MAINTENANCE-IQ

PUTTING THE POWER OF DATA VISUALIZATION IN THE HANDS OF PENNDOT PROFESSIONALS

NASCIO 2020 State IT Recognition Awards

Category: Data Management, Analytics, and Visualization

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EXECUTIVE SUMMARY

Tasked with maintaining over 40,000 miles of state roads and over 25,000 bridges, the Pennsylvania Department of Transportation (PennDOT) Bureau of Maintenance and Operations team needed a better way to manage improvement projects. Challenges included: significant time and effort to generate maps for project planning; keeping assets within defined maintenance cycle schedules; ensuring assets are maintained in a way that avoids unnecessary rework (i.e. repairing a road and then having to dig it up to replace an underground pipe); and efficiently allocating and deploying maintenance crews, equipment, and materials to job sites. While PennDOT possessed ample data within multiple systems related to transportation assets, staff struggled to leverage and correlate these data to achieve their objectives.

PennDOT developed Maintenance-IQ to harness the power of geospatial technology to efficiently plan and schedule maintenance activities, new construction, and other projects. Maintenance-IQ combines information from 13 separate systems and provides users with an intuitive, mobile-integrated, easy-to-use interface. Maintenance-IQ also supports PennDOT's fulfillment of the federal requirement for states to implement a risk-based asset management plan.

With more than 13,600 users and an average daily user count of 100, Maintenance-IQ is having a significant impact on infrastructure maintenance planning in the commonwealth.

Benefits of Maintenance-IQ include:

- **Reducing Inefficiencies:** As a single-source GIS solution for 150 data tables, Maintenance-IQ streamlines the maintenance and operations processes. It eliminates out-of-sequence rework, gets selected maintenance activities on-cycle, and reduces mobilization and travel costs.
- **Increasing GIS Users:** By making the data more accessible through easy-to-use GIS interfaces, this application increases productivity, improves project quality, facilitates vendor coordination, and reduces equipment repair and replacement costs.
- **Expanding Functionality:** Based on Esri® technology, Maintenance-IQ has shown valuable flexibility. Its functionality has easily expanded from its core use for operations and maintenance management to cover other needs such as stormwater control, monitoring bridge warranties, and addressing safety needs with guide rail management. The expandability of this solution will save both time and money.

Because PennDOT maintenance staff members can better detect highway deficiencies, determine roadway treatments, plan operations, and monitor production, the traveling public realizes greater service and savings. Smoother highways result in reduced vehicle wear and tear and less pressure to increase fees and taxes that fund PennDOT. Application efficiencies also help PennDOT lessen traffic congestion, promote enjoyable commutes, lower vehicle carbon emissions, and support enhanced environmental compliance.

CONCEPT

Challenge

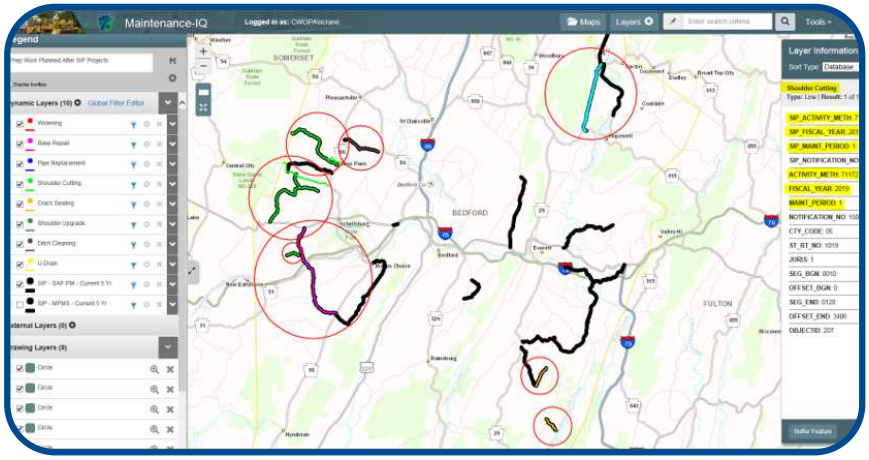
Tasked with handling the roadway wear and tear from more than 225 million miles traveled every day throughout the commonwealth, PennDOT's Bureau of Maintenance and Operations team needed a better way to manage improvement projects. The bureau's central office oversees maintenance duties throughout the state's 67 counties that are organized into 11 engineering districts. With maintenance and supporting data stored in disconnected systems at multiple locations, it was a challenge for bureau, district, and county staff to find, decipher, or communicate information quickly.

