ArcGIS Enterprise environments supported by ArcGIS Online as

the central system of reference and presentation. This architecture reflects a systematic mindset—multiple purpose-built ArcGIS Enterprise environments operate independently yet are integrated through ArcGIS Online to support scalability, resilience, and diverse business needs.

The four enterprise environments serve specific functions. The Linear Reference System environment, supporting about five users, manages routes and reference posts that form the backbone of departmental data. The Business Support System serves central office functions including right-of-way management, server automation, and workflow management. The Digital Construction System handles everything from preconstruction planning through construction execution. The Project Support System serves UDOT's four regional offices, which manage day-to-day operations and projects with needs that are distinct from central office or construction groups.

"By developing this architecture where we have these separate systems, we're able to cater them to support the specific needs of these programs and groups," Unger said. This flexible approach ensures a well-positioned system designed to meet diverse organizational needs.





↑ A Utah Department of Transportation dashboard tracks improvement projects and more.

Engagement: Driving Adoption Across the Organization

The department gained adoption across all areas that could make the most of a geographic approach by clearly articulating benefits and highlighting ways GIS improves processes and decision-making in focused areas.

“We look at GIS as providing not just a map but a solution,” Unger said.

This engagement strategy led to innovative use cases across divisions. UDOT’s legislative tracking solution, which monitors potential laws affecting transportation, is one example where GIS technology solved a problem with minimal spatial components. This streamlined processes for the entire department and boosted the GIS program’s reputation for innovation.

“UDOT gives out innovation awards every year,” Unger said. “Last year, three out of four of those awards were for GIS-based solutions.” This widespread adoption demonstrates truly successful use of GIS across the organization.

Capacity: Training Requirements and Career Development

UDOT recognized early that technology alone wouldn’t drive adoption; instead, people needed the skills and motivation to use GIS effectively. The department now requires training—frequently from Esri Academy—before granting system access to staff, assessing their current proficiency levels and tailoring development opportunities to meet specific needs.

“When people request accounts to our systems, we require that they take certain training so that we know that they at least have this basic level of competency before they are allowed access,” Unger explained.

Training varies by role, whether the user is a GIS analyst or a maintenance worker. For example, staff using the Mobile Worker user type must complete training modules for ArcGIS Field Maps, ArcGIS Survey123, and ArcGIS Online editing, while those with a Creator user type are required to take courses on ArcGIS Experience Builder, ArcGIS Dashboards, and other ArcGIS applications.

Beyond initial training, UDOT also established a career ladder that provides GIS analysts with a clear path for advancement. This capacity-building approach helps UDOT retain trained staff, maintaining institutional knowledge and supporting quality standards. This enables teams to execute projects, better leverage technology, and make valuable contributions.

Delivering Measurable Impact Through Geospatial Excellence

Integrating all five components of the Path to Geospatial Excellence has given UDOT a strategic edge and a proven framework that drives exceptional effectiveness and sustained success. Asset tracking is one example. The department can now assess the condition of road signs, identify those in poor condition, determine their locations, and estimate replacement costs.

In addition, a winter weather dashboard shows the benefits of integrated data analysis. By combining automated vehicle location data from snowplows with maintenance information and weather data, UDOT can estimate storm-related costs such as personnel time, salt usage, and equipment. This helps the department plan for future storms, Unger said.

UDOT's digital data delivery initiative continues expanding to more projects, driving the need for proactive infrastructure scaling. A planned migration to Linux will reduce costs and improve scalability, Unger said. Collaboration with Utah's Department of Technology Services and Esri Professional Services remains central to the

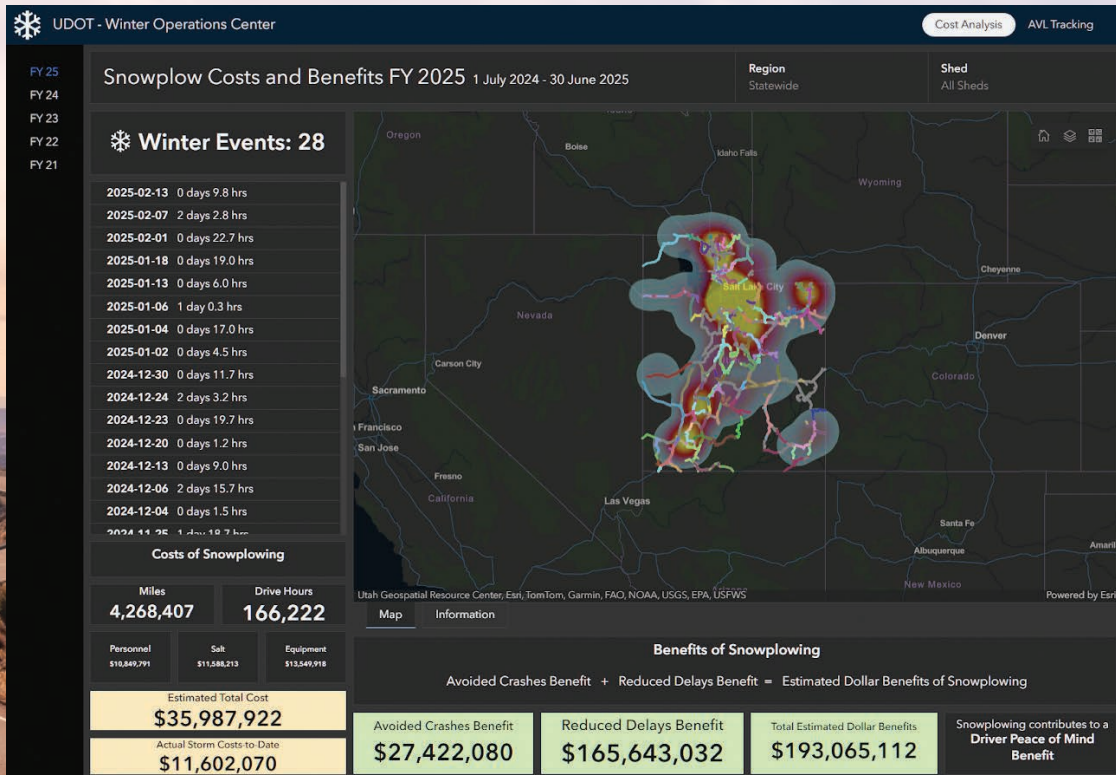
strategy, with annual planning meetings that establish goals such as digital twins, cloud migrations, and infrastructure optimization.

"It has taken a while to set it all up this way," Unger reflected, noting that the evolution from enthusiastic adoption to structured enterprise system required patience, strategic planning, and consistent focus on geospatial excellence.

UDOT's experience demonstrates that building a strong geospatial foundation requires balancing all five components of the Path to Geospatial Excellence. Together, these elements create what Unger describes as sustained trust that "allows innovation to flourish at organizational speed," making UDOT a model for organizations seeking to maximize the impact of their GIS programs.

About the Author

Brian Cooke is a writer and contributing editor for the Esri publications team. He helps readers stay informed about ArcGIS technology and tells compelling stories about how Esri partners and users apply Esri technology. Cooke has worked as a marketplace researcher, an enterprise technology analyst, a technical writer and editor, and an environmental science writer for clients such as the US National Park Service and the US Forest Service. In addition to a bachelor's degree in science writing from Lehigh University, he has a master's degree in natural resource stewardship and a certificate in conservation communications—both from Colorado State University.



← A winter weather dashboard combines automated vehicle location data from snowplows with maintenance information and weather data, helping the Utah Department of Transportation estimate storm-related costs.



GNSS Accuracy Unlocked: How Correction Methods Improve Field Data Collection

By Morgan Zhang

When a utility technician needs to locate an underground valve buried beneath snow and vegetation, or when a construction inspector must verify that a newly installed water line matches design specifications within a few centimeters, basic GPS accuracy isn't enough. Today's GIS professionals need positioning precision that ranges from submeter- to centimeter-level accuracy. Understanding the correction methods that deliver this precision—and knowing which method fits your project requirements—can mean the difference between efficient operations and costly mistakes.

What Is GNSS?

GPS has become the common technology for determining outdoor location using smartphones or specialized receivers. However, GPS is just one component of a broader positioning infrastructure, the Global Navigation Satellite System (GNSS). Many countries and regions now operate their own satellite navigation systems, including GLONASS (Russia), Galileo

(European Union), BeiDou (China), QZSS (Japan), and NavIC (India).

The original GPS constellation, established in 1973 by the US Department of Defense, maintains about 31 active GNSS satellites out of the more than 100 operational satellites that orbit the Earth. In California, a multiconstellation GNSS receiver typically tracks more than

25 satellites simultaneously—a dramatic increase from the early days when users had to carefully plan collection windows to ensure adequate satellite visibility.

Why More Satellites Matter for GIS

To calculate a three-dimensional position, a GNSS receiver must track signals from at



least four satellites. More satellites provide several advantages for GIS data collection, including the following:

- Improved availability in difficult environments. Urban canyons and dense forests that once blocked GPS signals now allow positioning, thanks to multiple GNSS constellations providing alternative satellite coverage.
- Enhanced accuracy via multifrequency signals. Modern GNSS satellites transmit multiple radio frequency signals. For example, GPS now broadcasts L1 C/A, L1C, L2C, and L5 signals for civilian use, expanding from the original single L1 C/A signal. These multifrequency signals help receivers reduce ionospheric delay, which is the largest error source for stand-alone GNSS positioning.
- Better reliability for field operations. Field crews no longer need to schedule data collection around satellite availability, improving operational flexibility.

What High-Accuracy GNSS Can Do for GIS

Stand-alone GNSS typically provides two- to five-meter accuracy in open areas, but performance degrades in challenging environments with tree canopy, buildings, or other obstructions. For many GIS applications, this level of accuracy proves insufficient.

Consider these field scenarios where higher precision (submeter- to centimeter-level) matters:

- **Utility location and maintenance**—Precise positioning is required to efficiently locate underground assets hidden by snow, soil, grass, or vegetation. Higher accuracy helps technicians avoid delays, reduce excavation costs, and prevent damage during digging operations.
- **Construction verification**—Inspectors need centimeter-level accuracy to confirm that installed infrastructure matches design specifications. An out-of-tolerance installation that goes undetected due to

← The Global Navigation Satellite System (GNSS) provides a variety of services. These include helping transportation departments monitor traffic.



Most GIS users rely on existing base station infrastructure rather than deploying their own stations.

poor GNSS accuracy can trigger project delays or expensive rework.

- **Asset differentiation in dense areas**—Where multiple trees, valves, signs, or utility points cluster together, precise positioning becomes essential for distinguishing between similar assets and maintaining accurate records.

What's the Differential?

Differential correction techniques improve GNSS accuracy by calculating and removing systematic errors. The underlying principle has been the same for decades. Two

receivers located relatively close together experience similar atmospheric and satellite errors. By calculating these errors at a precisely known location and applying corrections to a roving receiver, differential methods achieve higher accuracy.

However, today's correction methods differ from methods of the past when it comes to implementation, coverage area, accuracy level, and cost structure. Understanding these differences helps you select the appropriate method for your projects.

RTK Positioning

Real-time kinematic (RTK) positioning remains the most popular correction method for achieving centimeter-level accuracy. It requires at least two GNSS receivers: a base station at a precisely known location and a rover collecting field data. The base station calculates errors by comparing its computed position against its known location, then transmits corrections to the rover.

RTK accuracy depends heavily on the baseline, which is the distance between base and rover. Manufacturers express

baseline accuracy in parts per million (ppm). One ppm equals one millimeter of error per kilometer of distance. For example, a receiver with 8 mm + 1 ppm horizontal accuracy starts with 8 mm base accuracy, but at 30 km from the base station, accuracy decreases to 3.8 cm. As accuracy degrades with distance, initialization time also increases.

Network RTK (NRTK) and real-time network (RTN) technology use multiple base stations to cover wider regions, overcoming single-base RTK distance limitations. Virtual reference station (VRS) systems create a virtual base station near the user's location by computing corrections from multiple reference stations.

