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TECHBRIEF: LESSONS LEARNED FOR THE DEVELOPMENT OF DIGITAL AS-BUILT OF ABOVEGROUND ASSETS FROM COLORADO DEPARTMENT OF TRANSPORTATION'S SUBSURFACE UTILITY PROGRAM

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EXECUTIVE SUMMARY

This Technical Brief examines Colorado Department of Transportation's (CDOT) subsurface utility program, focusing on the integration of digital as-builts (DABs). The primary objective of this brief is to share insights and lessons learned from CDOT's efforts to enhance DABs for aboveground utilities and assets. CDOT's program focuses on efficient utility coordination, precise mapping for design modifications, and real-time access during construction—all of which contribute to cost savings associated with data collection for future projects. CDOT adheres to a set of American Society of Civil Engineers (ASCE) standards, including ASCE 38-22 and ASCE 75-22. The standards provide technical guidelines and a comprehensive framework for utility standards; however; its use is not a Federal requirement. Quality levels and a subsurface utility engineering (SUE) workflow ensure that data are gathered accurately through planning, design, and construction.

CDOT's SUE project lifecycle is complemented by a sophisticated data dictionary architecture that provides a standardized approach to survey and geographic information system (GIS) integration. The agency's strategic approach extends to the operations and maintenance phase and ensures real-time updates of DAB records into the PointMan Enterprise dashboard.[1] A detailed review of the agency's operations during these phases demonstrates the efficiency gained through the integration of ASCE standards and proactive utility management.

This Technical Brief serves as a comprehensive exploration of CDOT's SUE transformative journey, offering a roadmap that agencies can consider when optimizing DABs in infrastructure management and implementing DABs for aboveground utilities and assets.

INTRODUCTION

DABs are emerging as a valuable repository of highway infrastructure project information. They capture changes made during construction and deviations from as-designed plans to provide a

[1] The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this document only because they are considered essential to the objective of the document. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

comprehensive and accurate representation of the constructed infrastructure. Furthermore, by digitally capturing and connecting project and asset information, DABs serve the information needs of the entire project lifecycle—from design and construction to operations, maintenance, and asset management, and back to project development.

An integral part of the highway project development process involves extracting existing asset data from enterprise information systems and historical records for a specific project area. This data extraction enables agencies to identify, at an early stage, the assets within the proposed project footprint and capture pertinent details of existing asset features, such as their types, quantities, and locations, thereby facilitating their use in design considerations. DABs streamline this workflow by seamlessly integrating data from various collection methods and sources, allowing stakeholders to access the most up-to-date and accurate data at all times, and managing them over the entire lifecycle. DABs can be used to effectively manage both above-surface assets and subsurface utilities.

The adoption of DABs has gained significant momentum over the recent years, with many States already embracing this approach. CDOT has demonstrated how a DAB workflow can be leveraged to enhance coordination with utility owners, accurately map subsurface utilities before and during construction, and use the information throughout various project lifecycle stages.

DIGITAL AS-BUILTS FOR SUBSURFACE UTILITIES

Identifying potential utility conflicts during the preliminary design phase is a best practice in the project delivery process. This step involves gathering information about existing utilities to determine property interests within the project right-of-way (ROW) and identifying potential impacts based on available records. However, the process is often hindered by the lack of comprehensive utility records maintained by utility owners, who frequently have incomplete knowledge of their subsurface utilities.

Even when utility records are available, difficulties associated with making utility data shareable and usable complicate the process, creating obstacles in coordinating utility relocations and managing project timelines. As a result, CDOT was observing a high number of utility delay claims during project delivery. Moreover, managing historical data from surveys and as-builts posed an additional challenge for CDOT. Therefore, CDOT developed robust strategies for collecting, updating, managing, and sharing utility data across the project lifecycle to improve project delivery outcomes.

