Charting the Roads That Connect the Vast Navajo Nation

Using GIS to Assess and Manage Tribal Transportation Infrastructure

Spanning approximately 27,000 square miles across three states, the Navajo Nation is the largest sovereign nation in the contiguous United States. It has a strong presence in US government and often leads the way in tribal efforts to promote key areas, such as economic development, health care, and education, at the national level. Despite its prominence, the sheer size and remote nature of the Navajo Reservation presents unique challenges in managing its infrastructure and resources.

Consider, for instance, the road inventory that tribes submit each year to the Indian Reservation Roads (IRR) program. The IRR program maintains the official inventory of reservation roads in the United States and is designed to allocate federal funding to tribal governments for transportation planning and road maintenance activities.

A component of the broader Integrated Transportation Information Management System (ITIMS) program, the Bureau of Indian Affairs (BIA) Division of Transportation (DOT) maintains the national reservation road inventory in its Road Information Field Data System (RIFDS). Each year, as part of the IRR program, tribes are eligible to submit their road inventory data to one of the 12 BIA regional offices. There are approximately 560 nationally recognized tribes that fall under the 12 BIA regions. The Navajo Nation submits its road inventory to the BIA Navajo Regional Office (BIA-NRO) in Gallup, New Mexico.

To evaluate its infrastructure and better meet federal tribal transportation funding requirements, the Navajo Division of Transportation created its own secure, GIS- and web-based, geospatially enabled road inventory and management system.

The Navajo road inventory was far from comprehensive. In early 2006, its official RIFDS inventory contained approximately 9,800 miles of roads. Roughly 6,000 miles were BIA roads, and the remaining 3,800 were primarily state and county roads, with very few tribal roads mixed in. Navajo transportation officials determined...
Why Use Cloud Infrastructure for ArcGIS?

Cloud computing is growing in importance for GIS professionals. Reasons for its importance include cost, scalability, flexibility, and rapid deployment. Two specific scenarios for geographic information system (GIS) technology in the cloud are particularly compelling:

1. **Increasing Operational Efficiencies with On-Demand GIS**—Cloud infrastructure allows GIS users to systematically or temporarily increase their computing power and data storage capacity without impacting their local IT infrastructures. Users are choosing this because of the cloud’s elastic scaling and load balancing features—in other words, its ability to extend an organization’s capabilities to support larger audiences and handle peak loads during the busiest times. In addition, the cloud environment involves zero up-front capital investment, complete access by any device anywhere and at any time, and low system administration cost.

2. **Streamlining Application Development and Deployment**—GIS application developers are finding ArcGIS in the cloud an ideal environment for building and testing application prototypes. They can carve out their own space in the cloud so that they can provision computing resources that match the destination infrastructure, pull in application templates, access hosted APIs and software development kit components, and connect to shared widgets and add-ins. When the applications and services are ready for beta testing, they can be shared with specific user groups or with the actual customers for gathering feedback and making refinements. When it’s time for deployment, the applications can be migrated to the on-premises environment or moved to a production environment in the cloud.

**ArcGIS Online Works to Complement and Extend Desktop and Enterprise ArcGIS**—ArcGIS Online is designed to function as a complete stand-alone Software as a Service (SaaS) application for web mapping and geographic information management. It has also been designed to fully integrate with ArcGIS software deployed on premises.

ArcGIS Online maps and services can be used in any client, including desktop, mobile, and web applications. Users can author their maps with ArcGIS Desktop software or simply create maps by uploading their data using a browser. They can then publish these maps as map tiles or feature services in ArcGIS Online and provide access for any ArcGIS client via open REST APIs to any web or mobile client.

Users can control access to the maps they wish to share while, at the same time, supporting multiple open collaboration opportunities. Once a map is created, it can be shared with a specific group or everyone. Because information is stored in the cloud, anyone who has access to the map can discover it, view it, add additional layers and graphics to it, and share it again as a new map—all in a cloud environment.