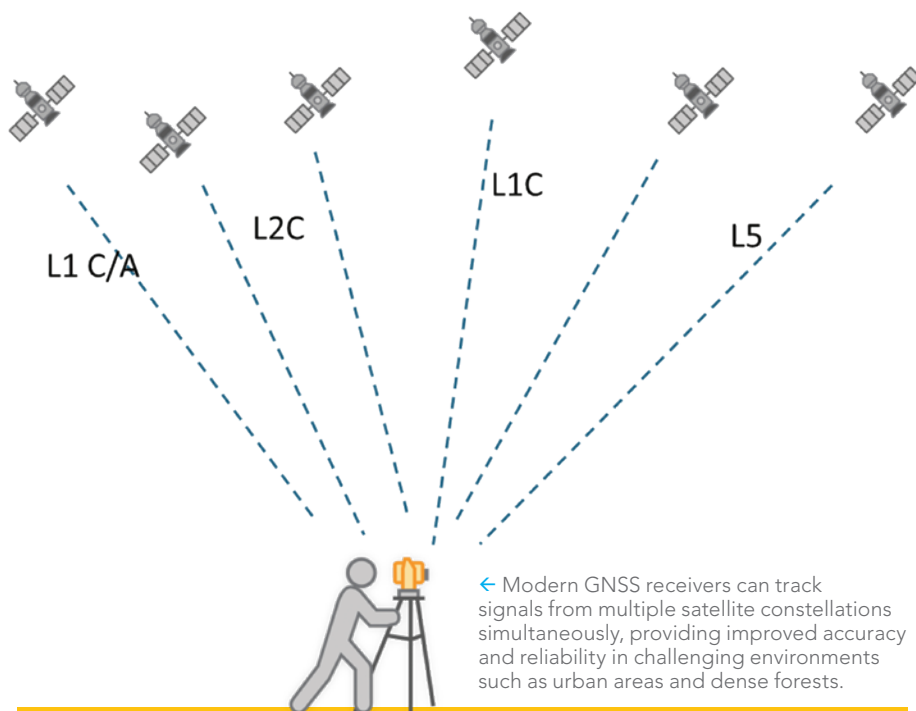
Most GIS users rely on existing base station infrastructure rather than deploying their own stations. Options include permanent company-owned stations and third-party services from government agencies or commercial providers. In the United States, some state departments of transportation provide free statewide RTK services.

Understanding RTK Data Standards

Standardization plays a critical role in RTK operations. The Radio Technical Commission for Maritime Services (RTCM) Special Committee (SC) 104 standardizes RTK correction data protocols. In 2023, RTCM SC 134 standardized narrow-band ultra-high frequency radio data links, improving on earlier proprietary manufacturer protocols.

For internet-based corrections, Networked Transport of RTCM via Internet Protocol (NTRIP) serves as the widely adopted standard. Finding an RTK correction source means identifying an NTRIP caster—a server that broadcasts correction data. Each caster offers multiple mount points, which are unique identifiers for specific correction data streams.

Mount point selection matters because it determines which satellite constellations your rover can use. For example, Esri's base station (a Trimble NetR9 receiver) in Redlands, California, provides three mount points: gisar23 (GPS only), gisar30 (GPS plus



↓ GNSS receivers help surveyors reduce position computing errors.



GLONASS), and gisaMSM5 (multiconstellation GNSS). Selecting gisar23 limits the RTK solution to GPS satellites, even if the rover supports additional constellations.

Satellite-Based Augmentation System

A satellite-based augmentation system (SBAS) provides free submeter-level accuracy in many global regions and commonly comes built into professional GNSS receivers. Government agencies operate SBASs, which collect corrections from multiple reference stations, relay data to a main station, and uplink corrections to geostationary satellites. Your GNSS rover receives corrections directly from these satellites. SBAS coverage regions include the following:

- Wide Area Augmentation System (WAAS)—North America
- European Geostationary Navigation Overlay Service (EGNOS)—Europe
- BeiDou Satellite-Based Augmentation System (BDSBAS)—China

- Multi-functional Satellite Augmentation System (MSAS)—Japan
- GPS Aided Geo Augmented Navigation (GAGAN)—India
- System for Differential Corrections and Monitoring (SDCM)—Russia
- Southern Positioning Augmentation Network (SouthPAN)—Australia and New Zealand

Each system covers a wide area—sometimes an entire continent. And because SBAS delivers corrections via satellite, it works in areas lacking cellular or internet connectivity.

Precise Point Positioning

While differential methods compute differences between base and rover measurements, precise point positioning (PPP) takes a different approach. It models error-causing factors and estimates corrections from a global network of reference stations. PPP offers several advantages: global coverage, no baseline distance limitations,

and better accuracy than SBAS. It typically achieves 3- to 10-cm accuracy after an initialization period of about 20 minutes.

PPP-RTK represents the latest evolution in correction methods, combining PPP and RTK techniques to reduce initialization time while maintaining near-RTK accuracy. It uses reference station networks to compute satellite and regional atmospheric errors, then broadcasts correction data. Unlike standard PPP, PPP-RTK provides regional rather than global coverage.

Each system covers a wide area—sometimes an entire continent.



↑ Several countries and regions operate their own satellite navigation systems.

Both PPP and PPP-RTK can broadcast via internet or satellite. Satellite signal delivery makes these methods valuable for accurate positioning in areas without internet access. Beyond commercial PPP services, some governments provide free services including

Japan's Centimeter Level Augmentation Service from Quasi-Zenith Satellite System (QZSS) satellites and Galileo's High-Accuracy Service (HAS). These services cover specific regions with varying accuracy and initialization performance.

Matching Methods to Your Project Needs

Determining your approach starts by defining your accuracy requirements. If submeter accuracy suffices, SBAS is a cost-effective solution that's often free and built into professional GNSS receivers. When projects demand centimeter-level precision, RTK or PPP methods may be a better choice. Also consider these factors:

- Available coverage and baseline distance
- Data delivery options (internet versus satellite)
- Service ownership and infrastructure costs
- Initialization time requirements
- Need for real-time positioning versus postprocessing

Selecting the right correction method balances accuracy needs, budget, and

Selecting the right correction method balances accuracy needs, budget, and operational constraints.

Postprocessing Methods

All these methods provide real-time corrections, eliminating office processing work. However, some applications benefit from postprocessing approaches. For example, the Post Processed Kinematic (PPK) data processing technique commonly supports drone mapping operations. It records raw GNSS data during flight, then processes it after completion using measurements from a nearby base station with a known location. In remote areas or complex environments where signal loss might occur, PPK can improve the yield of accurate positions during missions.

Choosing Your Correction Method

Method	Typical Accuracy	Initialization Time	Coverage	Internet Required
RTK (single base)	1–3 cm	Seconds	~10–30 km from base	Yes (or radio)
NRTK/RTN	1–3 cm	Seconds	Regional (network coverage)	Yes
SBAS	0.5–1 cm	Seconds	Continental	No (satellite)
PPP	3–10 cm	~20–30 minutes	Global	No (if via satellite)
PPP-RTK	2–5 cm	A few minutes	Regional	No (if via satellite)
PPK	1–3 cm	Postprocessing	Anywhere	No (real-time not needed)

operational constraints. Carefully evaluating project requirements alongside available infrastructure and service options can help ensure reliable positioning performance while optimizing efficiency and cost.

Expanded GNSS constellation and modern correction techniques have transformed field data collection capabilities for GIS professionals. Understanding these

correction methods, as well as their specific strengths and limitations, can empower users to capture the high-accuracy spatial data that their projects demand.

About the Author

With a background in electrical and mechanical engineering and over 15 years

of experience in mobile data collection, **Morgan Zhang** has consistently viewed GIS as a complex engineering challenge. As a principal product engineer at Esri, he brings a cross-discipline approach to tackling exciting problems in GIS, like integrating GNSS and other sensors with location-based field applications to create innovative solutions.

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↓ Because the Grand Mosque in Porto-Novo lacks the dedicated resources for it to be maintained beyond minimal upkeep, its digital preservation is vital.



Maps Are Memory

By Ben Van Voorhis

At first glance, the Grand Mosque in Porto-Novo, Benin, might seem like little more than a ruin. Built sometime between 1906 and 1912, the mosque has fallen out of use and into disrepair: discolored minarets, busted windows, splotches of flaking paint. Vegetation sprouts from its upper stories. Still, it's hard to deny the underlying beauty of the structure, with its ornate pillars and elaborately carved facade. As a once-grand building that lacks the dedicated resources for it to

be maintained beyond minimal upkeep, it's tempting to see the mosque as a monument to urban decay.

But the Grand Mosque also tells another story. In the late 19th and early 20th centuries, many West Africans and their descendants who had previously been enslaved in Brazil came to the region, some returning home, some arriving for the first time. Some settled in Porto-Novo. These were the Aguda people, who brought with them a different set of cultural practices, faiths, and ideas.

African Built Heritage Hub

Search, Visualize, Download, Create

Preserving Sub-Saharan African built heritage through local social participation and digital technologies

About

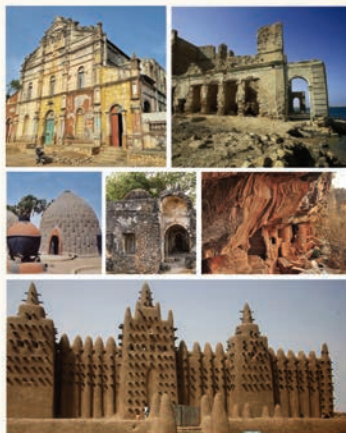
The African Architectural Heritage Hub is a digital platform that enables the preservation of Sub-Saharan African architectural heritage through local social involvement and 3D laser scanning, photogrammetry, and storytelling digital technologies, made available to users via a display interface.

The African continent has numerous declared World Heritage structures (cultural), with more than half located in various Sub-Saharan African countries. In contrast, many more significant structures and buildings remain unlisted as heritage sites.

As of 2018, 93 of these sites are on UNESCO's List of World Heritage in Danger due to threats from extractive processes (mineral and oil exploration), armed conflict, acts of terrorism, climate change, poaching, and uncontrolled rural and urban expansions ([UNESCO](#)).

The primary focus of this project is to explore and document how can heritage structures and cultural sites be conserved through the use of digital tools, technologies, and platforms.

Our research structure is based on a collaborative model that includes local communities who are the owners and custodians of these buildings, technical partners, academic institutions research & students both local and international, and funding partners that enable the training, capacity, and platform development.



Top left- The Grande Mosque, Porto-Novo, Benin; Top Right- Suakin, Sudan; Middle left- Musgum house, Cameroon; Middle- Ancient mosque ruins, Kilwa-Kiswani, Tanzania; Middle right- Grottes-de-Nok caves-in, Togo; Bottom- The Great Mosque of Djenné, Mali

Many had converted to Islam, sometimes as an act of protest. They'd spent decades building Christian churches and cathedrals all across Brazil, particularly in Bahia.

All of this is what led the Aguda to construct the Grand Mosque with its unique architectural identity—a West African mosque that looks like a Brazilian church. And is what makes it such a striking, significant part of Porto-Novo's history and identity.

But its future—like that of so many culturally or historically significant buildings across Porto-Novo, Benin, and West Africa as a whole—is uncertain. One local organization has begun the process of trying to rehabilitate the Grand Mosque and turn it into a museum. Other, similar sites are not so lucky.

"A lot of these buildings . . . both colonial and traditional buildings, are fast disappearing into the African landscape," said H. Killion Mokwete, assistant professor of architecture at Northeastern University. "They're being replaced."

In some ways, this is understandable. Older buildings are more expensive to maintain and modernize; often, it's more efficient and cost-effective to make way for new structures. At the same time, something is lost when these buildings disappear. A city's buildings comprise its history, its identity, and its memory. Although it's not always reasonable to try to preserve them forever, Mokwete and a team of researchers at Northeastern University are

trying to do the next best thing—map these buildings, give them context, construct geospatial ghosts that can inform residents' sense of where they live, and help others learn about the area's rich and complex history.

"The idea is to create a space where we can partner with local groups in the African context—primarily the francophone countries of West Africa—in order to document and digitize architectural built heritage," said Mokwete.

The result of this effort is the African Built Heritage Hub. Northeastern researchers are partnering with local organizations and using GIS tools such as ArcGIS Online, ArcGIS Survey123, ArcGIS Field Maps, and ArcGIS Hub—in conjunction with lidar scanning for the development of 3D digital models—to create a dynamic repository of imagery and knowledge about culturally and historically significant sites across Africa.

An Urban Context

Porto-Novo wasn't the first location the team had in mind. While traveling through Togo, Mokwete became fascinated by takienta—mud tower-houses scattered across the Koutammakou region, which stretches across northeastern Togo and western Benin. He was struck by the fact that the takienta appear to be part of the landscape, rather than imposed on top of it. It turned out, however, that many of the buildings in this area were being replaced by new brick structures.

"I was worried that over time we won't know we actually had these buildings," said Mokwete.

When he approached Northeastern University with the idea to digitally preserve structures like takienta, Mokwete was encouraged to think bigger. Where else could this idea be

↪ The African Built Heritage Hub is designed as a dynamic repository of imagery and knowledge about culturally and historically significant sites across Africa.

↘ An example of the takienta that Mokwete encountered in Togo.





✦ The Zangbeto Temple is one of many significant Vodun sites that the team surveyed.

✦ A significant part of the project was the collection of images from the interior of each site, like this photo from inside the Zangbeto Temple. The images could then be included alongside information about the sites on the Porto-Novo Building Explorer.

applicable—and where were historically significant sites disappearing at ever-faster rates?

