CDOT GeoHub

Turning Raw Data into Actionable Insight *with* Location Intelligence

CATEGORY

Information Communications Technology Innovations

START DATE

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END DATE

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NASCIO STATE IT RECOGNITION AWARDS

COLORADO

Governor's Office of Information Technology

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Executive Summary

Departments of Transportation are now operating in a growing and complex data landscape. Transportation networks are fast becoming information highways due to the exponential growth of big datasets from internet-connected systems, devices and sensors. As new data streams expand in diversity and size, advances in technology have brought about an unprecedented opportunity to fundamentally change the way that data is used, collected, accessed, valued, analyzed and visualized. Notwithstanding disruptive technologies and trends, (IoT, V2X, Connected Vehicles, and more), CDOT's (Colorado Department of Transportation) commitment remains the same: *Operational Excellence*.

Big data, artificial intelligence and machine learning have become a core part of CDOT's data and digital strategy. Complementary to the digital strategy is CDOT's geospatial strategy. Viewing data through the lens of location involves grounding information, predictions, actions and decisions in the common language of geography. By enhancing context, location data helps inform us of our surroundings with unparalleled enrichment and accuracy. Location intelligence is integral to a holistic understanding of the transportation network.

The CDOT GeoHub is helping usher in this new age of location intelligence in transportation. In hosting fit-for-purpose apps, it is helping shift the paradigm from reactive to proactive to improve situational awareness, to better understand the causes and variables on the transportation network, to help more accurately predict and forecast and to help better identify the most effective solution options. CDOT Is harnessing the power of location, and the next generation of geospatial capabilities for location intelligence. The GeoHub is expanding awareness, discovery and utilization of data and geospatial tools across the agency.

Applications are a key dimension of the GeoHub. They capture data from the field and/or ingest data from disparate data sources and silos with the purpose of synthesizing and displaying the data in a standardized, dynamic, interactive, engaging and easily consumable way. The apps are helping identify trends, distilling increasing amounts of information, enhancing workflows and transforming raw data into actionable insight. The visualizations help render large, complex data into images which maximize understanding and provide new avenues for analyses.

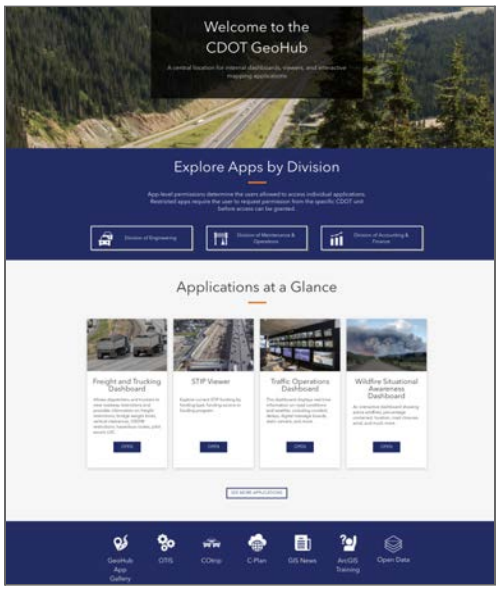
The GeoHub allows users to explore mobile applications and data-rich dashboards from across CDOT Divisions related to maintenance and operations, engineering, infrastructure and more. The applications within the GeoHub are broad and wide ranging, spanning situational awareness, data management, field mobility and analytics. The GeoHub has created a single point of entry for communicating digital content with location as its core. GeoHub content intertwines interactive visualizations and integrated data by using the common language of location which links the network, communities and us all. Most important, the content furthers the end state goal of the GeoHub to:

- Maximize business insight.
- Improve the flow of information.
- Enhance data quality through data transparency.
- Foster interoperability and break down data silos.
- Advanced data discovery, access, analytics and utilization.
- Inspire innovation, and creative and cooperative problem solving.

Project Narrative

Idea

Emerging transportation technologies and the world of big data have generated new opportunities for innovation within CDOT to keep pace with the rate of change. CDOT recognized the need to address its data challenges and position for the future. CDOT also acknowledged the need to reengineer business processes, redesign workflows, reduce manual transactions, and use analytics to improve the effectiveness and efficiency of our programs. In response, CDOT embarked upon an effort to transform and modernize these processes - paper forms and manual inputs would be digitized and siloed data would be integrated and shared. The need to use location data to address a wide variety of business use cases led CDOT to leverage its geographic information systems (GIS) and incorporate location intelligence as a core part of its business strategy. These efforts resulted in the development of the GeoHub.