In this context, implementing DABs addresses a multitude of challenges inherent to managing utilities in project delivery. By facilitating a structured process for managing utility data, DABs enable proposed designs to be overlaid with existing utility data. This process allows project stakeholders to identify potential conflicts and constructability issues early on and discuss potential resolution strategies, thereby reducing costly errors and schedule delays. The benefits of DABs are multifaceted:

- Enabling the systematic collection of utility data from various sources, including utility owners, field surveys, and historical records.

- Integrating data into a centralized database for easy access and reference.
- Improving data sharing and collaboration among project stakeholders, including designers, contractors, and utility owners.
- Contributing to safety by providing accurate, up-to-date information that can prevent potentially hazardous incidents.
- Addressing the shortcomings associated with poor, outdated, or inconsistent utility and pipeline records.

OBJECTIVE

CDOT has adopted a strategic approach to managing utilities within its ROWs by implementing a comprehensive DAB program. By leveraging a combination of traditional paper-based red-line markups, electronic PDF red-line markups, and design computer-aided design (CAD) DGN revisions, CDOT has successfully transitioned to electronic and digital records that incorporate utility data.

This strategic approach enables CDOT to collect and use utility data throughout the planning, scoping, design, and construction stages of a roadway design project. As a result, the agency can identify potential utility conflicts with highway construction activities early on. Once necessary relocations have been carried out to avoid these conflicts during the construction phase, all relocated utilities are documented in the DAB to create an accurate record for future use. These as-built data, required by CDOT during construction and data handover for utilities within the ROW, are seamlessly integrated into asset management for efficient lifecycle management.

The purpose of this case study is to discuss CDOT's lifecycle and data management approaches for subsurface utilities using DABs. The case study outlines CDOT's approach to capturing utility data across various project delivery stages, from preconstruction to construction, while highlighting the importance of adhering to new industry standards such as the ASCE 38-22 guidelines for SUE and ASCE 75-22 for recording and exchanging utility infrastructure data.

COLORADO DEPARTMENT OF TRANSPORTATION UTILITY PROGRAM CASE REVIEW

Colorado has taken a proactive approach by enacting and implementing legislation and regulations that require location data for subsurface utilities for public civil engineering projects throughout the State. The impetus for this transformative change came in April 2017 when a fatal gas explosion occurred in Firestone, Colorado, prompting widespread public attention and underscoring the importance of preventive measures.

According to Article 1.5 "Excavation Requirements" of Title 9, Safety - Industrial and Commercial of Colorado Revised Statutes,[2] it is essential for excavators to gather important details about the location of subsurface utilities before starting excavation to minimize safety

[2] Colorado Revised Statutes. (2023). Title 9, Safety - Industrial and Commercial. Retrieved from https://leg.colorado.gov/sites/default/files/images/olls/crs2023-title-09.pdf

risks. Specifically, Clause 9-1.5-103, "Plans and Specifications," requires a licensed professional engineer of the excavating agency to obtain general information about the description, nature, and location of underground facilities in the area of the proposed excavation. This general information must be included in the State's plans or specifications to inform an excavation contractor of the existence of such facilities. In addition, in accordance with the State's statutes, the licensed professional engineer must meet or exceed the ASCE 38 standard for underground facility location, strive to achieve ASCE 38 Quality Level B for all utilities, and document reasons for any deviations from these standards.

According to the State's statutes, the utility owner or operator must provide documentation of the location of the underground facilities in the form of a digital sketch, a hand-drawn sketch, or a photograph that includes a readily identifiable landmark, where practicable. All new underground facilities installed on or after August 8, 2018, in Colorado, must be electronically locatable when installed.

Consequently, SUE surveys are required for most public civil engineering projects, while project owners are required to notify the Colorado State OneCall center for SUE surveys and bear the survey costs. The results, endorsed by a licensed surveyor or engineer, are then submitted to CDOT, emphasizing adherence to ASCE Quality Level B for utilities. Additionally, the legislation revamped the Colorado 811 notification process, granting utilities two days to mark the site before excavation, and stipulating that all newly installed utilities need to be electronically locatable. Furthermore, the creation of the Underground Damage Prevention Safety Commission equips the State with the authority to levy fines on non-compliant utilities. Enacted into law in August 2018, these State provisions aim to bolster utility safety and accountability throughout Colorado.