“The idea was that if we started with an urban context, there’s much more depth,” said Mokwete. “Buildings in an urban context have to deal with more demand for space and rapid urbanization.”

Other factors influenced the decision as well. Bahare Sanaie-Movahed, GIS specialist at the Northeastern University Library, noted that considerations such as changing climate conditions, infrastructure limitations, economic pressures, and conflicts across

the continent meant that West Africa was the most viable region to pilot the project, with the intent to operate farther afield in the future.

Mokwete scouted a few different locations and ultimately settled on Porto-Novo. If the team members were able to test their idea in an urban area to determine if it was applicable in multiple contexts, the project could expand to more rural landscapes across Africa like the Koutammakou region and beyond.

GIS Is the Backbone

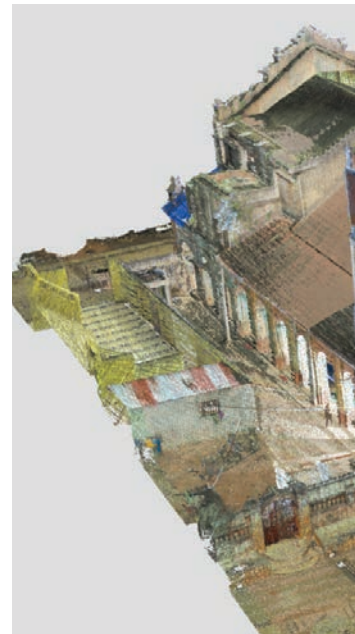
Once the team settled on Porto-Novo, it was time to collect the project data. This process required two crucial components: buy-in from local stakeholders and geospatial technology.

Since the hub’s primary purpose is to accurately document and preserve the heritage of the sites surveyed, local stakeholders were fundamental in ensuring the success of this mission, and often provided personal interviews that the team recorded and ultimately integrated into the hub. The team worked with organizations such as École du Patrimoine Africain and staff from the Royal Palace Musée Honmé, among many others.

The main data collection tools were ArcGIS Field Maps and ArcGIS Survey123, which the team used to survey and record data about individual sites, including details about the architectural features, historical or religious significance, and condition of each structure. These tools were also used to gather information from social participants—residents of the area who had expertise or knowledge about each site.

“GIS is the backbone of the work,” said Sanaie-Movahed. “We also brought in photos through [ArcGIS] StoryMaps, [ArcGIS] Dashboards; and then we started putting all this together in one ecosystem, which is ArcGIS Hub.”

In addition to the Grand Mosque, the team surveyed Zangbeto Temple—a major site in the West African Vodun religion—as well as the Musée Honmé and other significant examples of traditional Beninese, Aguda, and colonial architecture.



Some sites, such as the Grand Mosque, Zangbeto Temple, and Places Vodùn Rénovées d'Adjina—a compound containing multiple Vodun shrines—were good candidates for 3D modeling. The team used drones and lidar scanners to collect visual data on these sites that could then be used to construct digital models, allowing people to explore each site remotely.

This wasn't always a smooth process—drones rely on satellite imagery to design a flight path, and the team was frequently working in areas where this imagery was slow to load.

"Imagine that you are looking on a blank page and then trying to design the flight," said Sanaie-Movahed. "It was really challenging."

"It's like the [lidar] scanner," added Mokwete. "At one point it just overheats because it's so hot out here, and humid. These things are designed in cooler climates. When you bring it here, you have to cool it, otherwise it just breaks down on you."

One of the central technological challenges was processing and hosting the massive files produced by lidar scans in a form that could be easily interacted with, especially in areas with limited internet access or slower internet speeds.

"I think if there's any technological development in the way we process data, that is probably the frontier of making it easier to work with lidar," said Mokwete.

The Past and the Future

"Once we were back in the United States, we started not only creating the hub and then bringing all those stories together, but also digitizing maps that we brought back from Africa," said Sanaie-Movahed. "We brought back images of maps from books, from walls. And then we started digitizing the maps and creating interactive dashboards."

This process of digitization and data aggregation was often done in ArcGIS Pro, and culminated in the Porto-Novo Building Explorer, a dashboard created with ArcGIS Dashboards that allows visitors to the African Built Heritage Hub to explore information about Porto-Novo's historical buildings in context. This dashboard is where much of the survey data the team collected in Benin now

lives, composing a vital living geospatial database of the city's architecture.

"Some of the buildings we saw don't exist anymore," said Mokwete. "We were here a year, maybe two years ago, and the buildings have been demolished to make way for new developments. So if we hadn't georeferenced it, you could have a picture, but no idea of where that picture was taken."

The hub also includes multiple stories created with ArcGIS StoryMaps, as well as the 3D models created from lidar scans. Many of the current models are of highly visible buildings that are likely to be preserved in some physical form, but future scans may help digitally preserve buildings that could soon be erased from the landscape. Being able to explore them in a virtual reality context provides an extra layer of enrichment.

"Interactive engagement means that it's not just an archive," said Mokwete. "It's also live information that people can engage with."

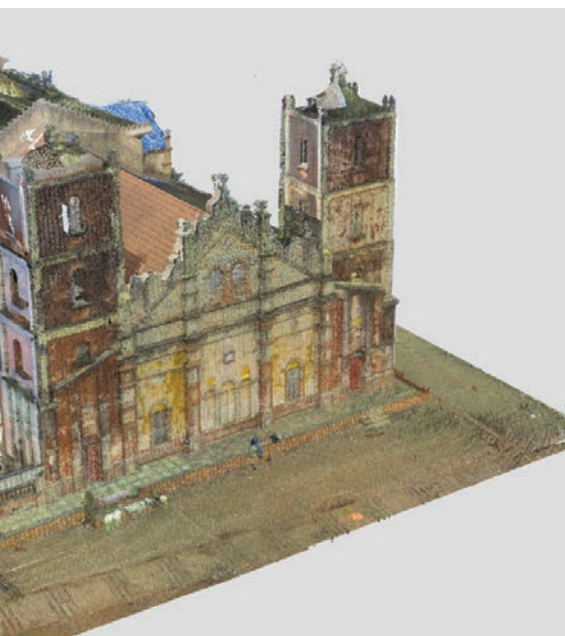
But one of the benefits of an archive, interactive or not, is that it allows residents and nonresidents alike to view the city with a full breadth of context. It can help change how these sites are treated, even within a local framework.

"We are confident that the approaches we tried and piloted in Benin work," said Mokwete. "We're working with students, working with local organizations and partners. After the scanning and the data we've got now, we're in the process of getting grants to rehabilitate one of the buildings based on the work we've done."

This success is especially important as the team looks to expand the scope of the project beyond what has been accomplished in Porto-Novo and Benin.

"These Afro-Brazilian buildings are not only in Benin, they're actually in Togo, Benin, Nigeria, and Ghana," said Mokwete. "So for us, the idea is of continuing that as a thread, almost like a network where we can map, digitize, and geolocate these buildings across the corridor from Togo to Ghana."

↓ The team used drones and lidar scanners to collect data that could be used to construct digital models, like the Grand Mosque (left) or the Places Vodùn Rénovées d'Adjina (right). The 3D models are collected on the African Built Heritage Hub.



For both Mokwete and Sanaie-Movahed, a significant aspect of the project has been the relationships their team has built in the local community, and seeing the impact the project has already had on the ground. When they went to survey Porto-Novo, they found a serious appetite for geospatial memory building.

“There’s just so much potential for impact in the African context,” said Mokwete. “There’s just so much that has not been done and has not been digitized and mapped. There’s such a need and there are partners that are willing.”

“[Residents] use the tool to see what is happening around them,” added Sanaie-Movahed. “How can you create a map that is not necessarily data heavy, but truly engaging for them? They can select something on a dashboard and then look through exactly the building that they are looking for. Select the schools or the universities, whatever we mapped. See the way

➤ The Porto-Novo Building Explorer is where much of the survey data the team collected in Benin now lives, composing a living geospatial database of the city’s architecture.

➤ The team spent a significant amount of time building relationships with residents and local stakeholders, who often provided personal interviews that the team integrated into the hub.

Porto-Novo Building Explorer
Touring Cultural and Political Icons in Architecture

Building Selector
Click Here

Building Name	Architectural Style
NAABI MESAN	

5 of 10

Historical Narrative of Ecole Du Patrimoine Africain- EPA

Architectural features	The buildings are in the colonial style typical around Porto Novo, Benin. The foundation is outlined in a thick concrete structure. Baroque stone balustrades tie the structure to its European roots. The hallways wrap around interior rooms. This paired with large shuttered openings allow for temperature regulation through cross-ventilation.
Building Name	Ecole Du Patrimoine Africain- EPA
History of the building	EPA is a key player in the preservation of African heritage.
Images	View
Religious, political and intellectual importance	EPA (Benin Ecole du Patrimoine Africain) was founded as part of a network of African institutions dedicated to cultural heritage preservation on the continent. Over time, due to changes in national interests among other factors, units around the continent closed down. EPA is the last of its kind, and is now the converging point for pan-African heritage preservation. EPA operates as a training center for young conservationists, a research and exhibition center, and a conservation organization. EPA currently operates out of a set of buildings previously used by colonists and then returned to the custody of the state who gifted the buildings to EPA.

Primary Use: Government,other

the city urbanized. The colonial parts, the different architectural areas on the map. What is unique about this project is this transformation of the heritage of Benin from a static archival map to a living dynamic resource.”

About the Author

Ben Van Voorhis is the editor of *ArcUser*. He has worked as a real estate writer and literary magazine editor, and his short fiction has appeared in numerous publications. He holds creative writing degrees from the University of California, Riverside, and Eastern Washington University.

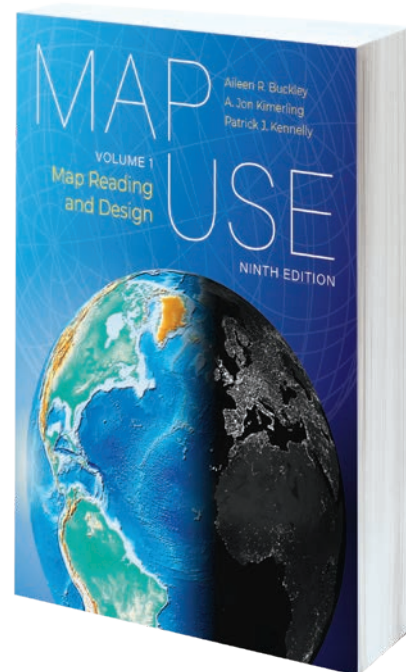


Bookshelf

Map Use: Map Reading and Design, Volume 1, Ninth Edition

By Aileen R. Buckley, A. Jon Kimerling, and Patrick J. Kennelly

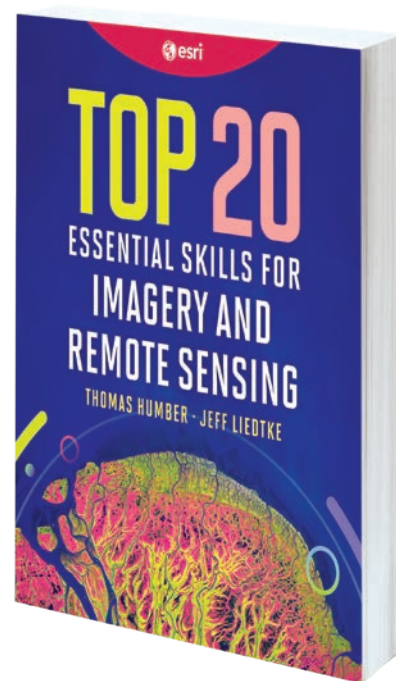
Maps convey as much about how people think and communicate as they do about the mapped environment. *Map Use: Map Reading and Design*, Volume 1, ninth edition, is a comprehensive primer on how to read and understand maps, design and make maps, and recognize their limitations and inaccuracies. Combining authoritative text with hundreds of stunning visuals, the book describes foundational cartographic concepts in the context of the industry's latest innovations. Changes for the ninth edition include reindexing; revised datums, maps, and images; an updated map projection guide; a new state plane coordinate system; and updated text. An online glossary is also available. March 2026, 334 pp. Ebook ISBN: 9781589487765, paperback ISBN: 9781589487758, and hardcover ISBN: 9781589488816.



Top 20 Essential Skills for Imagery and Remote Sensing

By Thomas Humber and Jeff Liedtke

Top 20 Essential Skills for Imagery and Remote Sensing guides readers through key techniques needed to visualize, process, analyze, and manage imagery and raster products. The book contains concise chapters with easy-to-follow tutorials and practical examples. This is an approachable resource for users of all skill levels, from GIS professionals who want to deepen their understanding of imagery to students who are eager to learn about remote sensing. March 2026, 250 pp. Ebook ISBN: 9781589488229, paperback ISBN: 9781589488212, and hardcover ISBN: 9781589488731.



