TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 2110-S
Project 0-2110: Development of a GIS Platform for Inventory of Utilities Located within TxDOT Right-of-Way

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PROJECT SUMMARY REPORT

Utilities in the Right-of-Way Inventory and Data Management

Each year, thousands of utilities are installed within the Texas Department of Transportation (TxDOT) right-of-way (ROW). With the proliferation of utilities within its ROW, TxDOT is finding it increasingly difficult to allow more utilities and to manage its own transportation system effectively. Knowing the location and current operating status of utilities is crucial for managing the ROW and for planning and executing transportation improvements. Unfortunately, TxDOT has no system-wide capability to capture and inventory utilities or medium by which to document and display them in reference to existing and proposed transportation improvements.

What We Did . . .

The main objective of the project was to develop a prototype geographic information system (GIS)-based platform for the inventory of utilities located within the TxDOT ROW. As part of the project, we:

- compiled and reviewed existing sources of utility data at TxDOT;
- developed a GIS model to represent the location of utility facilities located within the TxDOT ROW and associated attribute data such as ownership, purpose, size, type, and other pertinent characteristics;
- developed a prototype Internet-based data entry procedure and accompanying administrative procedure to capture installation notice data;
- provided recommendations for implementing and expanding the prototype GIS platform; and
- provided recommendations for standards and minimum requirements for quality and content.

What We Found . . .

Existing Utility Data Sources

A number of processes within TxDOT deal with utilities. Most of the information comes from the installation notice (also known as utility permit) process. Unfortunately, while the amount of documentation available is quite sizable, the usability of current records—from the point of view of developing a statewide GIS-based inventory of utilities—is limited.

There is considerable variability in the amount of information and level of detail included in installation notice applications. Further, very few drawings are scaled, include coordinate system data, or reference the location of utility installations to the highway alignment. There is also considerable variability in the way individual districts manage the installation notice process and associated data. Finally, utility companies are not required to submit as-built documentation, nor are they required to notify TxDOT about changes in ownership or operational status of the facilities after they are installed in the field.

TxDOT is increasingly using the subsurface utility engineering (SUE) process to document underground utility installations within the ROW. The level of detail and quality of SUE deliverables depend on the type of surveying requested. Historically, there has been considerable variability in the way SUE data collection methods are defined and characterized. A new American Society of Civil Engineers (ASCE) standard will provide a uniform mechanism for documenting the data collection methodology and overall survey quality through the use of quality level (QL) indicators. The ASCE standard does not associate horizontal positional accuracy numerical indicators with QL indicators, leaving that responsibility to project owners.

TxDOT also manages joint use agreements with utility companies. TxDOT uses a database to keep track of the joint use agreement process and keeps all associated documentation in paper folders. Unfortunately, the database is not relational or geo-referenced, and it lacks a unified identification mechanism for joint use agreements at TxDOT. These characteristics limit the scalability potential of the current database and the feasibility to integrate that database with other utility data sources at TxDOT.

Many utility companies use automated mapping/facility management (AM/FM) information systems. Unfortunately, data management practices, geo-referencing standards, and procedures vary widely among utility companies. Further, utility companies tend to be specialized, and current utility data management systems and models offer little flexibility to document the considerable level of interaction

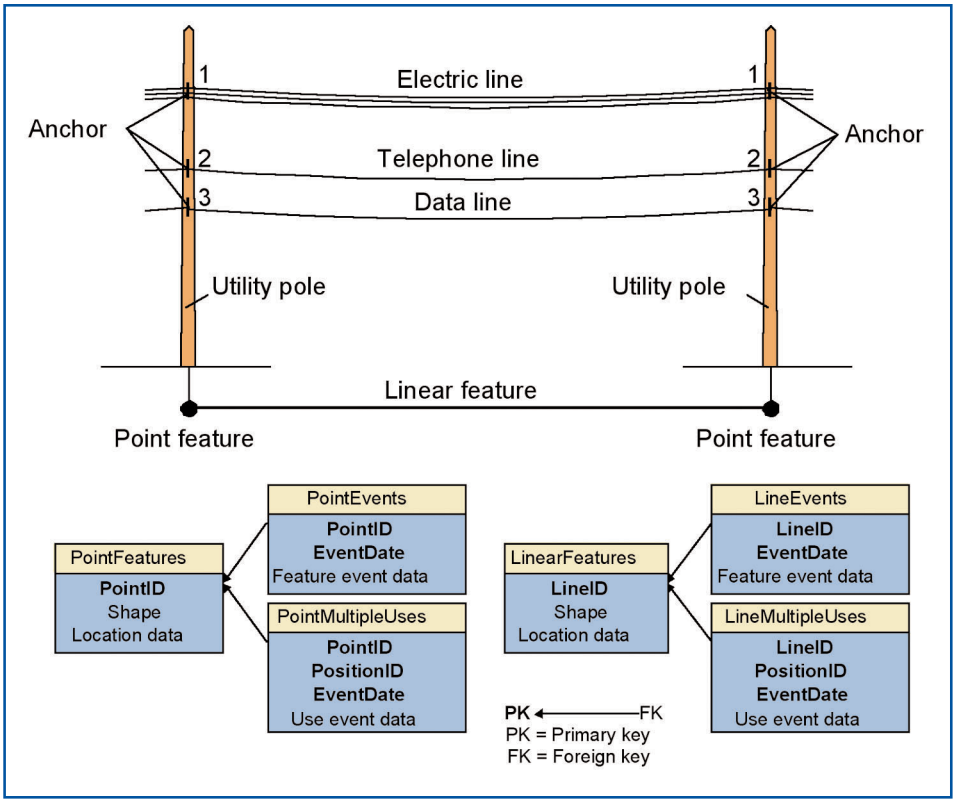

Figure 1. Prototype Utility Data Inventory Model.