**ArcGIS Online Is a Cloud-Based GIS**—Organizations can leverage their investment in GIS by publishing their maps and data for others to use in ArcGIS Online. At the same time, smaller organizations and even individuals can share their data and maps as map services without having to acquire their own GIS server software. ArcGIS Online provides access to powerful capabilities that can be implemented by anyone, from professional GIS analysts to the casual mapmaker.

For more information about ArcGIS in the cloud, visit esri.com/cloud.

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**Special Thanks to the Sponsors of the Federal Civilian and Sciences Reception**

This invitation-only event brought together the federal GIS community during the 2011 Esri International User Conference in San Diego. Thanks for making this great evening possible!

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Esri and Development Gateway Continue International Aid Work

Plans Include Mapping Project Data to Track and Coordinate Development Efforts

Esri and the nonprofit organization Development Gateway signed a memorandum of understanding that defines continued joint efforts to leverage geospatial technology to support international aid projects.

“Working with Esri, we intend to make aid information more visual so it’s easier for decision makers and the general public to access and understand,” says Nancy Choi, director of products and operations at Development Gateway. "Interactive maps help coordinate disaster relief activities and ensure that resources are distributed to the areas of greatest need. The same approach can work for long-term development efforts as well, especially in countries where there are dozens of donors implementing thousands of projects.”

By combining Esri’s technology and capabilities with Development Gateway’s data and expertise, the organizations plan to geoenable aid project information and develop tools that improve transparency, support decision making, and enhance effectiveness of aid donors and recipient governments.

Esri and Development Gateway recently worked together to create the Development Loop application for AidData, a joint initiative of Development Gateway, Brigham Young University, and the College of William and Mary. Development Loop presents a collaborative tool for planning, tracking, and assessing aid projects worldwide. Future work may support similar AidData projects as well as Development Gateway’s Aid Management Platform—a virtual workspace for governments and their development partners with implementations in 20 countries.

What’s Coming in ArcGIS 10.1

ArcGIS 10.1 will make it simpler to put mapping and geospatial analytics into the hands of more people without requiring that they be GIS experts. One of the most important aspects of this release is that ArcGIS users will be able to deliver any GIS resource, such as maps, imagery, geodatabases, and tools, as a web service.

Find out more about the next release, become part of the ArcGIS Beta Community, and learn about upcoming software name changes at esri.com/whatscoming.

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Esri Aeronautical Solution Supports FAA’s Airports GIS

Geographic information continues to play a pivotal role in the planning, management, and operation of America’s airports. Traditionally, for all new construction or capital improvement projects, survey crews would go into the field and collect data, providing their airport customers with deliverables such as CAD drawings, engineering diagrams, and paper as-built drawings. Storage rooms at airports have become filled with volumes of paper plots and documents, making it a challenge to quickly answer simple questions regarding the current condition of a particular structure or other feature at an airport.

When airports submitted new or updated plans to the Federal Aviation Administration (FAA) for approval, reams of paper drawings were printed and mailed between offices. By the time the documents were received and reviewed, weeks or even months had passed. A more agile and efficient process, integrating the latest information technologies, was needed.

In response to these and other issues, the Office of Airports within FAA has begun to revolutionize the way it oversees and manages US airports. With the publication of Advisory Circular 150/5300-18B, FAA has established a comprehensive digital data standard and road map—the old paper way of doing business is out, and geographic information systems are in. This regulatory document forms the basis of what is called FAA’s Airports GIS. Airports GIS will allow FAA to collaborate and analyze current airport data to facilitate better decision making. The system uses consistent and accurate data that will be verified through a rigorous quality assurance process. Additionally, Airports GIS is a key enabler for the next-generation national Air Transportation System, also known as NextGen.

By establishing a single authoritative source for survey and mapping data for airports in the United States, the web-enabled Airports GIS database can be leveraged by both internal and external customers to assist with regulatory and organizational requirements. Airports GIS will serve as the one-stop access portal to a variety of airport mapping and operations resources. Airports GIS will provide web tools for the creation of products such as electronic Airport Layout Plans (eALP). Airport airspace analysis and obstacles will be evaluated against design standards and used to assist in the establishment of instrument approach procedures. The Airports GIS information infrastructure will provide FAA with new and innovative ways to offer and use...
digital GIS data to improve and synchronize airport development, management, and operations activities.