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Make Maps People Want to Look At:

Five Primary Design Principles for Cartography

By Aileen Buckley

Cartographers rely on many design principles when compiling maps and constructing page layouts, whether on-screen or on paper. Five of these design principles form a system for seeing and understanding the relative importance of the content in the map and on the page. Without these primary principles, map-based communication is bound to fail.

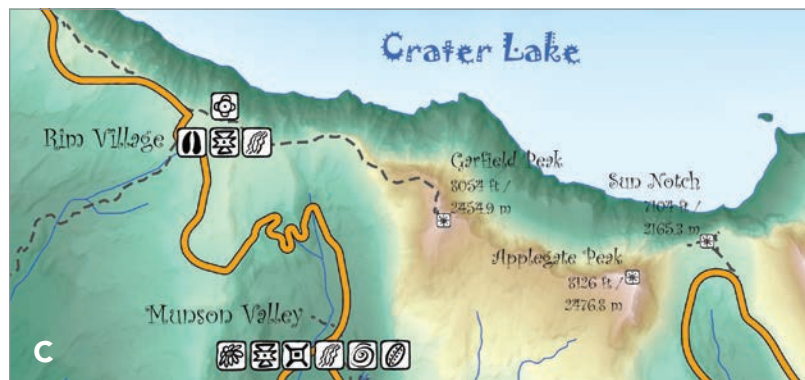
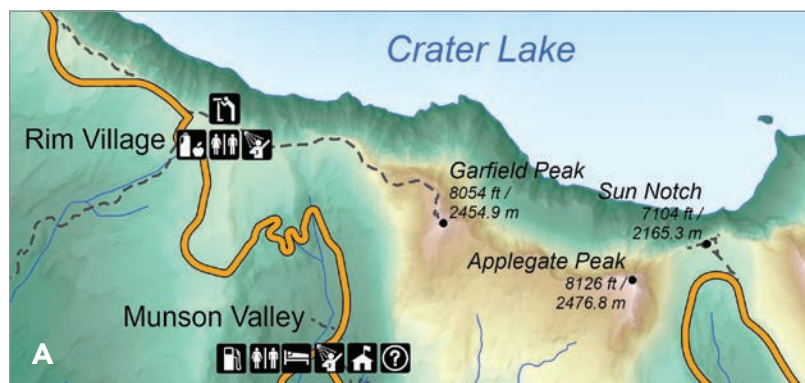
Legibility and visual contrast provide the basis for seeing the contents within the map. Figure-ground organization and visual hierarchy lead the map reader to determine the importance of things and ultimately find patterns. And proportion lends aesthetic appeal to the map and its layout.

These five principles are essential in cartography. It's worth noting that they are not applied in isolation but act complementarily. Together, they help cartographers create maps that successfully communicate geographic information.

1 Legibility

Legibility is the ability to be seen and understood. The size and complexity of text and symbols affect legibility. This becomes an even greater issue if the background is also complex. Readers effortlessly see and understand symbols that are appropriately sized and familiar. Geometric symbols are easier to read at smaller sizes, but their ambiguity often requires clarification in a legend. More complex symbols and text require more space to be legible.

→ Appropriately sized text and fonts with open space within and between letters can be more easily read. Familiar symbols and those that look like what they stand for can be more easily understood (A). Symbols and text that are too small are illegible (B). Complex text and symbols need to be larger to be seen and understood. Unfamiliar symbols can confuse map readers and require the use of a legend (C).





A

← Although black and white (A) provides the best visual contrast between colors, this is not always the best color choice for maps. When using colors of similar high (B) or low (C) saturation (brightness), the hues (red, green, blue, yellow) must be distinguishable. If not, varying the saturation or value (lightness or darkness) of a color can also create contrast. Line and symbol casings (B) and text masks (B and C) can help as well.



B



C

2 Visual Contrast

Visual contrast relates to how map features and page elements contrast with each other and their background. To understand this principle at work, consider your inability to see well in a dark environment. Because not much reflected light reaches your eyes, there is little visual contrast between the objects in your field of vision, and you can't easily distinguish one object from another or from its surroundings. Increase the illumination and you're better able to distinguish between features and their background.

The concept of visual contrast also applies in cartography. Good visual contrast can result in a crisp, clean, clear-looking map. Visual contrast helps emphasize differences, highlight important features, and improve readability. It can be achieved by varying symbol and text sizes and using contrasting colors. The higher the contrast between features, the more some features will stand out (usually those that are bigger, darker, or brighter). Conversely, low visual contrast can be used to promote a more subtle impression, and lower contrast maps can be used as basemaps on which thematic operational layers can be overlaid.

3 Figure-Ground Organization

Figure-ground organization is the spontaneous separation of the primary area of interest in the foreground (the figure) from an amorphous background. Cartographers use this design principle to help readers focus on a specific area of the map. There are many ways to promote figure-ground organization, such as showing the map as a closed form that only includes the figure, or using the techniques illustrated with this map of Botswana (left). Some of the techniques can be used together, as well as other techniques that allow you to highlight your area of interest.



A



B



C



D



E



F

← In a map, it is sometimes hard to tell the figure from the ground (A). Showing only the figure (B); adding a drop shadow (C); or using screening (D), illumination (E), or a vignette (F) can help.

4 Visual Hierarchy

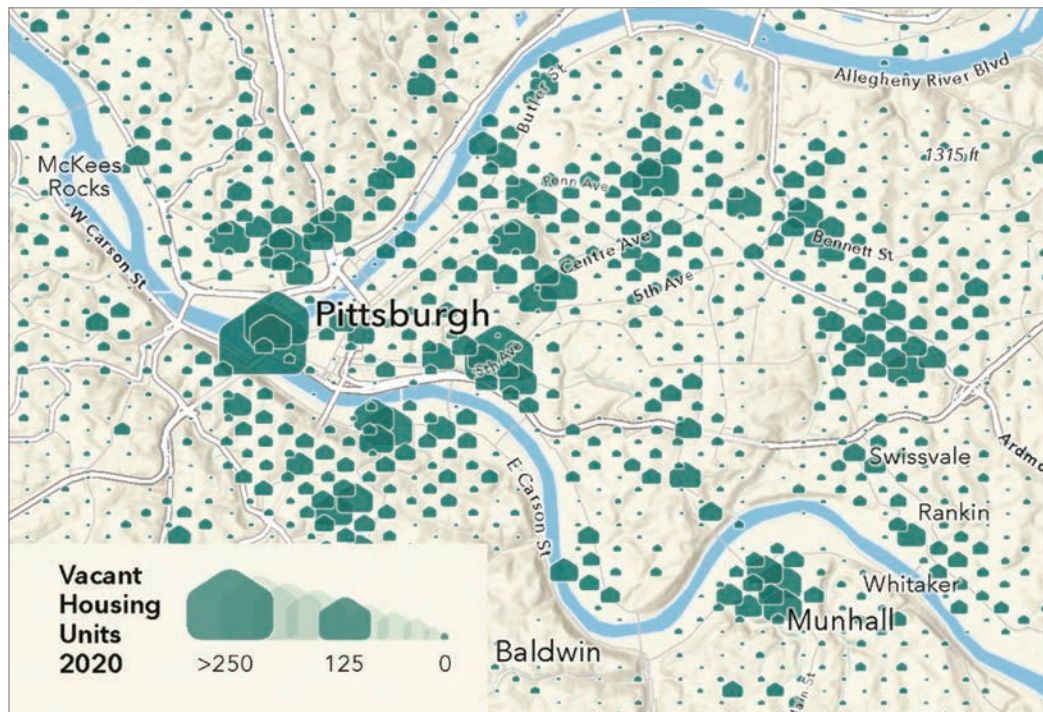
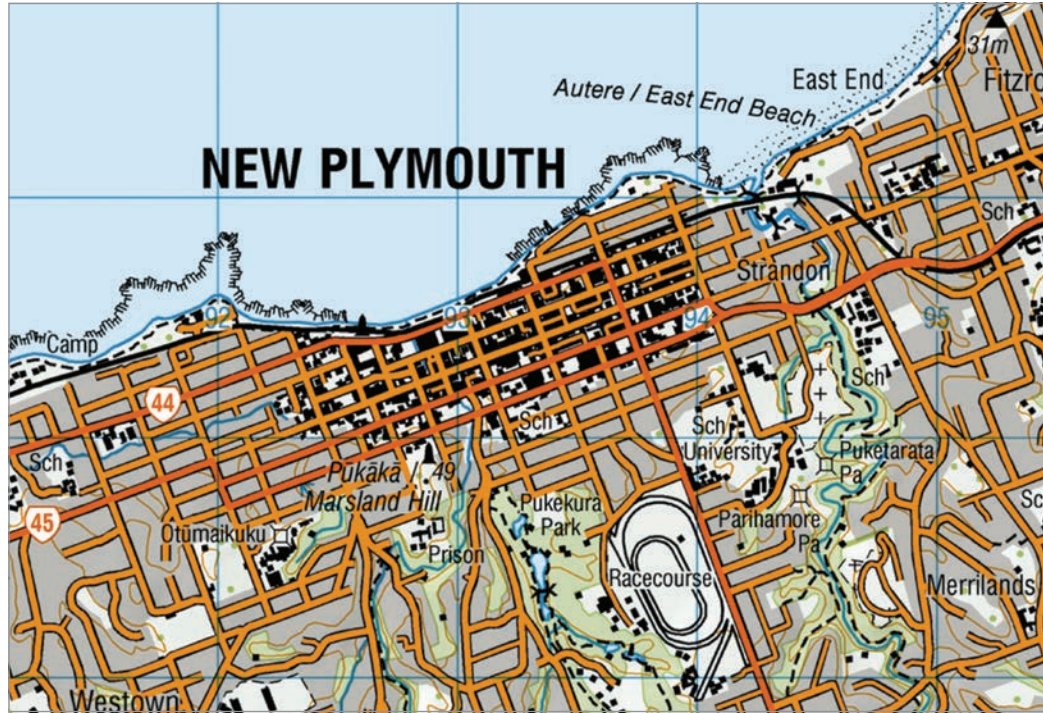
Visual hierarchy is the internal graphic organization or structure of the content in a map. Visual hierarchy helps cartographers communicate the relative importance of mapped features through a visual impression that prioritizes or orders the categories of features. This visual layering of information is fundamental to a reader's ability to understand a map. Correctly applied, visual hierarchy reflects an appropriate intellectual order by graphically emphasizing the most important map features and deemphasizing those that are less important.

The hierarchical organization for reference maps (those that show the location of a variety of physical and cultural features, such as terrain, roads, boundaries, and settlements) works differently than for thematic maps (those that concentrate on the distribution of a single attribute or the relationship among a few related attributes).

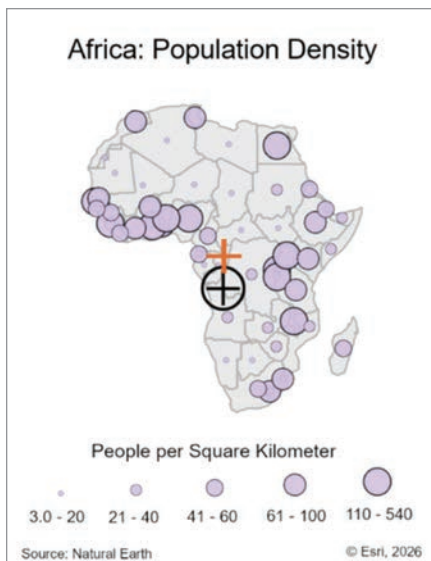
For reference maps, subtle differences order the layers. Often, the order depends on the way layers occur geographically, with physiography on the bottom, followed by hydrography, vegetation, and human-made features, then boundaries and administrative features on top. For thematic maps, reference layers recede to the background, allowing the thematic layer to ascend to a higher visual plane. Labels remain on the highest visual plane to ensure legibility.

➤ In reference maps, different colors, patterns, and sizes for the text and symbols help distinguish among features on the same layer and between layers. Overlaying one layer onto another provides the subtle separation needed to understand the hierarchy of feature layers. (Courtesy of Land Information New Zealand)

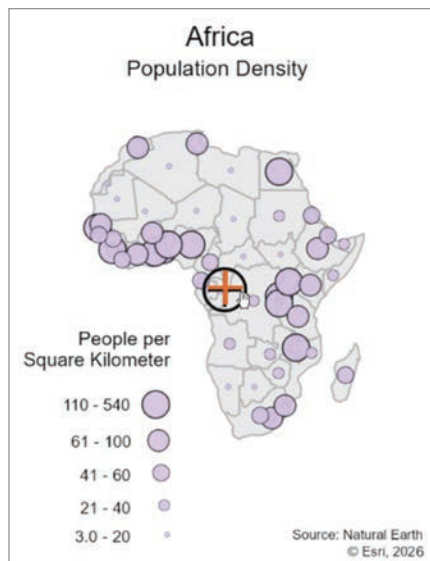
➤ When mapping thematic data, the base layer content is kept to a minimum so that the thematic layer lies on the highest visual plane in the hierarchy.