The CDOT GeoHub is built upon Esri® ArcGIS Enterprise and the Colorado Office of Information Technology (OIT) Amazon Web Services (AWS) cloud environment. At its core, the GeoHub is an online GIS platform that enables staff to develop, share and use geospatial applications, web maps, and data. To date, 15 robust application suites have been developed and released within this environment.

In addition to helping CDOT further goals regarding data democratization and reduction of data silos, the GeoHub meets several 2021 State CIO top ten priorities for strategies, policy issues and management processes including digital government/digital services, cloud services, data management and analytics and consolidation/optimization. The GeoHub also fulfills the following 2021 State CIO top ten priorities for technologies, applications and tools: cloud solutions, legacy application modernization/renovation and data analytics.

Implementation

The GeoHub was built within a sustainable AWS cloud environment using the Agile project management method in coordination with CDOT and OIT subject matter experts. The whole of CDOT was engaged via discovery sessions conducted across all CDOT business units and regions. These discovery sessions were foundational in gaining an understanding of business workflows, processes, and priorities. Credibility and trust were developed by showing visible progress and producing results early and often. Based on the discovery session results, a prioritized list of applications was developed.

A Phased Approach

The GeoHub was implemented in four phases. Phase 0 established the technical foundations for the project and identified key project and app team members. The project team designed a detailed GeoHub system architecture design and established a development environment utilized for app prototype iteration reviews, testing, and configurations. The project team also developed the functional prototypes for the top three identified apps. In addition, Phase 0 involved testing and refinement of the business unit engagement patterns for app design, testing, feedback, data source discovery, and data dependency diagramming. Phase 1 commenced the build-out of the three-tiered system architecture and initial app development. System governance and training plans were also initiated in Phase 1. Phases 2-3 consisted of app development sprint cycles. These sprint cycles involved collaboration with the application sponsors via iterative review and Quality Assurance/Quality Control (QA/QC) measures. Thorough field testing of the apps by business unit staff took place before the apps were migrated to the GeoHub production environment.

Collaboration is Key

The GeoHub represents a true collaborative effort between the CDOT Chief Data Office (CDO), the GIS Section, program staff from across multiple agency divisions, business units, CDOT regions, and OIT. In addition, we closely collaborated with a sister state agency, the Colorado Avalanche Information Center (Colorado Department of Natural Resources), on the Avalanche Mitigation Dashboard. Partnership with OIT was critical to the success of the project and OIT staff members stepped up to assist in implementing the complex, geospatially-enabled cloud architecture.

Architecture

Working closely with OIT, the project team built the real-time enabled ArcGIS Enterprise system within the AWS cloud environment behind the CDOT firewall. The infrastructure was developed in compliance with OIT's cybersecurity policy. The backend of the system currently includes 22 AWS server instances and seven SQL server databases configured in a high availability environment. The three-tiered architecture includes development, staging and production environments. CDOT's AWS ArcGIS Enterprise system includes the deployment of several Esri® software products including ArcGIS Server, GeoEvent Server (real-time component), ArcGIS Big Data Store, ArcGIS Web Adapter (outside the firewall), ArcGIS Sites and the ArcGIS Enterprise Portal. The system front end or "portal" was dubbed the GeoHub and is now the premier online GIS portal for CDOT. The system also leverages and builds upon existing geospatial technology and maximizes these investments for application development and field mobility.

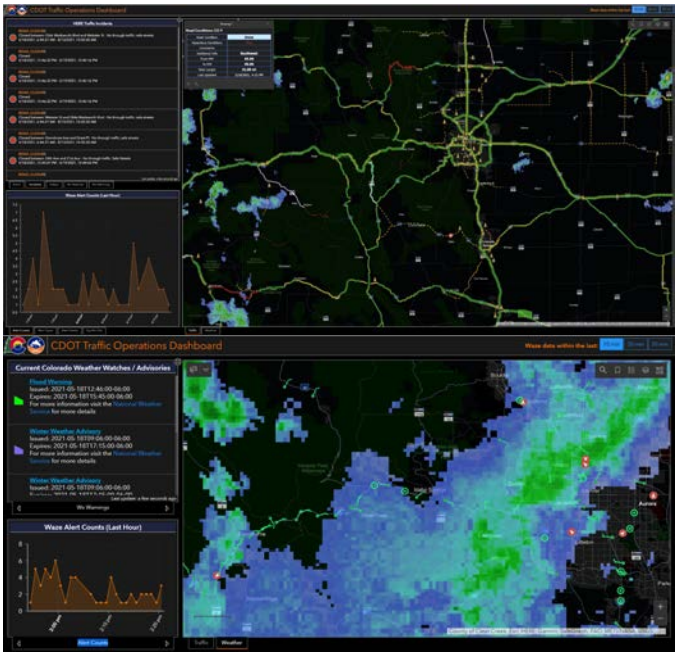
The system allows integration with real-time feeds from a variety of sources including CDOT's own Intelligent Transportation System (ITS) XML feeds and the CDOT's Data Lake and Kafka® feeds. The real-time data feeds are currently integral to two GeoHub applications that are crucial for traffic operations and wildfire situational awareness.