One example of this challenge is generating maps for maintenance planning and asset management. In the past, a GIS operator with appropriate software was needed to develop multiple versions of maps for each project. PennDOT's pavement management process required almost two full weeks for the operator to create 20 different types of maps representing a one-time snapshot for surface improvement planning.

The inability for PennDOT staff to effectively leverage its massive data stores also made it difficult to keep assets within defined maintenance cycle schedules; sequence projects to avoid unnecessary rework; and effectively allocate resources across Pennsylvania's 67 counties and PennDOT's 11 engineering districts.

Solution

In response to these maintenance planning challenges, PennDOT developed Maintenance-IQ, a mobile-integrated, user-friendly GIS application, to improve statewide maintenance planning and coordination and help keep improvement projects on-cycle. With Maintenance-IQ, PennDOT's maintenance community at all levels can integrate information from several systems to create maps using the most current data available, without having to be a GIS guru. From an IT perspective, an enterprise GIS was necessary to help staff more efficiently implement a maintenance planning and scheduling system.



Through an easy-to-navigate interface design, the application enables PennDOT maintenance employees to visualize, analyze, and map planned and completed improvement projects from a central intranet location. The capability allows them to better understand how this information relates to transportation infrastructure assets and engineering conditions. Maintenance-IQ synthesizes maintenance-related data from 13 diverse PennDOT information management systems, including bridge maintenance, contracts, electronic document management, environmental protection, Google Street View, highway performance monitoring, multimodal project management, pavement

management, political boundaries, roadway management, spreadsheet visualization, strategic environmental management programs, and video logs.

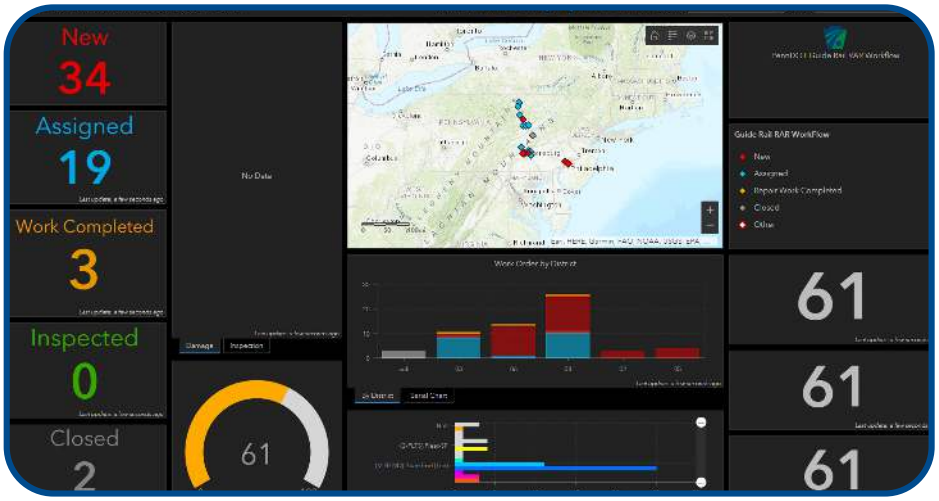
In addition to facilitating access to existing data stores, Maintenance-IQ also supports the collection of new data from PennDOT's PA Guide Rail App, a mobile survey application for guide rails and pavement data. This app acts as a workforce management and collection tool to identify, locate, and assess the condition of assets, including guide rail, stormwater facilities, shoulders, bituminous and concrete pavements, and unpaved roads. The integration with Maintenance-IQ allows the app to go beyond data gathering to become an immersive mobile workforce management tool – locating the correct asset, collecting damage images, and sharing information with the repair team.

Architecture: PennDOT uses a cluster-based architecture for the database along with a robust backup through COOP (continuity of operations) procedures. Intranet-based Maintenance-IQ features active directory control for security, login, and user profiles. The application also integrates the mobile survey app component that provides photos taken in the field to document highway and bridge deficiencies or needs and subsequent repairs.

Maintenance-IQ ingenuity includes Esri® ArcGIS Server (AGS) dynamic services, data staging processes, and data owner coordination to build and consume data services, and the ability to save maps and share maps between users easily. The application requires managing a high volume of data from 13 separate systems into nightly refresh cycles along with cooperative team development of a common GIS framework. Built on Esri® and Oracle® platforms, Maintenance-IQ uses standard core components called "PennBOTs" – plug-and-play widgets for any PennDOT web application – to provide new PennDOT groups with GIS and reduce future re-coding.