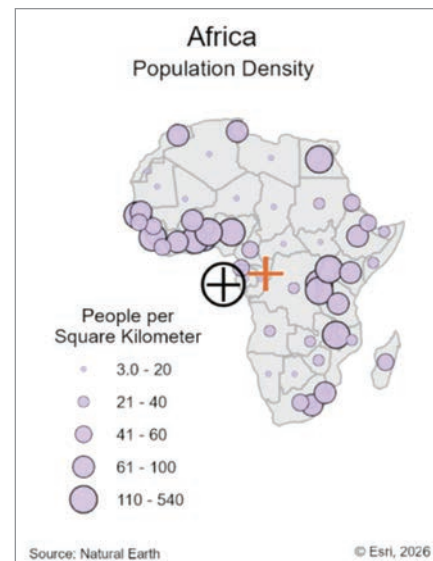
A



B



C



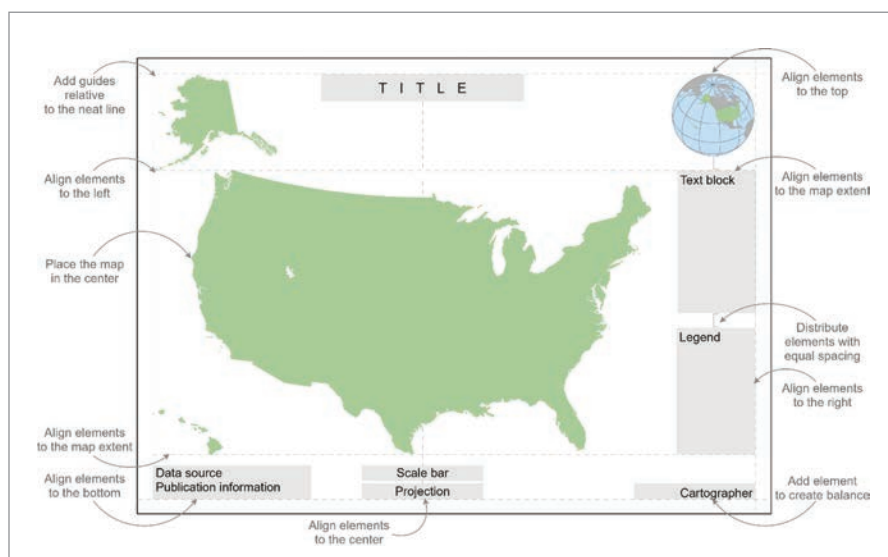
- ⊕ Geometric center of the page
- ⊕ Visual center of the page

5 Proportion

Proportion helps the map and its elements come together as a cohesive whole to form an aesthetically pleasing visualization. Proportion is the relationship between one element and another in the map and on the layout. Design concepts that relate to proportion include symmetry, balance, and harmony.

Balance is the distribution of visual weight within a map or on a layout. The impression of visual balance is controlled by the size, visual weight, and location of the contents in the map and the elements on the layout. Visual balance can be promoted by placing the map figure in the visual center of the layout, which is a point just above the geometric center. This is the point on which the eye first focuses, and it serves as the fulcrum, or balancing point, for the layout. The visual center of the whole image shifts as changes are made to the elements on the layout.

When a layout has harmony, the map and its elements have a cohesive arrangement and present a meaningful whole. Harmony can be promoted through alignment and distribution. Alignment positions elements relative to each other (left, center, right, top, bottom). Distribution spaces elements evenly between each other. Both can be employed with objects within elements—for example, the locator map, text block, and legend in the layout of the map of the US above.



About the Author

Dr. Aileen Buckley is a cartographer researcher and senior principal GIS engineer at Esri. She works on the ArcGIS Living Atlas of the World team making, writing, and talking about maps. Buckley is also involved in a number of cartographic societies and associations and is the chair of the International Cartographic Association (ICA) Ethics in Cartography Commission.

↑↑ On the first layout (A), the map is positioned at the visual center of the layout, and map elements are arranged in a symmetrical manner to create formal balance. The other two layouts (B and C) are designed with informal balance. The position of elements on the layout can also cause the eye to move in a desired direction, for example, from the title to the map to the other elements on the page.

↑ Symmetry, balance, and harmony work together to promote good proportion.

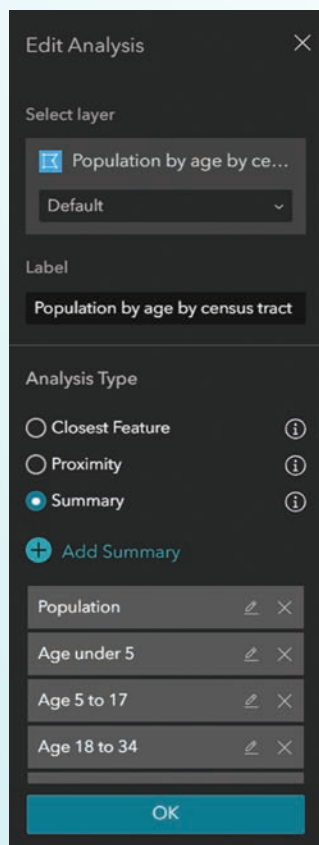
Create New Variables with the Near Me Tool in ArcGIS Experience Builder

By William McConahey

ArcGIS Web AppBuilder is retiring, and existing Web AppBuilder apps will no longer function as of 2027. If you haven't already migrated your apps to ArcGIS Experience Builder, now is the time. However, some Web AppBuilder functionalities don't have an exact analogue within Experience Builder, which can sometimes make the switch tricky.

One of the strengths of Web AppBuilder, for example, is the ability to use it to gather the sum of values that intersect an area of interest. This has many applications, including for emergency management and public health, and can be done using both the Situational Awareness and Incident Analysis widgets—two of the most widely used widgets within Web AppBuilder.

↓ Accessing the Summary analysis option.



These tools allow users to specify a location and analyze information from a defined area and have the following search methods: Closest Feature, Proximity, and Summary. Closest Feature records the nearest point feature to the user-defined area, while Proximity records all the features within the user-defined area. Summary calculates the sum of a feature item by adding the total of each geographic unit that intersects with a user-defined area.

While the Incident Analysis and Situational Awareness widgets are not currently available in Experience Builder, the Near Me tool is often recommended as a replacement for the Web AppBuilder widgets, since this tool allows users to find and analyze features with a defined area. The Near Me tool also includes the same search methods: Closest Feature, Proximity, and Summary.

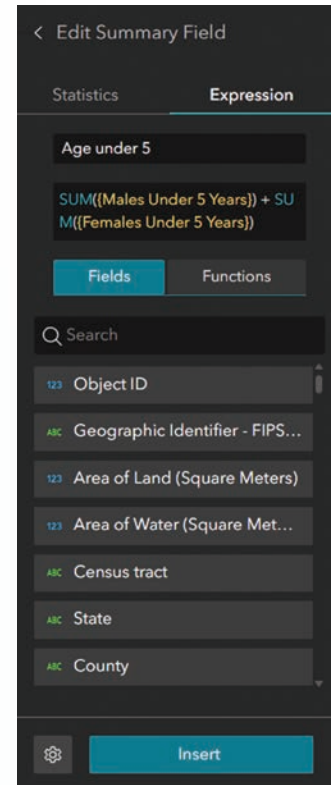
The current configuration of Experience Builder allows

you to create new variables to calculate the sum of single or multiple items and to calculate percentages and rates based on existing values within a web layer. This workflow focuses on how to create variables in the Near Me tool with multiple items within a web layer, using an ArcGIS Living Atlas of the World dataset based on 2023 United States Census Bureau American Community Survey (ACS) five-year estimates for population by census tract.

The Workflow for Multiple Items

To create variables in the Near Me tool using multiple items within a web layer, complete the following steps:

1. Add the Near Me widget to the existing Experience Builder app.
2. Open the Near Me widget.
3. Once the Near Me widget has opened, choose the map to be used for the analysis under Analysis Settings. In this example, the map is called *Population by census tract*.
4. After selecting the map, make sure to select the layer within the web map to be analyzed. In this example, the layer is called *Population by age by census tract*.
5. Enter a label for the layer name.
6. From the Analysis type, choose Summary.
7. Click Add Summary.
8. In the Add Summary box, click the Expression tab.
9. On the Expression tab, add a name for the variable in the top text box.
10. Click the Functions tab to add a function in the second text box. This box is where you can assign the fields and variables to be used in the calculation.



↑ The Near Me tool allows you to create variables via the sum of features.



11. Once the function is added, be sure to click the Fields tab to include an attribute within an existing web layer. Insert the variable in between the parentheses of the function.
12. For variables that cover multiple items, be sure to click Fields and Functions as many times as needed. In the example on page 58, SUM is the function, while the variable name is the field.
13. In the second text box, use SUM(variable) + SUM(variable) for as many variables as needed.
14. Click Insert and then click OK when done. The category is now included as part of the analysis.
15. Repeat these steps to add more variables.
16. Save and publish the application.

The Workflow for Rates and Percentages

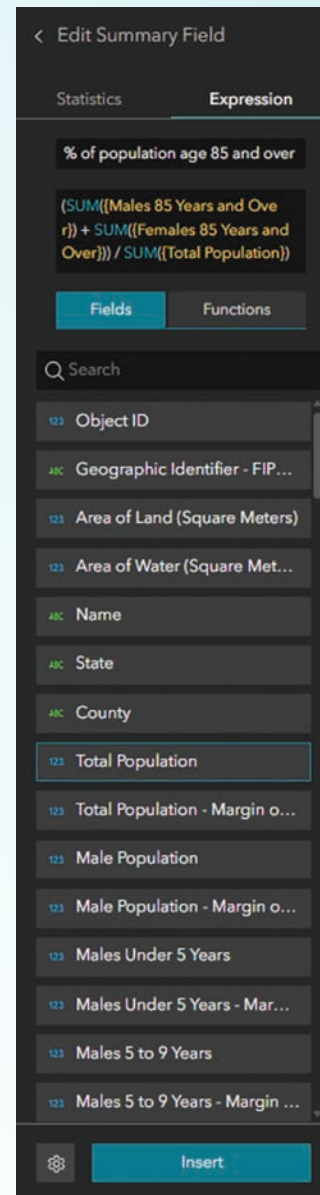
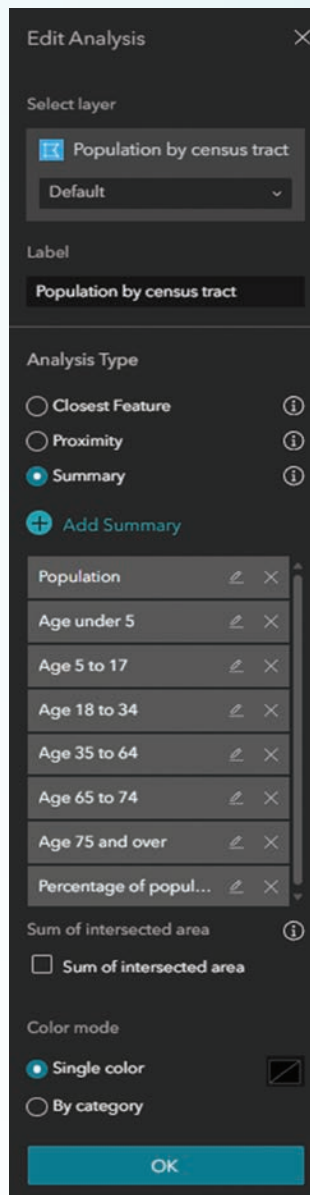
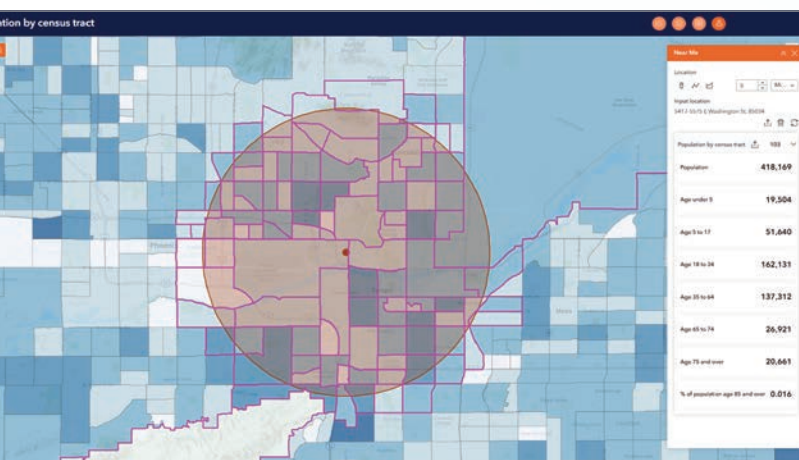
The Near Me tool also allows you to create new variables to calculate rates and/or percentages within a defined area. This workflow includes many of the same steps, but with key differences.