To support these new capabilities, the Airports GIS database requires accurate and high-quality GIS data. The FAA Office of Airports has produced a comprehensive suite of regulatory, procedural, and management guideline documents for collecting and submitting Airports GIS data. Supporting these guidelines, the Office of Airports and its partners will perform comprehensive validation checks as part of the review process on data submitted to the Airports GIS. Airport sponsors and consultants face challenges in submitting quality data that complies with these regulations without the need for reworking.

While some airports have compiled and used GIS data for many years, a large number have never worked with digital geographic information. Whether familiar with GIS data or not, complying with these new federal regulations can be a daunting task. Because of that, the Esri Aeronautical Solution now includes tools, templates, and workflows specifically developed to assist airports and their consultants in meeting the data requirements set forth by FAA’s Airports GIS program.

Key Airports GIS capabilities available with the Esri Aeronautical Solution include:

- Preconfigured airport layout and map templates that can be used out of the box or easily customized to an airport’s specific requirements
- Customizable workflows providing structured step-by-step instructions incorporating software automation that simplify recurring tasks associated with preparing, reviewing, and submitting Airports GIS data to FAA
- Automated data validation tools with more than 200 preconfigured checks developed from the FAA’s 18B specification
- Preconfigured 18B data editing templates that make the creation and management of Airports GIS consistent and efficient
- Automated tools for creating and visualizing FAA Part 77 and ICAO Obstacle Identification Surfaces
- A ready-to-use 18B geodatabase template provided by FAA that eliminates costly and time-consuming database design and helps ensure consistency and compliance with 18B requirements

Esri is committed to its partnership with the airport community and supporting FAA’s Airports GIS program. As the Airports GIS program continues to mature and evolve, Esri will continually expand and update Aeronautical Solution support for this initiative. New tools and templates will be offered via download from the ArcGIS Resource Center (resources.arcgis.com/content/esri-aeronautical-solution/10.0/about).

For more information, or answers to questions regarding the Esri Aeronautical Solution Resource Center or Airports GIS, contact aero@esri.com.
that the road inventory was substantially underperforming in two key areas:

**Road Mileage Quantity:** The current inventory reflected only a small percentage of the reservation’s tribal roads. It was widely believed that there were thousands of miles of tribal public roads that were eligible for the inventory but were not yet included.

**Data Quality:** Of the 9,800 miles of roads in the 2006 inventory, only a portion generated funding in the RIFDS allocation formula. Some roads in the existing inventory were missing key pieces of information, which excluded them from funding. Misinterpretations of program regulations resulted in a lack of quality data, exacerbating the effect of the low mileage numbers.

To address these issues, in April 2006, the Navajo Division of Transportation launched an aggressive campaign that would expand its internal capacities, establish a systematic method for identifying eligible public tribal reservation roads, remove subjectivity from regulations, and build a system to improve both the quantity and quality of the road inventory data. With the support of the Navajo Nation Transportation and Community Development Committee (TCDC) and under the direction of former Navajo Division of Transportation director Tom Platero, the Navajo inventory team and consulting project manager Nick Hutton embarked on an innovative and challenging endeavor that would span more than four years.

The first step was to fortify the Navajo DOT’s existing technology infrastructure. New enterprise-class servers were put into place, network bandwidth was expanded, and new data was collected. The Navajo DOT implemented a spatially enabled, multitiered, web-based information architecture that was part of an integrated hardware and software solution provided by the INLINE Corporation (now IceWEB) and Esri. IceWEB servers were preloaded with ArcGIS for Server Enterprise Edition and Microsoft SQL Server and were pre-configured to optimize system performance. This saved many hours of work by allowing the Navajo project team to focus on developing core programs and data instead of testing and tweaking the new system.

The next step was to obtain and develop the required data. The project team was able to acquire brand-new, reservation-wide aerial photography captured as part of a joint project between the Department of the Interior and the State of New Mexico. Once the imagery was loaded into the new system, it was time to start digitizing road centerlines.