Program Goals

To strengthen the foundation of utility safety measures and foster heightened accountability, CDOT formulated and upholds a set of comprehensive goals pertaining to data standards. These objectives are designed to govern the accurate and efficient management of utility information throughout the lifecycle of civil engineering projects. The agency goals are outlined as follows:

- Having attribute data about each utility enables more efficient and productive coordination with utility owners.
- Knowing the location and depth of utilities enables designers to change designs to avoid costly utility relocations and delays in project delivery.
- Providing mapping systems during construction that accurately display the location and depth of the utilities allows contractors to avoid utilities and prevents delays.
- Storing data in a single platform can minimize the cost of data collection on future projects.

Colorado Department of Transportation's Policy Guidance

Within the framework of CDOT standards that govern utilities (encompassing survey, as-builts, and asset management), a comprehensive set of guidelines is observed. These include:

- ASCE/CI 38-02: the Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, incorporating attributes and Quality Levels (D, C, B, and A).
- Federal Geographic Data Committee (FGDC)-STD-007.4-2002: the Geospatial Positioning Accuracy Standards Part 4 focusing on standards for Architecture, Engineering, Construction (A/E/C).
- International Organization for Standardization (ISO) 15489-1:2016: Information and Documentation-Records Management-Part 1: Concepts and Principles.
- ASCE/UESI/CI 38-22: the Standard Guideline for Investigating and Documenting Existing Utilities.
- ASCE/UESI/CI 75-22: the Standard Guideline for Recording and Exchanging Utility Infrastructure Data, complementing ASCE/UESI/CI 38-22.

Quality levels, as defined by ASCE 38-02, are integral to CDOT's utility standards. These include:

- Quality Level D: The most basic level, relying on existing records and verbal recollections that are facilitated through services including 811 Locate, OneCall, and Diggers Hotline.
- Quality Level C: Involves surveying visible utility features, either above or below ground, to estimate approximate underground locations.
- Quality Level B: Encompasses the use of comprehensive geophysical methods to designate the existence and reproducible horizontal position of all subsurface utilities.
- Quality Level A: Represents precise mapping achieved through exposure of utilities, providing detailed information on type, size, condition, material, and is commonly referred to as "locating," complete with X, Y, and Z coordinates and test holes.

SUBSURFACE UTILITY ENGINEERING WORKFLOW IMPLEMENTATION

Process Flow

The integration of a centralized repository, Transparent Earth, facilitates the seamless collection, consolidation, and sharing of three-dimensional (3D) multi-utility data within CDOT. CDOT's permitting process mandates utility company participation through the OneCall Center, ensuring comprehensive and updated data within the repository. Existing location requests are strategically leveraged to guarantee ongoing updates to Transparent Earth. This dynamic system harnesses data from diverse sources such as surveys, SUE, CAD, GIS, utility relocations, new installations, and OneCall locates. The cohesive use of PointMan and Transparent Earth enhances data integration, providing a comprehensive and real-time understanding of the utility landscape for effective decisionmaking and infrastructure management.

Data Submitters and Data Users

Data submitters and data users encompass entities such as CDOT, SUE teams, utility companies, and designers within the infrastructure management framework. The initiation of data collection follows established protocols. Data submitters are responsible for uploading information onto the central PointMan Enterprise repository. These uploaded data encompass survey data, SUE data, GIS data, and CAD files. The seamless collaboration between PointMan and Transparent Earth is pivotal for data users who leverage this cohesive system to access and use the 3D utility data securely. Data are used for utility relocation, new installations, OneCall locates, and upcoming projects. The ongoing data collection by data submitters adheres to standard protocols, ensuring a continuous influx of information into the cloud. Concurrently, data users are tasked with responsibly accessing and using the utility data through the secure 3D utility data access interface.