First, repeat steps 1–12 as listed above. Then, complete the following steps:

1. In the second text box, use SUM(variable) + SUM(variable) for as many variables as needed for both the numerator and denominator.
2. Add a divide symbol (/) between the numerator and denominator.
3. If the numerator and/or denominator includes multiple items, place parentheses () around the SUM. This will ensure that the calculation is accurate. Also make sure to format the calculation like so: (numerator) / (denominator).
4. Click Insert and then click OK when done. Repeat these steps to add more variables.

Once the configuration is complete, be sure to save and publish the app. After the app is published, run the Near Me tool. In this example, the Near Me tool calculates the sum of all the population variables. A list of the sum or percentage values for each item is included.

↓ The result of creating new variables with the Near Me tool.



↑ The Near Me tool provides a list of summary categories (left) and allows you to calculate percentages (right).

This workflow does more than replicate the summary analysis capability that currently exists in the Situational Awareness and Incident Analysis widgets within Web AppBuilder. It also includes the ability to create new variables based on the sum of existing features within a feature layer. Using these methods expedites data processing and analysis time for a variety of applications.

About the Author

William McConahey is a GIS epidemiologist with Maricopa County Public Health. To improve integration of GIS within the organization, he has held monthly meetings with epidemiologists and geographers to share valuable tips and insights on incorporating GIS into the decision-making process. In his current job, McConahey has created several web applications that allow for quicker and more accurate decision-making. He has an MA and a BA in geography. For more information, email him at william.mcconahey@maricopa.gov.

▶ How ModelBuilder Can Streamline Your GIS Workflows

By Stephanie Oliver

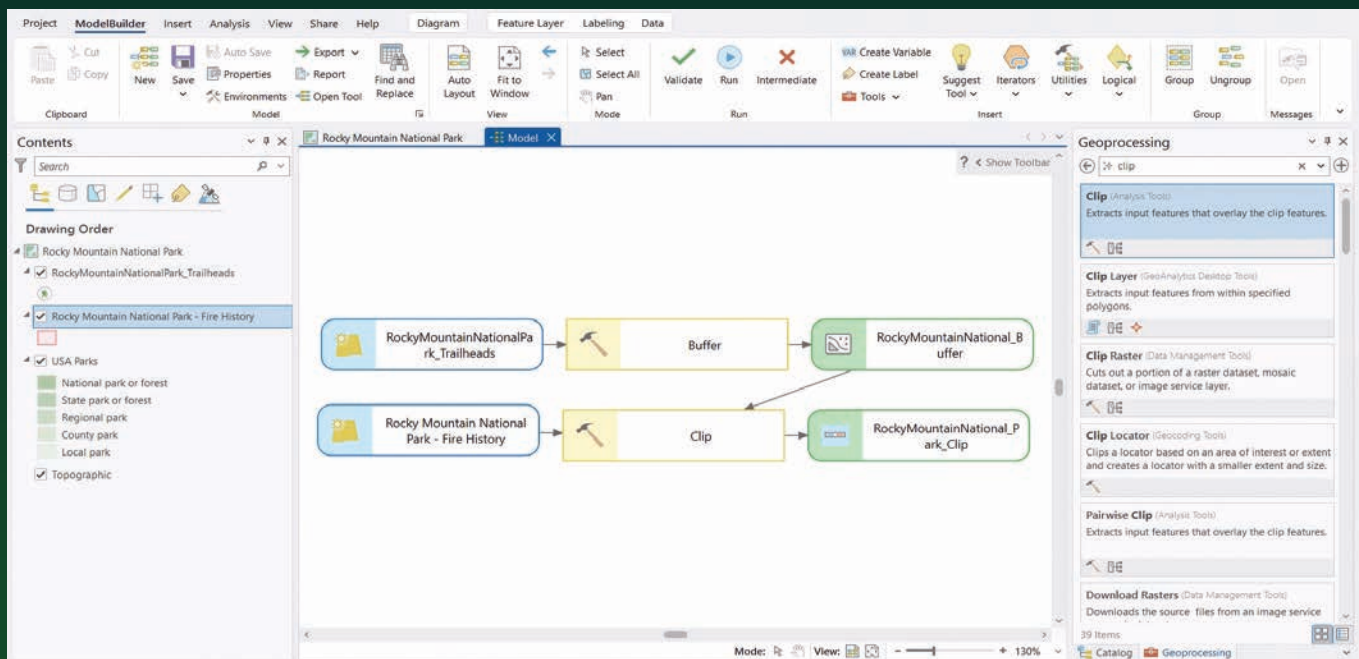
Every GIS professional faces repetitive tasks that consume valuable time. ModelBuilder, the visual programming language included with ArcGIS Pro, helps automate workflows to run efficiently and consistently. Models function as workflow maps with built-in directionality, using visual elements to communicate process status. When designed for reuse, they become powerful tools for conducting sophisticated analyses and completing geoprocessing tasks faster.

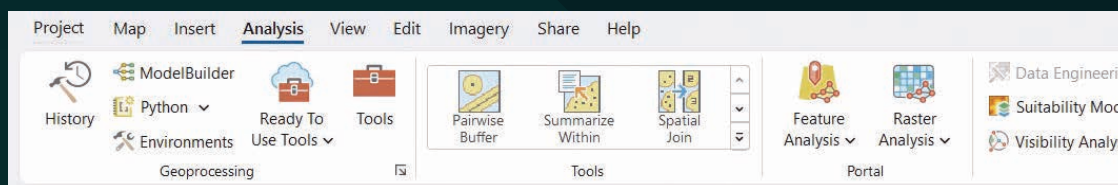
The good news is that if you're interested in using ModelBuilder to streamline your workflow, a simple five- or six-step process can get you started.

1 Plan the Workflow

Before creating a model, you should know what you want the model to accomplish. The planning process involves listing the data input, identifying the required geoprocessing tools, and describing the desired output. For simple workflows, thinking through the process mentally may suffice. More complicated workflows may benefit from sketching everything on paper or a whiteboard. If you are unsure which tool to use or what inputs a tool requires, check the online ArcGIS Pro tool reference.

To start, click ModelBuilder on the Analysis tab in ArcGIS Pro.





← If you are unsure which tool to use or what inputs a tool requires, check the online ArcGIS Pro tool reference.

2 Create the Model Shell

In ArcGIS, a model must be stored inside a toolbox. When you create a project in ArcGIS Pro, a toolbox with the same name as the project is automatically created.

On the Analysis tab, clicking ModelBuilder opens an empty model window. You can also open a new model by right-clicking the toolbox folder in the Catalog pane and choosing New > Model.

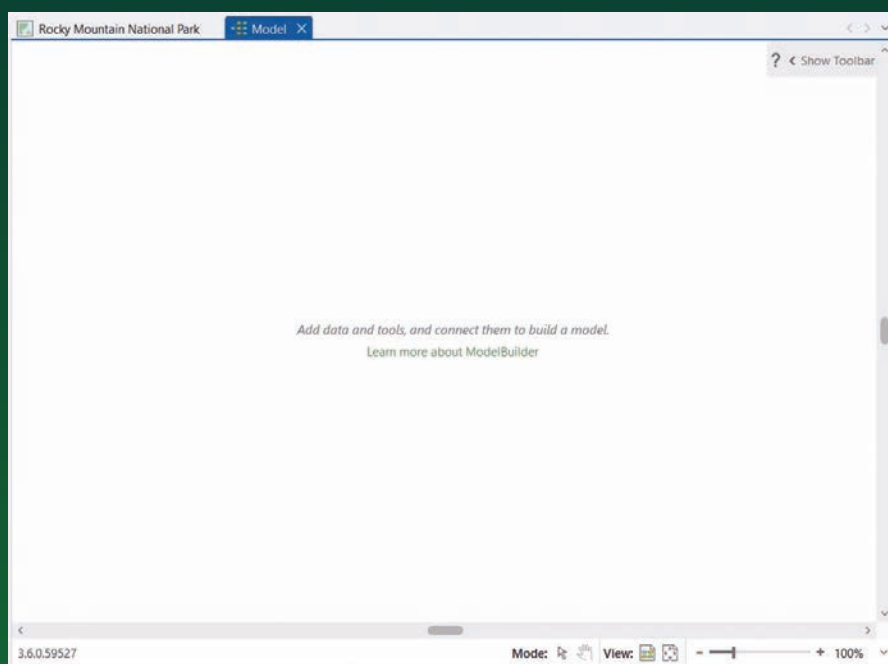
After the model window opens, the next step involves setting the model properties by clicking Properties on the ModelBuilder tab.

On the General tab, select the Option To Store tool with a relative path. Using relative paths helps ensure that the model continues working properly if data is moved.

Setting these properties completes the model shell:

- **Name:** Type the file name with no spaces.
- **Label:** Provide a plain name that can include spaces.

Click OK to open a blank canvas for building the model.



3 Add Tools and Set Parameters

With the basic setup complete, the model-building process begins. ModelBuilder provides easy drag-and-drop functionality for building and experimenting, but understanding some ModelBuilder vocabulary can help you get started.

A model consists of one or more processes. Each process has three elements: input data, a tool, and the tool's output. Each output can become an input for the next process.

When you add a tool to a model by dragging it from the Catalog or Geoprocessing pane, its output element is also added, and both elements appear in light gray. In model terminology, gray means it's not ready to run.

Double-clicking each tool allows you to set its parameters. A red asterisk next to an item in a tool dialog box indicates the parameter is required. Setting tool parameters requires paying attention to red asterisks.

If input data has selected features or records, models—such as individual ArcGIS geoprocessing tools—will process only the selection.

Once you click OK to set the tool parameters, the input element displays and the process changes color.

As processes are added, the model window may fill up. The Auto Layout and Fit to Window buttons help you see the big-picture view and zoom in and out as needed.

Click Save on the ModelBuilder tab to save your work periodically.

To visualize the model's final output on a map, right-click its model element and choose Add To Display. Otherwise, you will need to manually add the output as a layer to the map.

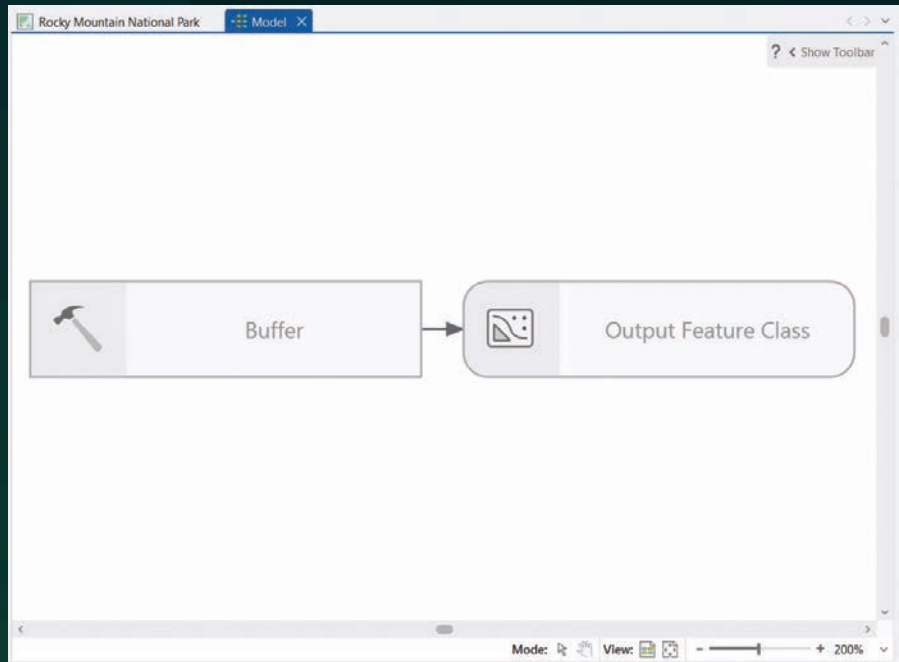
←← When designed for reuse, models are powerful tools for conducting sophisticated analyses and completing geoprocessing tasks.

← On the Analysis tab, clicking ModelBuilder opens an empty model window.

4 Validate the Model

After adding all the tools and setting their parameters, ensure that the model will run properly by validating it. Validation is straightforward—initiate the process by clicking the Validate button with the green check mark on the ModelBuilder tab. During validation, if an error occurs, processing will stop at the process with the problem.

After determining what's wrong and then making the fix, you should validate again. Once the model is validated, complete this step by saving it and the ArcGIS Pro project.