among utility installations in the field. In addition, utility companies do not easily share electronic data with outsiders and typically do not guarantee the accuracy of the data they provide.

In summary, current procedures make utility data sources at TxDOT incompatible with each other and unsuitable for the development of a robust GIS-based inventory of utilities. Existing utility data sources could be used to support the inventory of utilities, but substantial modifications to current data collection procedures would be required.

Prototype Utility Inventory Model

Current AM/FM technology is designed to address the daily operational and maintenance needs of utility companies. However, TxDOT's needs are different. To address this issue, we developed a simplified prototype utility data inventory model (Figure 1). The model uses point and linear physical spaces that characterize the "footprint" on the ground occupied by one or more utility installations. Utility installations that share the same "footprint" are considered users of the physical space (or feature) they occupy. Each point or linear feature has a unique identifier that remains with the feature throughout its lifetime. The model assumes the X, Y coordinates associated with a feature are determined independently of any highway base map. However, the model contains data fields to linearly reference the location of utility features along highway routes. Each feature has horizontal and vertical positional accuracy numerical indicators as well as a QL indicator that follows the new ASCE standard described previously. The model assumes feature location updates are handled using utility map versioning. QL changes are also tracked using feature event tables in the database. The database model uses a three-table architecture for both point and linear features to keep track of feature events and feature user events. In addition, the database uses lookup tables to provide a basic level of characterization to individual features and feature users.

We tested the prototype utility inventory model using data collected along a 7-mile stretch of SH 16 between IH 410 and Loop 1604 in northwest San Antonio. The result was a series of ArcView 3.2 format GIS files—and corresponding Access® database records—that document point and linear utility features along SH 16. The horizontal positional accuracy of the data collected in the field was submeter given the type of global positioning system (GPS) receiver used (mapping). Finer accuracy would be possible using a surveying-type receiver.

The process to convert GPS data into GIS features was fairly time-consuming and could not record data associated with multiple user installations efficiently.

Prototype Installation Notice System

As mentioned before, most utility-related activities within TxDOT focus on processing installation notice applications. Unfortunately, procedures, data formats, documentation requirements, and quality of the spatial information provided by utility companies vary widely. In addition, the installation notice review process is manual, labor-intensive, and time-consuming.

To address the limitations of the current process, we developed a prototype system that follows an Internet-based data entry approach. We chose an Internet-based data entry approach because of three characteristics that make the installation notice process at TxDOT appropriate for the implementation of online, automated data collection and data processing strategies: little face-to-face contact with utility companies, spatial distribution, and asynchronous processing. Figure 2 shows the data flow of the prototype system. The prototype system is an enhanced, automated version of the current process at TxDOT and includes a number of controls and automated steps to make the review process more efficient.

The prototype uses a relational database to manage all data associated with the installation notice process. The prototype uses a centralized data management architecture with distributed map and data access capabilities that enables data and file uploading and access to utility data using online tabular forms and maps. The system architecture includes two subsystems—a notice data management subsystem and a web mapping subsystem—that support a utility company user interface and an administrative interface. The prototype system allows users to download and print copies of the application and approval forms, as well as supporting documentation such as special provisions and coordinate data files. The printable installation notice form is an expanded version of a draft provided by TxDOT that would replace current forms 1023 and 1082 with a single unified form. It includes text fields that are automatically