Gathering the Data: By extending Esri®'s Survey123 and combining it with Esri's Operations Dashboard and data from PennDOT's Roadway Management System (RMS), PennDOT was able to create a workforce and asset management mobile solution, the PennDOT Guide Rail App, also known as the mobile survey app. Every repair is documented, with the information and images captured. Repair information is shared with inspectors who review the repair and document the changes to the sites, noting changes to the asset and the scope of the repair.

The new mobile workforce management tool allows access by multiple users in different roles and responsibilities throughout the process. Locations are fed into Survey123 from RMS, and changes and updates are sent back to keep RMS up to date. Users can select and survey the assets from an online or offline map using their iPads on location. The updates occur automatically online, allowing PennDOT employees to monitor the status of the repairs and collection in real time.



Creating Adaptability: Maintenance-IQ enables PennDOT to perform GIS temporal (time) and spatial (space) analyses at statewide, political district, engineering district, county, and municipality levels. Layers and filters can be quickly added or removed from a map to evaluate multiple potential scenarios, if necessary. Also, users can view and export the table data used to generate the GIS maps so that an additional spreadsheet or statistical analysis can be performed on map data without difficulty.

The application's self-service environment combined with the PennDOT extract, translate, and load (PETL) plug-in allows operators to complete tasks in minutes that would have previously taken weeks, enabling staff to be more productive. A unique integration, PETL accepts linear referenced spreadsheet data and creates data layers within Maintenance-IQ that can be filtered and analyzed with innovative techniques.

Another original design concept creating adaptability is the storage of user-specific views. Maintenance-IQ uses a central database to store user-specific views of robust data and maps that can be rapidly displayed, shared, and edited for other users through query layer services.

Communications & Training: To ensure its employees were well-equipped to use the application, PennDOT developed resource materials and facilitated the initial 11 weeks of application training spanning 36 sessions across the commonwealth. More than 500 Maintenance-IQ users participated in that training, including district maintenance managers, county maintenance managers, assistant county maintenance managers, roadway program coordinators, and technicians. PennDOT has conducted additional training for more than 250 users, through on-site engagements or live webinars.

Hands-on learning sessions enabled PennDOT employees to understand and start using Maintenance-IQ to improve their jobs immediately. PennDOT also provides an intranet-based portal for their team through an online Knowledge Center that contains application overviews, instructions, and a wealth of resource information.

> *"More than 500 individuals were trained in Maintenance-IQ, and the feedback has been incredible…new requests for functions and ideas are received daily, along with user testimonials on how the application is helping to get the job done."*
>
> — Shawn Crane, project manager with PennDOT Bureau of Operations and Maintenance

SIGNIFICANCE

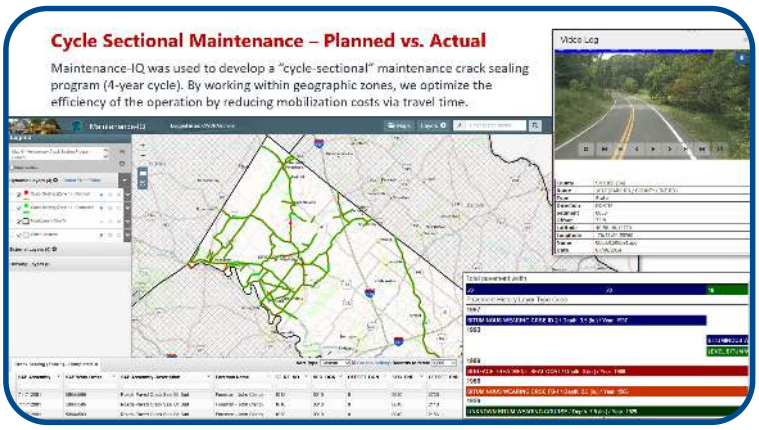
Maintenance-IQ meets the primary need in PennDOT's Transportation Asset Management Plan (TAMP) required by the federally mandated Fixing America's Surface Transportation Act (FAST Act). The FAST Act requires each state department of transportation to develop and implement a risk-based asset management plan. A significant part of taxpayers' investments is in Pennsylvania's transportation assets – roads, bridges, and other vital infrastructure. These assets need regular maintenance, sometimes require significant repairs, and eventually must be replaced. Maintenance-IQ helps PennDOT complete the right maintenance or treatment at the right time, helps infrastructure last longer, and squeezes the most value from transportation dollars.