Along with a team of GIS technicians using Esri’s ArcGIS technology, GIS consultant and Esri partner Data Transfer Solutions, LLC (DTS), began the digitization process. It wasn’t until this time that the team realized the full extent of the project. After several months of heads-up digitizing, the team mapped more than 70,000 miles of roads and trails. While not all the digitized centerlines were eligible for the official IRR inventory, the potential challenges associated with managing these roads were daunting to DOT officials. This realization underscored the notion that automation would be an absolute necessity in the development of the Navajo DOT road inventory system. While the GIS techs continued the digitization process, the programming staff at DTS and the Navajo DOT project team were busy developing the inventory management system.

The team concluded that the system must be secure; web based; geospatially enabled; usable by staff members without GIS expertise; and capable of mapping automation—specifically, strip map automation. In addition, the team identified the need for a robust querying component that included bidirectional filtering between the map interface and the filtering page.

What emerged was the Navajo Roadway Inventory System (NAVRIS). In addition to web, GIS, and automation capabilities, NAVRIS incorporates a series of validation scripts to ensure that the data is entered in accordance with program requirements.

One of the most challenging aspects of the project was establishing consistent interpretations of the IRR program regulations between the BIA-NRO and the Navajo DOT staff. This took many months of research in collaboration with BIA-NRO chief engineer Harold Riley and his staff. To the credit of both agencies, considerable common ground was established, and the findings were subsequently programmed into the core automation and validation logic of NAVRIS. As a result, the percentage of roads questioned by the BIA because of missing or incorrect data has declined dramatically.
As of the 2010 IRR submission cycle, the Navajo DOT has significantly increased the number of miles in its inventory. It grew from 9,800 miles in 2006 to nearly 16,000 miles, including approximately 6,000 miles of tribal roads. The additional mileage and updates to the existing data increased the Navajo Nation’s IRR funding by an average of 30 percent compared to its 2006 funding level. To date, the Navajo region has received a 15-fold return on the Navajo DOT’s initial investment in the IRR project. This adjusted allocation will allow critical transportation infrastructure improvements supporting access to education, health care, and other services for the nation’s widespread residents. In addition to the development of the NAVRIS system, the Navajo IRR project team also established a series of

to date, the Navajo region has received a 15-fold return on the Navajo DOT’s initial investment in the IRR project. This adjusted allocation will allow critical transportation infrastructure improvements supporting access to education, health care, and other services for the nation’s widespread residents.
programmatic policies and standards to supplement the technology. Due to the rural nature of the reservation, determining the public eligibility of tribal roads has been a historically difficult process. In an effort to establish consistency in properly identifying a public tribal road, the Navajo DOT developed a public roads identification guideline that provides a checklist of characteristics that a road must possess before it can be considered public.

The Navajo DOT also established a methodology for determining the proper functional classification of roads, which was another area lacking clear guidelines between the BIA and the tribe.

By creating NAVRIS and the supplemental policies and standards, the Navajo Division of Transportation has developed a systematic approach to maintaining its road inventory. Beyond supporting the immediate needs of the federal IRR program, NAVRIS serves as the foundation for a comprehensive infrastructure management system to support Division of Transportation activities.

Today, the Navajo DOT continues to develop NAVRIS as part of its ongoing IT strategy. NAVRIS offers the first consistent, verified interpretations of IRR regulations and the ability to programmatically generate the required BIA deliverables. By taking the initiative to build a geospatial road inventory program that helps define and facilitate the IRR process, the Navajo Division of Transportation has become a stronger, more sophisticated tribal entity with more time and resources to support the development and maintenance of its expansive infrastructure.

For more information, contact Jonah Begay, Navajo Division of Transportation GIS supervisor, at jbegay@navajodot.org, or Nick Hutton, director of asset management at Data Transfer Solutions, LLC, at nhutton@dtsgis.com.