Data

Within the CDOT SUE data lifecycle, adherence to ASCE 38 standards is paramount across the planning phase, 0-30 percent design phase, and 30-90 percent design phase. In the planning phase, as-built data from the database are collected and assessed, serving as a foundation for planning and SUE records in proposals. The 0-30 percent design phase mandates Engineering Design SUE Quality Levels B, C, and D with updates to existing utility data in the database, emphasizing the importance of Quality Level B for the 10 percent design goal. Progressing to the 30-90 percent design phase, SUE data become instrumental in engineering design, incorporating Quality Level A test hole data for 3D conflict analysis. As the project advances, the 90-100 percent design phase and construction phase necessitate compliance with Construction Management ASCE 75 standards. This phase involves final engineering design, early utility relocations, ongoing updates to the subsurface utility map (SUM), and concurrent construction management and as-built survey activities. The construction phase focuses on construction management and as-built surveys, allowing for the real-time updating of as-built data into the SUM. Throughout this lifecycle, utility coordination remains a pivotal aspect, ensuring seamless integration and accuracy across the subsurface utility data spectrum.

CDOT employs a data dictionary architecture that serves as the convergence point between survey and GIS functionalities. The survey systems use coding systems established by surveyors to ensure a standardized approach. Utility systems, spanning telephone, gas, and sewer, are each assigned a unique code that can be applied in MicroStation for streamlined integration. The seamless transition from survey to the GIS environment incorporates customized attributes such as material, facility, owner, size, type, depth, note, and feature code. This dynamic integration, facilitated by the cloud, allows for real-time visibility of changes in the field, enhancing adaptability and convenience. Additionally, this system is optimized for use on mobile devices, providing a versatile and accessible platform for field operations. CDOT uses the data dictionary schema to improve accuracies for geospatial XY and Z depth collected on a single platform for stakeout and directly or indirectly mapping surface or subsurface assets including utilities, geotechnical, and materials testing.

Tools and Technologies

CDOT employs an innovative suite of tools and technologies to enhance the accuracy and efficiency of its utility management processes. At the forefront is the PointMan mobile application that is seamlessly integrated with Trimble R10/R12 devices to ensure precision in utility relocation and as-built data within the tolerances mandated by the agency. This application achieves horizontal and vertical accuracy of plus or minus 2 centimeters and meets ground coordinate corrections between 0.06-foot horizontal and 0.16-foot vertical. Multi-utility data are acquired through global navigation satellite system (GNSS) real-time kinematic (RTK) surveys using mobile devices. These data, enriched with attributes, permits, survey pedigree, and custom form information, are consolidated and shared through the central PointMan Enterprise repository. In addition, CDOT uses Prostar PointMan's Software as a Service application for utilities, which is seamlessly integrated with Bentley OpenRoads Designer and MicroStation, Esri GIS, and AASHTOWare Project (AWS) Cloud Services. The license management system meticulously regulates roles and permissions, ensuring that utility companies have access to their specific data while maintaining security and confidentiality. CDOT also has embraced Trimble RTX services, offering satellite-based solutions for enhanced accuracy. Prostar PointMan, functioning as a real-time mobile application, is instrumental in tandem with survey GNSS/Global Positioning System (GPS) RTK rovers, handheld devices, and smartphones. It facilitates survey corrections for the seamless transition of data between CAD to GIS, GIS export to CAD, and projections, further streamlining CDOT's utility management operations.

Colorado Department of Transportation Utility Engineering Project Lifecycle

As shown on Figure 1, the CDOT engineering lifecycle commences with planning at the top and progresses in a clockwise direction. During the design phase, CDOT uses ASCE 38-32, the SUE standard, mandated by Colorado Revised Statute 9-102.68 for most projects. As project planning starts, CDOT evaluates the scope of work to decide whether it is a SUE project. As the project advances to the 10 percent design phase, a high-quality set of SUE data are meticulously gathered, serving as the foundational utility data throughout the entire project. This robust SUE dataset is instrumental in resolving conflicts, conducting test hole operations, and capturing 3D attributes at Quality Level A between 30 percent and 60 percent of the design process. Progressing to the 90 percent design phase, early utility relocations and red-line activities leverage Construction ASCE 75-22, the as-built standard. This comprehensive approach continues into roadway construction, relocation activities during construction, and the subsequent operation and maintenance period, looping back into the planning stages for the next lifecycle project. CDOT consistently employs ASCE 38-22 and ASCE 75-22 throughout the entire lifecycle. Moreover, CDOT finds the integration of utility coordination efforts within this data capture framework to be crucial.