Impact

The most significant impacts of the GeoHub are realized across the 15 (and growing) current app suites housed within the system. The internal GeoHub user base currently numbers over 1,400 that spans all of the CDOT divisions and regions. Apps are supporting internal operations such as Night

Inspections, Operations Readiness, Avalanche Mitigation, Wildfire Situational Awareness, Building Inspections, Traffic Operations, and ADA Curb Ramp Compliance as well as apps designed for the public such as Freight & Trucking. The following summaries and testimonials illustrate the positive impact of the GeoHub: significant time and cost savings, improved business workflows, heightened situational awareness, and enhanced insight into asset conditions.

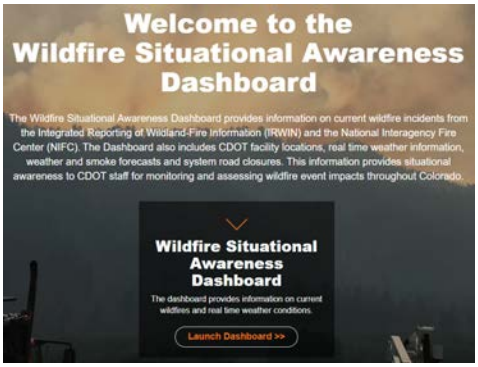
Traffic Operations Dashboard



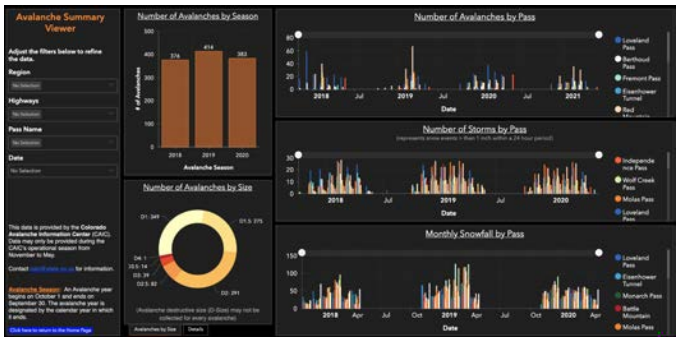
The Traffic Operations Dashboard fills an important gap that is not currently covered in the CDOT ITS Colorado Traffic Management System (CTMS). The dashboard eliminates the need to open multiple screens and tabs by displaying diverse and new data sources onto a single interface. It was designed for and customized to the needs of the CDOT Traffic Operations Center (TOC) and includes several real-time datasets including WAZE alerts, HERE traffic, NWS radar, watches and warnings, road conditions and alerts and snowplow locations. The TOC used the dashboard to track storms and watch weather patterns over the past two winters before the storms hit Colorado. They also used it to identify crashes reported by motorists before they were alerted by local police agencies. Finally, the dashboard has helped monitor some of the ITS field devices in real-time such as variable message signs, cameras, friction sensors, weather stations and speed devices.

Wildfire Situational Awareness

In the aftermath of the 2020 fire season, the most active and devastating fire season in Colorado's history, the Wildfire Situational Awareness Dashboard was developed. The dashboard synthesizes multiple data sources and data-rich content into a single interface to provide heightened situational awareness to CDOT staff for monitoring and assessing wildfire events throughout the State. In addition to wildfire location and perimeter information, the dashboard includes real-time wildfire event information including total acres burned statewide and by county, the number of personnel involved and the percentage of a fire contained. The dashboard also includes CDOT facility locations, real-time and forecasted weather, smoke forecasts, locations of top wind gusts and speeds, top temperatures, system road alerts, historic fire perimeters, and much more.