Bidirectional Filtering of Data between the Map Interface and the Filtering Page in NAVRIS
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A Powerful Combination for Quicker, More Accurate Damage Assessment

With recent advancements in wireless technology and network speed, nearly everything you can do on the desktop can be performed in the field. Not long ago, streaming live video or surfing the web from your phone seemed implausible. Imagine the implications for more critical mobile tasks, like assessing damage and allocating resources after a disaster.

As a geographic information system (GIS) professional focused on emergency management and disaster recovery, Karyn Tareen understands the value of gathering and sharing timely, accurate information so that cities, counties, and states can prioritize their relief efforts, seek federal reimbursements, and rebuild after a major event. Her company, Geocove—an Esri partner—provides cutting-edge tools and services that help local governments collect, map, and report damage assessment information and community needs.

Using ArcGIS technology and APIs from Esri, Geocove developed an application called ARM360 that gives field-workers a real-time, dynamic picture of the situation from a mobile device, tablet, or laptop. Digitally enabling damage assessments allows information to be collected quickly and accurately, instantly enhancing maps and reports that become powerful decision-making tools. Because ARM360 references an organization’s in-house GIS data, it also provides emergency personnel with a common operational picture.

“By using ArcGIS for Server Advanced, we can now support our customers through a hosted environment or allow them to keep their data stored in-house, which is important to many government organizations,” says Tareen. “If they don’t have the advanced server version in-house, they can still use our mobile application in the field.”

ARM360’s communication capabilities can be powered by AirCard® mobile broadband devices from Sierra Wireless, whose products are available through AT&T. The devices provide Geocove a quick and reliable way to connect to the Internet anywhere there is AT&T network coverage. Even if the application is not connected to a network, ARM360 offers full functionality and automatically synchronizes when connected. An integrated GPS in the AirCard device ensures geographic accuracy and simplifies the data collection process. To streamline large-scale government rollouts, the AirCard can be inserted into virtually any laptop and programmed to automatically connect to virtual private networks to ensure the secure transfer of data.

When damage assessments are collected on paper without requiring that all factors be accounted for, local governments can miss out on significant federal funding. ARM360 eliminates the need to manage vast paper files and includes customizable forms to ensure that all required pieces of information are collected and measured on a consistent scale.

In ARM360, incident and initial damage reports may be viewed as a dashboard summary or in detailed assessments, depending on current needs. An incident assessment report lo-
cates information such as downed wires, debris blocking roadways, and flooded areas. A human services assessment report collects data on public health or community needs, such as water, medical services, and transportation, to facilitate an appropriate and timely response.

After a disaster, Tareen says the most immediate damage assessment need is a basic summary of areas with major structural damage. Current satellite imagery of the area can be brought into ARM360 to help quickly identify unsafe areas so officials can protect citizens from danger. Next, building inspectors and engineers are dispatched to collect detailed assessments and post warnings in severely damaged areas. During the assessment process, the application can reference other geospatial data, such as property tax information, to generate intelligent estimates of the cost of the damage. Finally, field-workers can use ARM360 to track the safety precautions they take and the proposed next steps in the rebuilding effort.

**ARM360 in Action**
**Supporting Damage Assessment after the 2011 Tornadoes**

When massive tornadoes ravaged southeastern states recently, emergency crews from Geocove played a major role, helping Tuscaloosa, Alabama, city officials assess the extent of tornado damage. Geocove specialists provided a tool that coupled satellite images with GIS databases to produce a thorough preliminary damage assessment within days. Tuscaloosa was able to rapidly and accurately determine not only the number of structures affected by the storm but also the estimated cost of the damage to assist in planning for recovery efforts and requests for adequate funding.

“When the damage grid is that sensitive, it would take weeks to compile the assessments using standard protocols,” Tareen says.

**About Geocove**

Geocove, Inc., provides scalable assessment solutions built using the power of GIS across a multitude of industries. The Geocove team has extensive experience in providing assessment, reporting, and mapping tools for emergency management, building officials, public health, and other government agencies as well as utilities and other private industries. Geocove, Inc., a privately held corporation located in central Florida, is an authorized partner of Esri, the world’s leading GIS software provider.