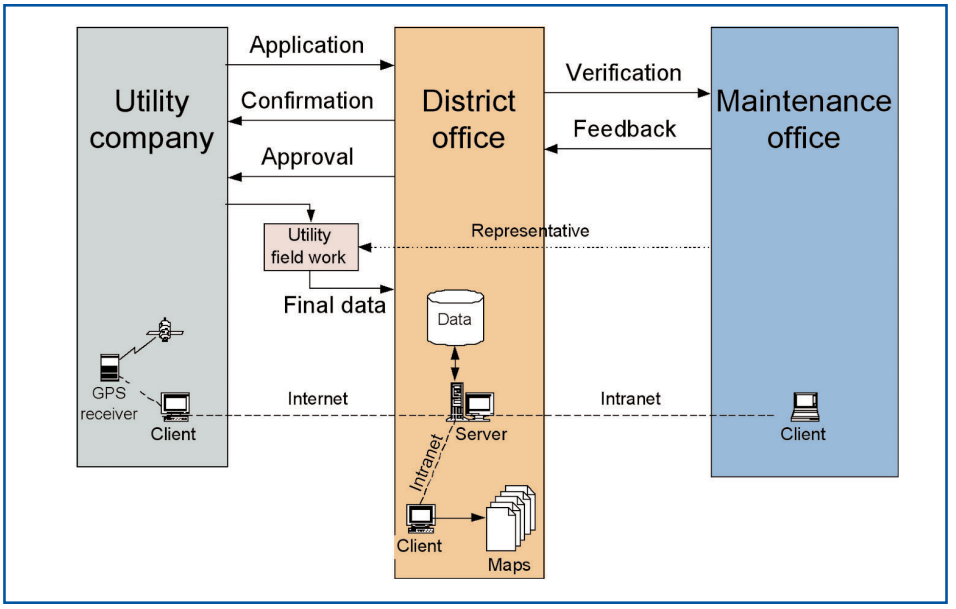

Figure 2. Prototype Data Flow and Data Collection for Installation Notices.

populated using data from individual installation notice applications.

Completing the online installation notice application, assuming all supporting documentation is ready, takes anywhere from five to fifteen minutes. Once submitted, there is a permanent database record of the application, and the associated data are automatically available to TxDOT officials. No paperwork is generated—everything is digital throughout the review process, including the installation notice application and corresponding approval form. For optimal performance, the prototype system assumes users are connected to the Internet using a high-speed connection, particularly for uploading files and/or displaying utility maps. For other operations such as reviewing the status of pending applications and printing forms, a slower dial-up connection is adequate.

The system uses a disaggregated "shopping cart" approach to document individual proposed actions in the field. This approach may be needed to support utility companies that do not have strong computer-aided design (CAD) or GIS capabilities, but it might prove to be burdensome for utility companies that do have those capabilities in place. These companies might prefer to prepare all files offline, making sure they comply with the utility inventory model described before, and then use the interface to upload those files in a single operation. The prototype would need to be modified to support this process. The interface would also need to be modified to support the display of uploaded CAD or GIS files on the utility map—currently the prototype supports the display of uploaded coordinate data files. Two more areas for potential improvement include engineering seal data identification and text fields to document the positional accuracy and QL of the data uploaded as part of the installation notice process.

The Researchers Recommend . . .

General Recommendations

- Select a district to conduct a pilot inventory of utilities located within the TxDOT ROW using, as a foundation, the prototype inventory model developed in this project.
- Extend the utility inventory data model. Three areas in particular require attention:
  - Data elements: Add critical data elements that were not included in the original version of the prototype.
  - GIS platform: Convert the prototype inventory model from ArcView 3.2 to ArcGIS following TxDOT's decision to adopt ArcGIS as part of the core GIS architecture.
  - Data collection: Develop a customized data collection tool to increase the efficiency of the utility inventory process.
- Extend the inventory model to private utilities and, in general, any type of "hidden" infrastructure, e.g., intelligent transportation system (ITS) devices, located within the ROW.
- Select a pilot district to test the Internet-based installation notice system. The pilot effort would need to be deployed in phases to ensure a smooth transition from the current process. Parallel to those developments, TxDOT would have to evaluate possible changes to the current utility accommodation policy to ensure its compatibility with the prototype installation notice system.
- Develop a database schema and associated data collection procedures for other utility-related processes within TxDOT, in particular joint use agreements. The database and data entry interface development process would take into consideration aspects that uniquely pertain to the joint use agreement process.
- Explore additional e-government and web-based strategies within TxDOT, particularly in situations that require little face-to-face contact with customers and are spatially distributed and asynchronous.
- Develop and deliver application-specific GIS training modules to TxDOT users. At the end data user level, training should focus on the use of GIS tools to derive data to support engineering and planning workflows. At the GIS development level, training should be more in-depth.

Recommendations for Standards and Minimum Requirements

- Require utility-related data submitted to TxDOT to comply with the TxDOT utility inventory model. To ensure that users are familiarized with the spatial and database architecture of the utility inventory model, TxDOT should post a copy of the model, including data samples, on the TxDOT web site.
- Require utility-related drawings and data submitted to TxDOT to be signed and sealed by a registered professional engineer.
- Require all positional data associated with existing utility installations to include a horizontal positional accuracy indicator, a vertical positional accuracy indicator, and a QL indicator. Horizontal and vertical positional accuracy indicators should be consistent with current TxDOT specifications.
- Require all positional data to be submitted in ArcGIS-compatible format and to include appropriate coordinate system and projection data.

For More Details . . .

The research is documented in the following reports:
Report 2110-1, *A Data Platform for Managing Utilities along Highway Corridors*
Report 2110-2, *A Data Platform for Managing Utilities along Highway Corridors: User Manual*

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TxDOT Implementation Status
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This project developed a prototype GIS-based platform for the inventory of utilities located within the TxDOT ROW. A web-based utility installation notification system was also developed for managing utility changes. The research will enhance TxDOT e-business while ensuring quality control of the utility inventory in TxDOT ROW. The research has been successfully tested in the San Antonio District and statewide implementation is likely.

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