3D Utility Location Data Repository R01A Lessons Learned

A challenge at transportation agencies nationwide is how to manage information about utility facilities that occupy the right of way in ways that facilitate data extraction and data analysis and contribute to an effective management of the right of way. The challenge is both during the process to deliver transportation projects and over the lifetime of both transportation and utility facilities (Figure 1). Transportation agencies are transitioning from 2D to 3D design and construction workflows. The challenges that agencies face with information managed in a 2D environment are compounded when information is managed in a 3D environment.

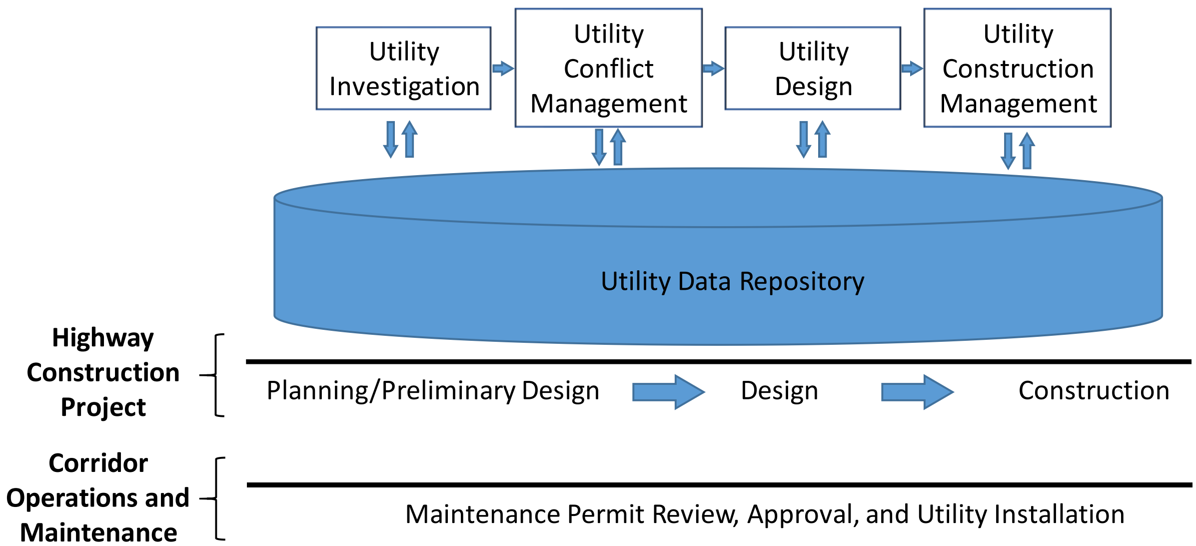

Figure 1. Lifecycle of utility data management at a state DOT

The R01A SHRP2 project, **3D Utility Location Data Repository**, tested a procedure to manage utility data during project delivery. As part of the second Strategic Highway Research Program (SHRP2) Implementation Assistance Program (IAP), 11 state departments of transportation (DOTs) received grants from the Federal Highway Administration (FHWA) to conduct a pilot utility data repository implementation (Table 1). The goals and scope of the implementations varied widely depending on the needs of the individual state DOTs, but generally ranged from developing a 2D standalone geographic database of existing utilities within the right of way to developing an enterprise system architecture to manage utility facilities in a 3D environment. As part of the IAP, FHWA also provided one brainstorming training session to each state that requested it. The purpose of the brainstorming session was to discuss topics such as implementation goals, challenges, leadership buy-in, information technology (IT) involvement, and ideas for implementation scope and schedule. In cases where the state DOT had also received an R15B grant, the brainstorming session was held in conjunction with the one-day utility conflict management (UCM) training course.

Table 1. Agencies that Received Funds to Implement the R01A, R01B, and R15B Products

Round 3	Round 5	Round 6	Round 7
R15B: • Iowa • Kentucky • Michigan • New Hampshire • Oklahoma • South Dakota • Texas	**R01A:** • California • DC • Kentucky • Texas • Utah	**R01B:** • Arkansas • California • Ohio • Oregon **R15B:** • California • Delaware • Indiana • Maryland • Oregon • Utah	**R01A:** • Indiana • Michigan • Montana • Oregon • Pennsylvania • Washington **R01B:** • California • Indiana • Montana **R15B:** • Montana • Pennsylvania • South Carolina • Utah • Vermont • Washington

Lessons Learned

It is critical to obtain and maintain buy-in from the administration

Utility data repositories are a new concept at transportation agencies. Leadership is probably unaware of the importance of managing utility data effectively. Identifying champions within the administration who understand this concept is key to secure support for developing sustainable utility data repository implementations.

Because the concept of utility data repositories is new, it is not necessarily clear what offices or units should be responsible for developing and maintaining the data repositories. There is a consensus that IT personnel should be involved throughout the process, but the requirements for their involvement or the funding to sustain that effort are usually not clear. Making the administration aware of these challenges is critical so that appropriate strategies can be identified and implemented.