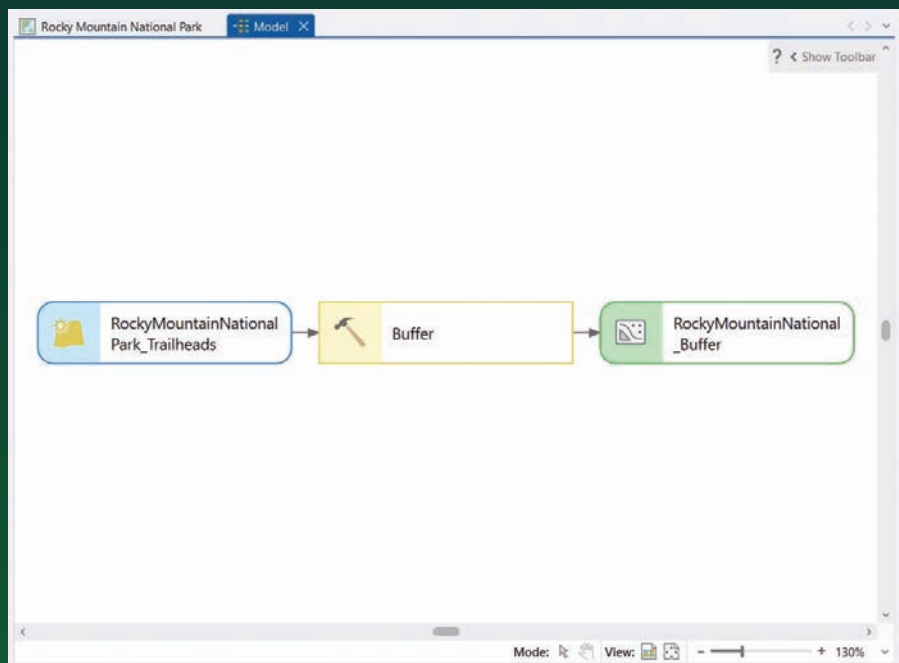


↑ When you add a tool to a model by dragging it from the Catalog or Geoprocessing pane, its output element is also added and both elements are displayed in light gray.

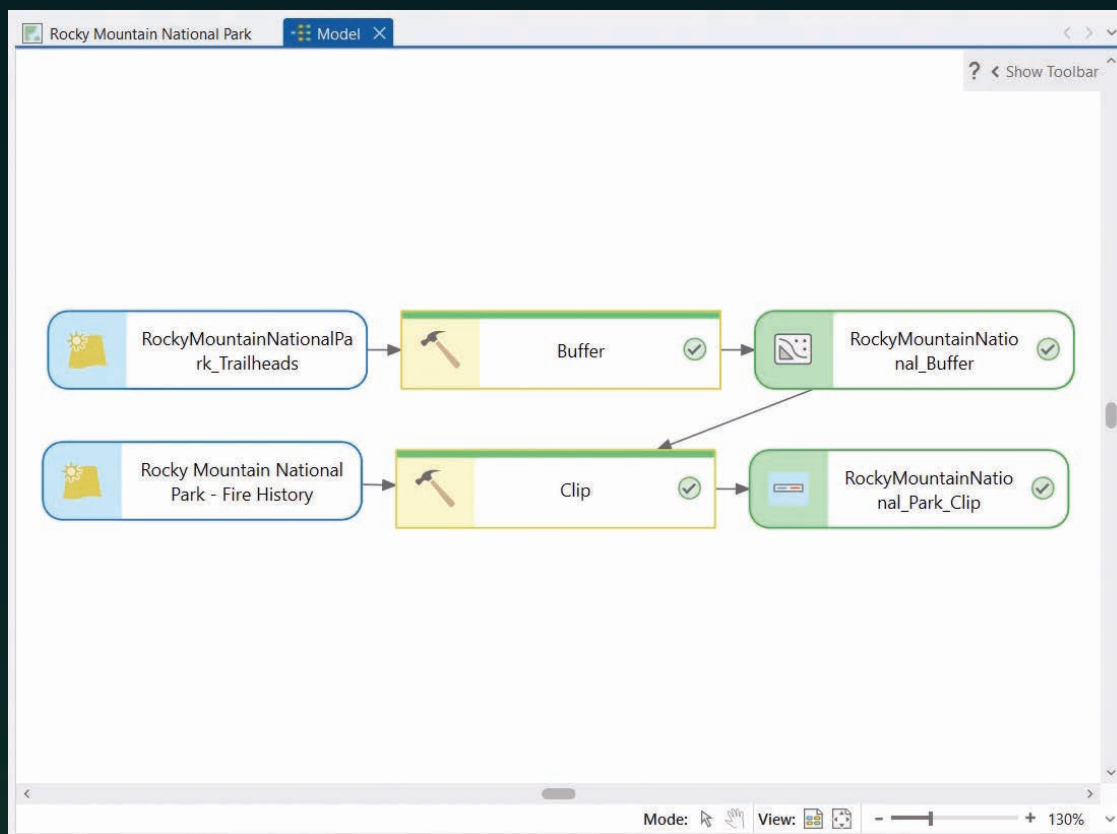
5 Run the Model

You have two options for running a model: inside or outside ModelBuilder. Running a model inside ModelBuilder involves clicking the Run button. As the model progresses, the tool shows a green progress bar. Once the model is run, each tool shows a green status bar and green checkmark. All successful outputs will also show a green checkmark. If a process turns gray, something needs correction and the model stops running. If you have validated your model, this should not happen.

Models can also run outside of ModelBuilder as a tool or service. Running a model as a tool or service provides advantages for collaboration and sharing.



↑ Once created, models can be used repeatedly as a fast alternative to manually performing individual steps in a workflow.



← A green checkmark indicates a process has completed successfully.

6 Run It Again (optional)

A model's final output may raise questions. For example, suppose a model process created a 50-meter buffer around a map feature. After examining the model output layer on the map, you might wonder what the impact would be if a 100-meter buffer was used instead. To find out, simply open the Buffer tool; enter the new distance value; and run the model again, starting at the buffer process, by right-clicking the Buffer tool and choosing Run. Because you are not altering preceding processes, you don't need to rerun the entire model. This flexibility represents one of the key advantages of modeling.

Built for reuse, models provide an effective way to explore and test what-if scenarios. Similar to scripts, models are encapsulated workflows. Once created, they can be used repeatedly as a fast alternative to manually performing all the individual steps in a workflow. You can build a model to automate any geoprocessing workflow, whether complex or simple and straightforward.

With these essential steps for creating a simple model, you can begin building your own automated workflows.

About the Author

Stephanie Oliver is a senior instructor with Esri Training Services who teaches ArcGIS classes on desktop and enterprise topics. Oliver has worked in the GIS industry for over 15 years, much of that in the public sector. She has extensive experience with cartography and the application of GIS to enhance transportation and emergency management workflows.



What Does It Take to Build a Career in the Drone Industry?

Drone technology is becoming increasingly ubiquitous across the world of GIS. The drone industry has come a long way from its overly optimistic beginnings, and drones are now an essential tool for data collection and analysis, invaluable in nearly every field that uses GIS technology, from agriculture to emergency management.

Jeremiah Johnson, a lead solution engineer at Esri, has been a part of the drone industry for the majority of its evolution. With a background in spatial sciences and experience as a certificated airplane pilot, Johnson has a unique perspective on the convergence of aviation and data science. A recognized drone technology evangelist, Johnson is responsible for Esri's drone-

related initiatives and oversees the flight certification process for Esri employees.

In this interview, he provides guidance and suggestions for anyone interested in the burgeoning field of drone piloting and the diverse career paths it provides, whether you are just starting out in the industry or thinking about diving deeper into the world of drones.

↓ A drone pilot performs preflight checks on a drone before a mission.



Q: For recent graduates of drone piloting programs, what are the steps to transition from education to employment, and what certifications beyond Federal Aviation Administration (FAA) Part 107 are valuable?

A: Decide the industry that you want to work in after college—utilities, construction, agricultural, or something else. Be sure you’ve taken courses that are related to that field. This will help you develop a network of contacts in that industry. And get to know people outside of the university who’re actually using drones and then reach out to them after graduation.

Also, be aware of how drones are being used today—inspection, mapping, filming, photography. And actually get out in the field. Having some stick time is important because there are only a few organizations that would hire somebody with zero practical drone piloting experience.

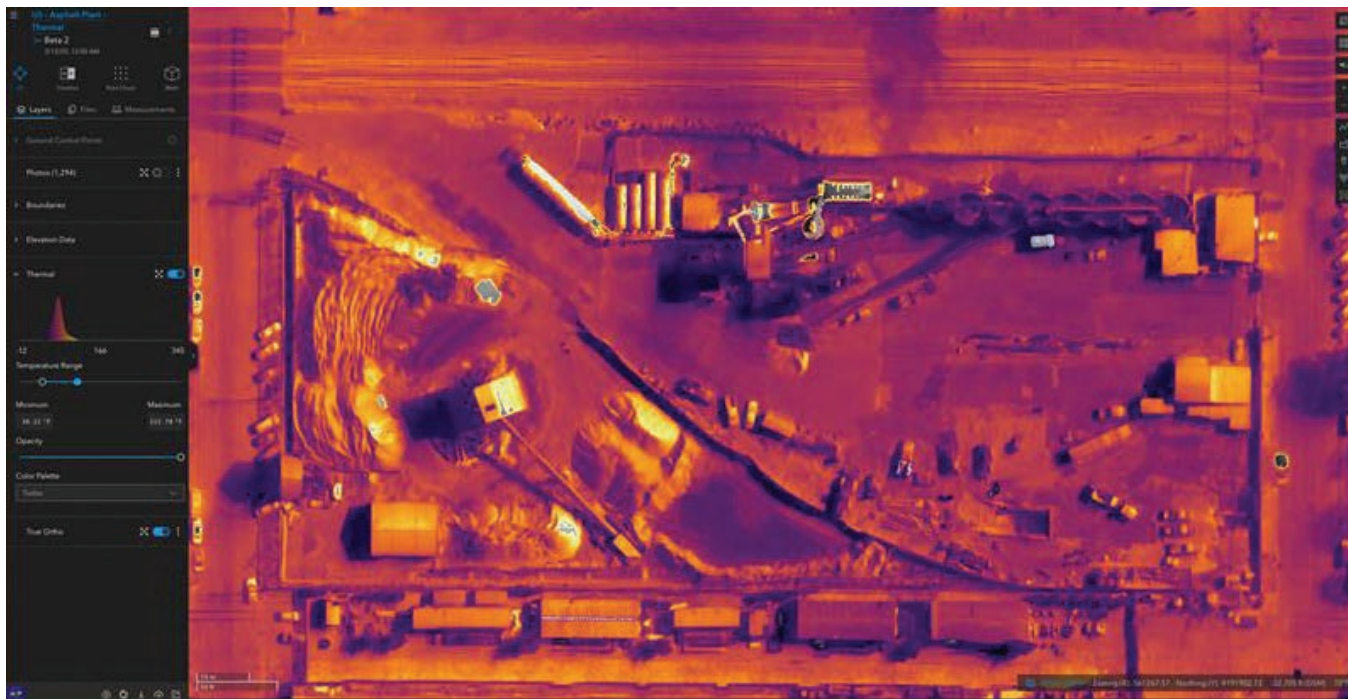


↑ A drone-acquired 3D mesh of historic buildings on Angel Island State Park in Northern California.

↓ A thermal orthomosaic image captured by a drone and processed in Site Scan for ArcGIS.

Q: How important is building a strong portfolio, and what should it include?

A: It’s important, particularly in showing what software you’ve worked with. Look at what software is available to you as a student and use it to develop various maps or models—maybe some deep learning or machine learning applications that show that you have end-to-end experience. Your portfolio should show not only that you can fly a drone, but that you understand why the drone was flown in the first place and how derivatives can be generated from drone data.





↑ A Freefly Astro drone being prepped for missions over Angel Island State Park, in Northern California.

Q: How can new pilots identify reputable companies?

A: A lot of reputable companies post their work on LinkedIn. Conferences are also great. At an Esri conference such as the user conference in San Diego or regional conferences, there will almost always be a booth with a drone on display. Going to those booths and talking to some of the people about their work in drones is very educational and provides an opportunity for you to get your name out there as a potential hire.

Q: What are the most in-demand technical skills?

A: Understanding the ArcGIS suite is really important. It's vitally important to be able to understand quickly why a drone is being flown in the first place, because that can determine which software to use. It could be ArcGIS Drone2Map, Site Scan for ArcGIS, ArcGIS Reality for ArcGIS Pro, or something else. And then there's oriented imagery and full-motion video—which is the best approach? Also, having an understanding of how different wavelengths of light can be processed is important. A really common one is thermal, so knowing thermography is important.

Q: What emerging niches should new professionals explore?

A: With the advent of Part 108 and FAA regulations changing with the technology, something that we're seeing deployed across cities, construction sites, and utilities is drones in a box being used for autonomous data collection, with no human in the loop.