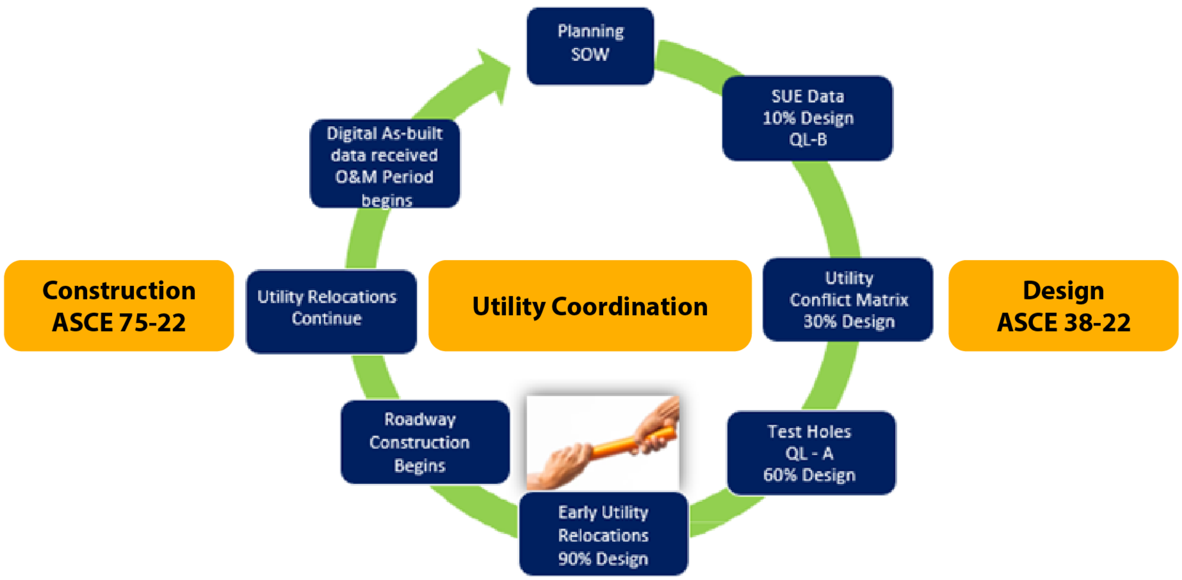

Figure 1. CDOT Utility Engineering Project Lifecycle (Source: CDOT, 2023).

Planning and Preliminary Design (10 Percent)

During the planning phase of the engineering lifecycle, CDOT implements a thorough data acquisition strategy that involves extracting data from existing as-builts and comprehensively analyzing historical infrastructure documentation. Employing traditional survey techniques, uncrewed aerial systems, or mobile applications, CDOT engages in a diverse and comprehensive approach to data collection. This phase adheres rigorously to the standards outlined by ASCE 38-22, ensuring a consistent and precise data collection process. Essential attributes are meticulously captured, encompassing details such as the type, size, condition, and material of subsurface utilities. The gathered data are subsequently published to the GIS database, laying a robust foundation for informed decisionmaking throughout the project's lifecycle. As the project progresses into the 10 percent design phase, CDOT gathers a high-quality set of SUE data. This dataset becomes the foundational utility data throughout the project and is instrumental in conflict resolution, test hole operations, and the detailed capture of 3D attributes at Quality Level A, spanning the critical design phases between 30 percent and 60 percent of the project's development.