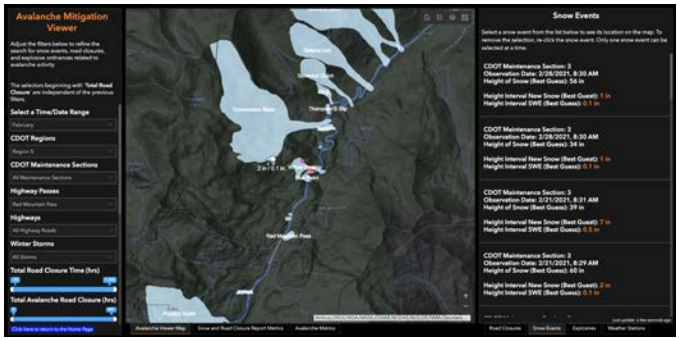
Freight & Trucking



CDOT's Freight Office transformed all of their static hand-drawn maps into interactive mapping applications in the GeoHub Freight and Trucking App Suite. For the first time, the community of users was able to interact and visualize construction restrictions, oversize curfews, chain station law, rest areas, runaway truck ramps, low or weight-restricted structures, hazmat routing and so much more. The Freight Office has also used the GeoHub to map years worth of data to highlight heavy use freight corridors and help identify weaknesses in the freight network. These visualizations have gone a long way in helping to select priority infrastructure improvement projects. They received $2 million to work on timber bridge structures as a direct result of the ability to visualize the data in an interactive mapping platform.

Avalanche Dashboards

The Avalanche Mitigation Dashboard provides key personnel-integrated views and metrics of snow events, snowfall, road closures and avalanche mitigation activity. It provides a single real-time authoritative view of avalanche activity to CDOT Management, Traffic Operations, Maintenance and Safety with an understanding of what the current situation is on the 278 known avalanche paths that CDOT maintains. The app also supports the ability of the DOT to track expenses related to road closures and potentially damaged assets. An accompanying summary viewer provides an interactive experience through the display of charts, trends, and patterns. An overview of avalanches by season, storms, and monthly snowfall bypass for four years is currently provided for analyses.



ADA Curb Ramp Accessibility

The ADA Curb Ramp Compliance App Suite has significantly enhanced CDOT's ability to monitor compliance with ADA Title II Federal regulations. The data collection tool that was developed ensures each technical requirement is obtained for more accurate reporting. The app allows personnel to update curb ramp measurements in real-time into the inventory and easily communicate progress toward compliance with requirements. This system has reduced processing time as well as potential human error associated with paperwork processing. Before the advent of this app, there were several disparate databases used to track this information with incompatible schemas. Within six months of working with the GeoHub team, the data was able to be reconciled under one schema with one database while including a new app interface. As a result of this effort, the app has established a central repository for data and supporting information that enables CDOT to comply with federal regulations and therefore leverages federal funding to make curb ramp upgrades.

Operations Readiness

The Operations Readiness App Suite provides maintenance users the ability to input, track and view current materials, equipment and personnel from their cell phone, tablet, or computer in a geospatially-enabled environment. This process used to be completed via an Excel spreadsheet and was not always efficient or accurate. In addition to staff time savings, this app has helped incur savings in costs due to reduced, unnecessary materials orders. The app has also increased staff accountability and efficiency of storm preparedness. One of the biggest advantages of using this geospatially-enabled system is allowing users to visually understand the number of materials available and where critical materials and resources are located.

Buildings Assessment Condition

The Building Condition App Suite has improved CDOT's building assessment process in several key areas. The mobile app has digitized building inspection data inputs which has resulted in significant time savings - both in the collection of the data and, now, seamless transfer into the SAP source system. It has also greatly enhanced data quality and consistency, resulting in a more accurate scoring methodology used to grade every CDOT facility. It has provided an accurate baseline inventory that can be queried to answer questions from the number of bays that exist to the functional and condition grade of each facility. Transparency has been enhanced as staff can visually see deficient facilities at a glance. In addition, the dashboard has resulted in improved budgeting. Targeted treatments can be readily identified and verified thanks to the collected data and photos in the dashboard and are more cost-effective, allowing us to maximize maintenance resources.

The GeoHub has successfully become the single point of entry for GIS-based applications incorporating over 250 distinct geospatial layers in the current apps. It will continue to grow and expand with new and enriched content, leveraging both internal and external data for its GeoHub applications. As utilization has increased with over 25,000 views to date, it is transforming the way CDOT accesses and utilizes data and technology to enhance day-to-day operations, advance data literacy and transparency, and make better spatially-informed decisions.

The GeoHub is instrumental in furthering the use of location intelligence to enhance operational excellence, advancing a data-driven environment, and helping transform raw data into actionable insight.