In many cities and in public safety, there's a concept called "drones as a first responder," which is putting drones in a box in several locations in a city, and if there's an emergency call or an alarm somewhere, a drone goes out first to scope it out versus waiting for a person to drive there. This is starting to be deployed in every major US city, and you don't need to be a police officer or a firefighter in order to be involved—they're looking for individuals who understand drone technology.

Q: How can pilots stay current with technical advances and regulations?

A: It's important to build out a network of people, because you can't learn everything yourself. In the United States, the best professional organization is AUVSI, which stands for Association for Uncrewed Vehicle Systems International. Joining your local chapter will help keep yourself in the loop.

Also, keep an eye out for new data products like Gaussian splatting, which is a brand-new layer type in ArcGIS, or tools for mapping more complex features and not just flat ground. Esri is adding new layers all the time, and it's important to know what these layers can do in imagery and remote sensing.

Q: What soft skills are crucial?

A: Curiosity is a really important soft skill because the technology is always changing. Safety is key, so you have to understand your own personal limitations. And communication will always be important because stakeholders don't necessarily always know what drones can do or can't do.

Q: How do you think drone-GIS integration will evolve, and what does this mean for careers?

A: Drone technology is going to continue to get more autonomous and the sensors are going to become more advanced. So, as drones become more autonomous, less energy is going to be spent on how to fly a drone in order to get the data that you want, and more energy will go into what flight plans and sensors are required to get the end result. The new career opportunities will involve understanding workflows, knowing where AI can and can't be helpful, and knowing how best to schedule and plan autonomous flights to get the best data for analysis.

Q: What are some common misconceptions about drone piloting careers?

A: One is that drone pilots' main job is to manually fly drones with a controller in their hands. That's increasingly not the case. The majority of my time as a drone pilot is spent planning drone flights and understanding what's the data I'm trying to get out of the project. I also spend a significant amount of time understanding regulations to make sure that the drone flight is legal, then handling data management after the flight.

Q: What final advice would you give someone starting a drone career?

A: It's a rapidly changing field, and people are developing new ways of doing things all the time. Staying curious is important and so is staying humble, because you're never going to know everything. This technology is really exciting, but it's also important to stay levelheaded about what can and can't be done with the technology.

The best way to increase your compensation or to be on the upper side of the salary band is to have a well-rounded set of skills. Organizations will pay top dollar for somebody who they can trust to not only manage the flying of the drone but manage the fleets, the data after the fact, and then to understand how the data will be used in the software that the organization uses.

↓ A 3D mesh of historical military buildings on Angel Island State Park in Northern California, captured by a drone and processed in Site Scan for ArcGIS.

↓↓ A drone-acquired Gaussian splat image of the Sweetwater Dam in Southern California.





The First Responder Who Aided Alaskan Villages She's Never Visited

By Carrie Speranza

When Typhoon Halong devastated western Alaska in October 2025, Faith Espinosa never left Anchorage. Working 16-hour days for weeks, the Alaska Department of Transportation and Public Facilities (Alaska DOT&PF) special projects coordinator helped build the operational maps, damage assessments, and field tools that guided the response. After so much time spent poring over high-resolution drone footage and 360-degree imagery capture of the 40 damaged villages, Espinosa felt like she'd been there.

"This is the worst day you could probably imagine," she said of the damage to homes and villages that appeared on her screens each morning.

Growing up in Alaska, with plenty of friends from remote villages, the tragedy felt close to home, regardless of where Espinosa was. Her focus was on housing the now homeless, dealing with the logistics of repairing homes, and getting community members back on their feet before winter set in.

In the aftermath of the typhoon, Espinosa's days started at 6:00 a.m. and

most ended at 10:00 p.m. Every morning, a hard drive arrived via GoldStreak, Alaska Airlines' cargo service. Espinosa and her team members would pull the drone footage off the drive, make a static copy, and run the files through a georeferencing script before uploading everything to the mapping platform.

What came off those drives was immersive. Field staff captured ground-level walk-throughs with 360-degree cameras and rode four-wheelers up and down board roads. Drone footage traced every roofline and foundation. An image comparison tool let anyone slide between pre- and post-storm imagery—buildings present on one side, gone on the other. In Kipnuk, houses had rotated, vanished from between neighbors, or drifted miles inland in the surge. With winter coming fast, staff knew they had to act.

Espinosa reviewed all of it. She used a large language model to generate building polygons and assign them house numbers to give each structure an identifier. These communities often don't have street addresses—a house is known by the family

inside it. That polygon was the foundation for every assessment and repair record that followed. Few people who had actually walked those board roads knew the structures as well as Espinosa did.

Go Bag

Many Alaska DOT&PF staff members, including Espinosa, relocated to Anchorage to better coordinate emergency response. When the call came, she had a go bag already packed. Construction work had made her comfortable jumping into the unknown. She was used to ever-changing field conditions.

"I'm pretty small, pretty lightweight," she said. "It's easy to throw me on a charter plane because they're not really worried about my weight."

This time she was Anchorage bound, working out of a command center that was set up in real time, living out of a hotel room, and facing a response unlike anything the department had run before.

Barge operators had already pulled their boats for the season. Construction crews had moved on to their winter work sites.

There was no ready way to move goods or people into roadless communities, and the window for doing anything before freeze-up was measured in weeks.

Recovery funds don't flow without proof of damage, and proof required data that only existed if someone could get there to capture it. Hard drives took roughly 24 hours to travel from the field to Anchorage. Espinosa processed them in three to six more. Within that 30-hour window, raw footage was processed and uploaded into damage assessment tools. The ability to view drone footage for impacted communities made the case to decision-makers thousands of miles away in Washington, DC. The federal disaster

declaration was approved on October 22, and money began to move.

With funding unlocked, the next problem was getting supplies in. Planes threaded short gravel runways in low visibility. Cargo flights dropped building materials directly into villages. Every flight and every GoldStreak run was part of the same improvised chain: Capture the conditions, document the need, gather supplies, deliver goods, and bring workers to put everything back.

“How Long Do I Have?”

More than 1,500 residents, most of them Indigenous Alaskans, had been evacuated from their villages with nothing but a backpack and the clothes on their back. For

people whose lives are organized around seasons—when to fish, when to hunt, when to store food, when to gather—the displacement went deeper than losing a home. It was losing a way of being.

The responders working alongside Espinosa understood this in a way that outsiders couldn't. Many had friends and family in these communities, and knew what it meant to be cut off from the land and the rhythms that make a place home. It was the reason nobody watched the clock.

The goal was to get them home. Espinosa and her team built the tools people used to report damage, managed access permissions for some 300 users across state and federal agencies, trained field staff in 10-minute bursts on software they'd never touched before, and fixed bugs in real time as teams called in from villages. When designers needed a new tool in an hour, they built it. When contractors replaced field staff and needed something simpler, she rebuilt it. “It wasn't a no,” she said. “It was, well, how long do I have?”

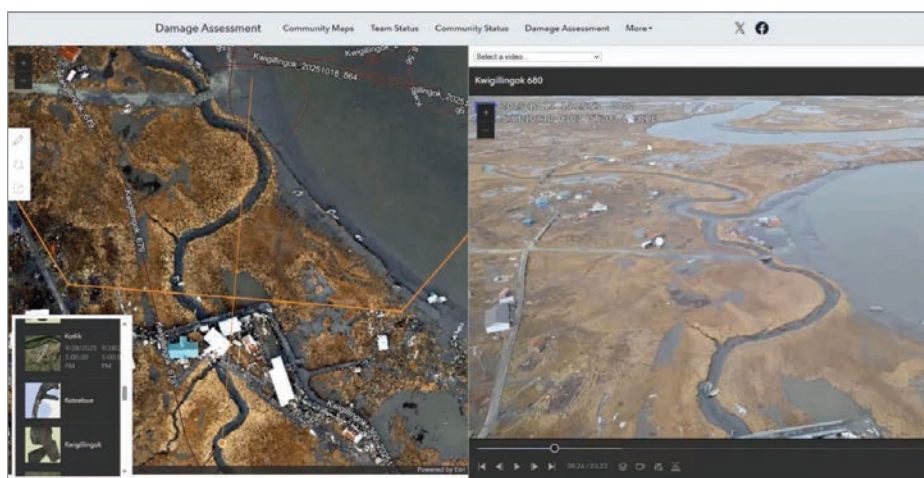
As conditions worsened, the tools had to keep up. Rain, snow, wind, and the particular misery of a touchscreen in near-freezing temperatures with wet gloves meant field teams were missing data fields because their fingers wouldn't cooperate. Espinosa enabled voice input. “Just hit the little microphone and talk straight to your phone,” she told them. Grammar didn't matter. Completeness did.

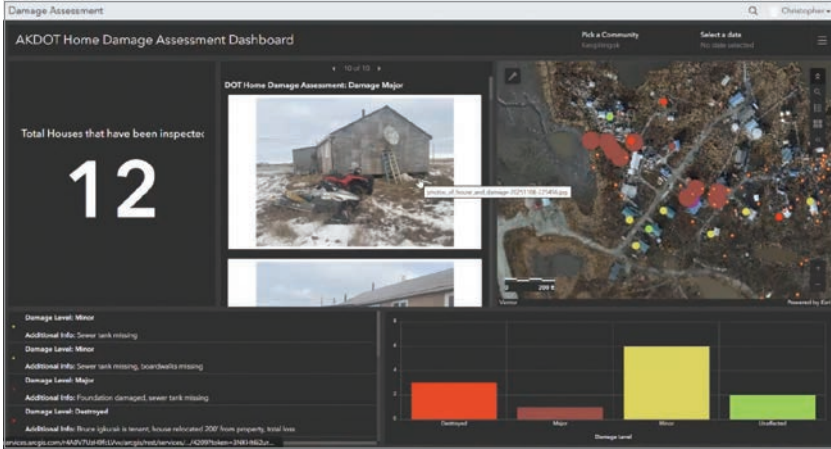
A large language model that was trained on federal damage criteria and western Alaskan building practices generated notes on damage to the structures to ensure that no damage went undocumented.

The model also had to learn what wasn't damage. Outside assessors flagged peeling paint and worn siding. In rural Alaska, that's normal. Paint can run \$70 a gallon at minimum. Houses sit on stilts with insulation underneath; in a flood, that insulation becomes a waterlogged block of ice that won't drain or dry in below-freezing temperatures.

🔗 Drone footage of Kwigillingok shows scattered structures, storm debris, and a coastline reshaped by surge—evidence that no written report could replicate.

🔗 Hard drives containing drone footage accumulated quickly as Alaska DOT&PF staff built the GIS tools needed to assess storm damage.





↑ In Kwigillingok, 12 inspected structures tell the full range of the storm's reach—from unaffected to destroyed, each record is tied to field photos, notes, and a map location on a damage assessment dashboard.

What you'd fix with a tarp in Georgia is lasting damage in Alaska.

"Don't worry if you break it," Espinosa told field staff who were new to the tools. "It's probably something I can fix. Let's move forward."

Becoming the Map

Ask Espinosa about the villages of western Alaska and she can describe them in operational detail. She knows which houses were upturned in Quinagak, where the boardwalks had washed out in Kipnuk, and which structures had foundation damage and which ones have since been repaired. As repair photos come in, she recognizes the structures. "They fixed the foundation on that house," she'll think, comparing the current image to what she first saw in those early hard drives.

That kind of awareness didn't exist before the event. Through months of drone footage, GoPro 360 walk-throughs, and repair documentation, she built something closer to a lived understanding of places most Alaskans have never seen. What it means when the landscape that people have known their entire lives is suddenly unrecognizable. Structures gone, board roads washed out, the physical markers of a community erased. For the families still waiting in Anchorage hotels, home had become a place they could no longer picture.

She has never been to any of these places. But after months inside the

data, Espinosa became the map, a conduit for what changed, what was lost, and what still needs doing. The engineers, contractors, federal assessors, and emergency planners who depend on that picture to act are better equipped because of the detail Espinosa's GIS tools can provide.

"I'm starting to understand how much more information one could want," she said. If another storm comes—and in western Alaska, another storm will come—she has a go bag. She knows what to pack.

"It didn't matter where you put me," she said. "I would willingly be there again."

About the Author

Carrie Speranza, CEM, director of emergency management solutions at Esri, is responsible for cross-cutting, industry-wide strategic initiatives. Previously, Speranza worked at the District of Columbia Homeland Security and Emergency Management Agency, where she served as deputy director. She is the first emergency manager in the US to hold the positions of president of the International Association of Emergency Managers (IAEM), and chair of the FEMA National Advisory Council (NAC), and was selected as a Top 40 Under 40 Award honoree in 2021 by IAEM-USA Region 3. Speranza is a graduate of the National Emergency Management Executive Academy.

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