Understand short-term and long-term needs and objectives

At the beginning of the pilot implementation, most state DOTs had difficulty conceptualizing what a utility data repository meant, both in the short term and in the long run. The level of understanding improved significantly once it became clear that data management needs and corresponding procedures may be different depending on whether a transportation agency interacts with utility owners during project delivery or over the lifetime of both transportation and utility features (Figure 1).

Utility investigation outputs are a necessary input to UCM. In turn, UCM is a necessary input to project and utility design, both of which are needed for developing utility relocation plans and utility agreements. State DOTs recognized the need to improve utility investigation practices and the connection between robust UCM practices and quality utility relocation plans and schedules. State DOTs also recognized the connection between UCM practices and the ability to reduce project risks, particularly during construction.

Examples of areas where utility data documentation practices could be improved, resulting in more effective utility processes at state DOTs, include:

- Utility investigation timing, scope, quality, and completeness. Utility investigation deliverables are often insufficient or inadequate to help officials determine whether a potential utility conflict is indeed a conflict. In many cases, utility investigation deliverables include utility locations, but no information about the size, capacity, or operational characteristics of the utility facilities involved.
- Mapping and documentation of utility data on project files. Utility data management issues extend beyond the utility investigation phase. For example, it is common to find design files showing utility locations where critical information from the utility investigation phase has been removed to limit the amount of clutter. Unfortunately, the information is also lost to subsequent project file users, including contractors.
- Documentation of as-built conditions. Frequently, state DOTs assume that utility owners will conduct the inspection and verification of utility work within the right of way (because utility owners are responsible for their own installations), but utility owners assume that state DOTs will conduct the inspections (because the installations are located within the state right of way or the utility work is a relocation needed for a transportation project). Because of the lack of clarity, inspections are frequently not carried out, and if they are, they do not conform to industry standards to produce quality as-builts.

Focus on the "low-hanging fruit" to begin a utility data repository

State DOTS that pursued a relatively simple utility data repository approach generally had fewer challenges than state DOTs that pursued a comprehensive IT solution. This type of implementation (whether 2D or 3D) was generally standalone and had highly simplified database architectures. Platforms included computer aided design (CAD) and geographic information systems (GIS). Most state DOTs that had a significant IT component as part of their implementation faced challenges such as (a) how to engage and maintain the level of involvement by IT personnel and (b) how to schedule IT development phases within the structure and schedule of the pilot implementation. At the same time, simple utility data repository implementations frequently lacked certain elements such as scalability and sustainability, which are important requirements for statewide implementation efforts.

It is critical to engage IT personnel even for relatively simple data repository implementations. It is also critical to engage other groups within the agency (e.g., surveying, design, and maintenance) because these groups can provide important input that can substantially improve the quality of the implementation at very low costs. For example, state DOTs that involved surveying in their pilot implementation realized that the agency already had data collection dictionaries that included a substantial number of utility facilities, such as poles, pedestals, junction boxes, manholes, and valves. Furthermore, the surveying group provided critical information related to positional accuracy requirements, data collection equipment, and compatibility with CAD and GIS software. To facilitate the implementation, all state DOTs that received R01A grants received information about the upcoming utility as-built standard that the American Society of Civil Engineers (ASCE) is developing.

In other cases, surveying involvement included data collection in the field. For example, the Michigan Department of Transportation (MDOT) developed a program called the Geospatial Utility Infrastructure Data Exchange (GUIDE) that included the collection of utility location data by surveyors "while the trench was still open" to ensure the department obtained accurate utility as-built data.

Follow standard IT phases for developing an enterprise utility data repository

Most state DOTs have highly structured processes to develop, deploy, and operate IT systems. This is particularly true for systems that include integrated enterprise-level database implementations. System requirements can be significant for 2D spatial data, and even more so for 3D data. IT regulations and practices vary from state to state. For example, some states encourage the use of distributed in-the-cloud storage solutions, while other states do not allow these solutions. Policies and regulations are also evolving quickly. At least one state DOT began the pilot implementation at a time when in-the-cloud storage solutions were allowed but had to adjust its pilot implementation plan mid-course after a policy change began to discourage these solutions.

Some state DOTs hired software consultants to work on its pilot implementation, but other state DOTs used internal resources exclusively. In at least one case, the state had already developed a prototype utility data repository prior to the SHRP2 implementation and used the R01A grant to migrate the limited prototype to an enterprise spatial relational database environment. The California Department of Transportation (Caltrans) had previously developed a prototype GIS database with utility features residing in standalone CAD files. Caltrans realized that this architecture would not be sustainable for a statewide implementation. As part of the R01A pilot implementation, Caltrans developed an enterprise database architecture and wrote scripts to automate the extraction of utility features that resided in CAD files into records in the spatial database. The CAD files were files that the surveying group had already prepared during the utility investigation phase. The Caltrans database environment supports 2D and 3D features. In the Caltrans implementation, all utility data resides in the spatial database, including information about the coordinate system used to generate each feature in the database.