For this to be genuinely significant, people must use this tool. The interactive system offers a single comprehensive visual on the assets and maintenance activities using 150 data tables without having to connect the dots on reports from disparate systems. The users of Maintenance-IQ include 18 different groups from the central office and throughout the district. The ease of use and visual,

comprehensive reporting of this system has assisted more than 13,600 users to date, more than 113,000 pageviews, with a daily average of 100 users. The numbers prove that users believe Maintenance-IQ is essential and significant to meet the needs of their work objectives.

IMPACT

Reducing Inefficiencies: A single-source GIS, Maintenance-IQ is revolutionizing how PennDOT plans and schedules maintenance activities. Maintenance-IQ streamlines the maintenance and operations processes – eliminates out-of-sequence rework, gets selected maintenance activities on-cycle, and reduces mobilization and travel costs. For example, the application could help identify opportunities to replace underground pipes in poor condition before paving a road. Before Maintenance-IQ, a road might be paved and then, a month later, dug up to replace deteriorating underground pipes, costing the commonwealth anywhere from $10K to $30K or more depending on the size and length of the pipes. Reducing these inefficiencies improves public perception and saves PennDOT resources.



Maintenance-IQ empowers bureau stakeholders to process data from multiple technology sources and physical locations while optimizing job performance. Maintenance professionals can access the web-based application to create, load, share, clip, print, or validate current data without the assistance of a GIS professional. Maintenance-IQ also enables PennDOT personnel to load existing maps or generate custom ones from an intuitive, self-service, and menu-driven toolset. Easy-to-use plug-ins allow users to drag and drop location-based spreadsheets and information for immediate visualization, while simultaneously displaying project-related electronic documents or video logs showing PennDOT's automated collection of pavement conditions and roadway imagery. Employee advantages include identifying and coordinating regional maintenance collaboration opportunities throughout the state, reducing mobilization costs, increasing daily production, better scoping of maintenance needs, and sequencing work assignments.

Increasing GIS Users: By making data more accessible, Maintenance-IQ helps PennDOT personnel improve project quality, increase productivity, facilitate vendor coordination, and reduce equipment repair and replacement costs. The Roadway Management System (RMS)--PennDOT's primary data warehouse for inventorying state-owned highway features, conditions, and characteristics--is a robust mainframe difficult for an experienced user to navigate and extract maintenance-related information. With Maintenance-IQ, the novice user can easily access RMS information necessary for funding, business planning, project design, and maintenance programming decisions. Thanks to the new level of intelligence garnered through Maintenance-IQ when using RMS, PennDOT District 3-0 transitioned specialized crews such as milling, surface treatment, and paving from county-based to regional locations. Projects assigned through regional crews help PennDOT management balance

workload, maximize efficiency, and facilitate additional coordination opportunities with district-based maintenance crews.

With wide-ranging benefits, Maintenance-IQ provides an application development roadmap that redefines the transportation GIS marketplace. It demonstrates how geospatial technology can be used to reach a broader audience and provide self-sustaining, advanced tools through common code initiatives and dynamic services that achieve practical results.

Expanding Functionality: Based on Esri® technology, Maintenance-IQ has shown valuable flexibility to expand from its core use for operations and maintenance planning through the management of transportation assets. Stormwater control, Public-Private Partnership (P3) Bridge Initiative, and guide rail management are three uses that were added through Maintenance-IQ.

PennDOT's environmental division needed to **manage Municipal Separate Storm Sewer System (MS4) permit program compliance**. The MS4 permit is designed to protect rivers, lakes, and streams from polluted stormwater runoff. Maintenance-IQ was easily adapted to manage the assets that would affect the waterways and provide the information needed to make reporting to the U.S. Environmental Protection Agency more efficient and reliable.

The structure of the warranties on the various assets of the bridges included in the **public-private partnership Rapid Bridge Replacement (P3 RBR)** impact how PennDOT personnel can conduct future maintenance. Each asset associated with the RBR project has a different warranty timeframe. To avoid inadvertently canceling the warranties, PennDOT is using Maintenance-IQ to **track the various deadlines for every warranty on each asset** and how planned PennDOT maintenance projects relate to those locations.

PennDOT needed to address **the safety concerns of damaged guide rails** throughout the commonwealth. As a result, the PA Guide Rail app was created to integrate with Maintenance-IQ. The app also **increases the reimbursement** process for repaired guide rails, leading to improved cash flow for the commonwealth. In the first year alone, 500 more invoices were processed than the year prior. The app extends Esri's Survey123 and combines it with Esri's Operations Dashboard and RMS.

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