Design (30, 60, and 90 Percent)

In the design phase, spanning 30 percent, 60 percent, and 90 percent of the engineering lifecycle, CDOT employs a comprehensive approach to ensure precision and efficiency. The process begins with exporting data from GIS to computer-aided drafting and design (CADD) platforms to facilitate seamless integration for designers' use. Field verification, conducted through test holes, further enhances the accuracy of the collected data. CDOT strategically leverages this dataset for clash detection, identifying potential conflicts that require resolution. The identification of conflicts informs the relocation strategy, ensuring that utilities are relocated before the construction phase commences. This process culminates in the delivery of final design deliverables tailored for construction, thereby laying the groundwork for a streamlined and conflict-free implementation phase. CDOT's proactive approach, incorporating field verification and clash detection, identifies and addresses potential challenges well in advance, contributing to the overall success and efficiency of the process.

Construction

During the construction phase, CDOT makes critical SUE information readily available to construction inspectors to foster informed decisionmaking. This phase is marked by construction observation records, including visual documentation through pictures and videos.

A notable illustration of CDOT's success in utility management is evident in the $1.2 billion Interstate 70 (I-70) Design-Build project in Denver. This initiative, which began in 2015 and concluded in 2023, employed advanced e-construction and surveying methods to collect model-based as-built utilities data to relocate utilities prior to construction and during construction to deliver the project and provide utilities asset information within the ROW for design, construction, and asset management use. Moreover, the I-70 Design-Build project demonstrated substantial cost avoidance, with an estimated return on investment ranging from $800,000 to over $4 million. The comprehensive digital processes for utilities, including model-based relocation and as-built data collection, were integral in delivering the project and furnishing utilities asset information within the ROW. Inadequate utility records increase project risk to cost, schedule, and public safety—all of which were reduced compared to previous projects by capturing and recording standardized utility data at the time of installation and systematically recording the data on existing utilities exposed during construction.

Operations and Maintenance Phase

Throughout the operations and maintenance phase, continuous updates of DAB records for subsurface utilities are promptly integrated into the PointMan Enterprise dashboard in real-time. This dynamic integration facilitates detailed visualization; quality assurance and quality control (QA/QC); and seamless data export into CAD for design, construction, and model record as-builts. Notably, professional certification is not mandatory for utility contractor as-built submissions; instead, reliance on metadata provides essential "pedigree" information, confirming accuracy through equipment type and survey accuracy data akin to traditional survey notes. The ASCE 75-22 guidelines include accuracy requirements, serving as a communication tool for conveying precision information to various stakeholders. CDOT's strategic approach enables construction field and office personnel to harness data from diverse sources within PointMan and PointMan Enterprise. This integration empowers PointMan Enterprise to stream remote online SUE files, encompassing existing and new utilities, CDOT designs, drone imagery, and OneCall excavation notifications directly to the mobile application at the project site. This comprehensive utility asset visualization, geolocation, mapping, and documentation process enhances overall project management efficiency.

CHALLENGES

CDOT faced challenges, particularly pushback from utility companies, in enforcing its mandated requirement for permits with accurate geospatial location and depth for utilities using the system. Initially, utility companies resisted CDOT's specification code, raising concerns related to homeland security and proprietary data. However, investigations by agency attorneys revealed that these concerns did not apply to utilities within the CDOT ROW, except for critical infrastructure. The utilities eventually complied with the permit requirements.

While certain areas have critical infrastructure, most utilities fall outside this category. To address the difference, CDOT implemented a permitting system, requiring utilities within the CDOT ROW to adhere to specific permits and specifications to ensure that CDOT is informed when critical infrastructure enters or exits the ROW. The agency previously relied on licensed surveyors for certifying as-builts, but due to practical challenges, this process was revised to maintain consistency in data, storage location, and equipment and process standards for utility data collection and verification. Utility location companies, consultants, and contractors also had liability concerns related to depth accuracy; however, the permitting process within CDOT's ROW necessitates compliance with this procedure.