Address challenges for developing robust 3D models

Extracting features from CAD files offers significant benefits, but substantial challenges remain. The feasibility of using software to automate the extraction of features (whether the software is developed internally or procured commercially) depends directly on how clean CAD files are. For example, CAD files that do not have a clear layer or level structure (i.e., one level for water line features, a separate level for water point features, and so on) dramatically increase the level of difficulty and amount of work to process the files. A similar consideration applies to CAD files that have quality problems such as duplicate objects, short objects, undershoots, overshoots, node clusters, dangles, or unnecessary vertices. During the pilot implementation, state DOTs faced these challenges and began to identify strategies to resolve them, while realizing that those efforts would need to involve multiple groups within their agencies, including the groups responsible for developing and maintaining CAD and GIS standards.

Utility data quality is an important requirement for most state DOT applications but is particularly critical in a 3D design and construction workflow (Figure 2). State DOTs recognized the dilemma between having incomplete utility datasets (with varying levels of horizontal and vertical positional accuracy) and the need to reduce the level of risk when developing 3D models of utility facilities. A strategy that state DOTs began to implement was to document the positional accuracy of utility datasets and make sure to include that documentation as part of the datasets, either as utility record attributes or in the metadata.

State DOTs also began to implement libraries of 3D objects to represent typical utility features in their 3D CAD software platforms. As part of the process, state DOTs recognized that developing 3D cell libraries of utility features could take a significant amount of time and effort. They also recognized that the shapes and outside dimensions of the 3D cells would have to meet certain minimum standards to ensure the usability of the 3D models beyond basic visualization applications, e.g., for clash detection. They also began discussions about the feasibility to develop 3D cell repositories where multiple agencies share the responsibility to develop 3D cells and have access to the 3D cells available in the repository.

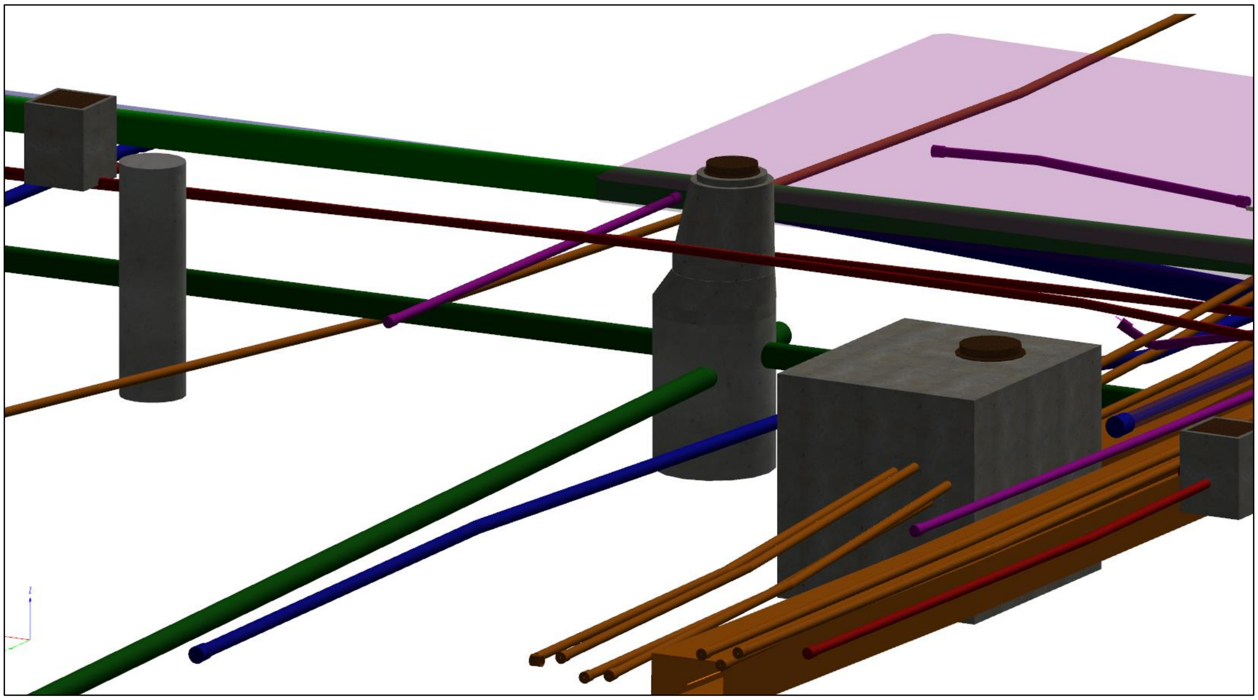

Figure 2. Sample 3D utility model