LESSONS LEARNED

CDOT's DAB program, which extends its focus beyond pavements and bridges, places a primary emphasis on model-based utilities within the ROW. This expansion reflects a forward-thinking approach that recognizes the importance of comprehensively incorporating utilities within the project scope. The implementation of model-based relocation and as-built utilities data has proven to be an effective strategy for managing utility relocation in highway construction projects. The advantages include accurately capturing existing utilities data using SUE surveys, enabling effective clash detection, streamlining the utility relocation process, and handing off accurate relocation records to the post-construction phases. These practices have yielded significant benefits, including improved safety, reduced claims, and improved overall project efficiency. The CDOT case study illustrates how subsurface utilities can be integrated into DABs, on par with above-surface assets, for design, construction, and asset management use.

The process of utility relocation has been a fundamental component of highway project delivery for many years. Agencies have followed a traditional process for handling utilities during project delivery that entails identifying significant utility-related issues during the planning phase; preparing utility relocation plans, schedules, and cost estimates in the design phase; and updating utility relocation schedules post-relocation during the construction phase. CDOT has adopted a phased and model-based approach, using utility data throughout this traditional project delivery process.

There are many noteworthy elements within CDOT's process that may inform other agencies' approaches to DABs:

- Maintaining minimum quality levels for utility data at ASCE 35-22 quality standards to ensure the reliability and usefulness of the data.

- Capturing essential data for utility as-builts and relocations for design, including attribute data, accurate location and depth data, and employing a single cloud-based repository for all stakeholders' use.

- Selecting an Esri GIS mobile platform with a survey-based solution that connects light detection and ranging (LiDAR) survey, CAD, and GIS.

- Leveraging advanced technologies, such as the PointMan mobile application paired with Trimble R10/R12 for improved accuracy of relocation and as-built data, and collecting multi-utility data via GNSS RTK survey with mobile devices.

- Collaborating with utility companies by leveraging utility permits to require their participation and linking with the OneCall Dig Ticket Center using their existing locate request process with an application programming interface (API) to the mobile application to continuously update the data repository with new information.

- Enabling data accessibility by allowing construction field and office staff to access data from multiple sources within PointMan Enterprise.

- Integrating utility data with other tools, such as augmented reality or virtual reality like Trimble SiteVision, and using Bentley OpenRoads/drainage/utilities CAD and Esri GIS for clash detection-resolution and combining data from various sources.

By considering these aspects of CDOT's process, other agencies may be able to optimize their DAB workflows to streamline utility data management, improve collaboration with stakeholders, and ultimately optimize their utility relocation process in highway project delivery.

CONCLUSIONS

The CDOT case study presents a comprehensive overview of the agency's DAB program, its focus on model-based utilities within the project's ROW, and its benefits in managing utility relocation in highway construction projects. The integration of advanced technologies, maintenance of data quality levels using ASCE quality standards, standardized processes, and collaborative frameworks have proven instrumental in facilitating early identification of utility relocation requirements, enabling efficient clash detection, streamlining the location process, and ensuring the creation of comprehensive digital records for seamless project handoff. Furthermore, the highlighted elements within CDOT's process also provide insights for other agencies to consider when looking to optimize their DAB workflows and utility relocation processes in highway project delivery.

CDOT has successfully piloted these advanced approaches, collecting utility data for a digital model-based relocation process, using them for conflict analysis, and developing as-built utilities data on large-scale infrastructure projects, such as the $1.2 billion I-70 Design-Build project in Denver and the roundabout redesign project in Vail. CDOT has also achieved statewide implementation across all five regions to streamline utility data collection and management using direct API connections to the Colorado 811 database for dig ticket management.

Drawing on the experiences of CDOT, there are opportunities for the DAB process to undergo continual refinement and evolution. The primary challenges that CDOT encountered were initial resistance from utility companies, the need for ongoing stakeholder dialogues, data-related issues, and liability concerns pertaining to depth accuracy by utility locators. By learning from CDOT's challenges and how it addressed them, other agencies can anticipate and mitigate similar obstacles in their own utility data management and DAB programs.

Overall, CDOT's approach to integrating subsurface utilities into DABs, on par with above-surface assets, can be considered by other agencies contemplating a similar DAB process to improve their utility data management and relocation process in project delivery.

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