NCHRP 20-07, Task 418

An Impact and Value Analysis of Requiring Geospatial Locations for Utility Installation As-Builts

Prepared for:

NCHRP
Transportation Research Board
of
The National Academies of Sciences, Engineering, and Medicine

Prepared by:

Philip J. Meis, P.E., M.S.
Roy E. Sturgill, Jr., P.E., Ph.D.
Richard Manser, P.E., M.S.
Thomas G. Swafford, A.A.S.
Jacob T. Roland, E.I., B.S.

Utility Mapping Services, Inc.
Clancy, MT
June 2020

The information contained in this report was prepared as part of NCHRP Project 20-07, Task 418, National Cooperative Highway Research Program.

SPECIAL NOTE: This report **IS NOT** an official publication of the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, or The National Academies.

Acknowledgements

This study was conducted for the AASHTO Standing Committee on Planning, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-07, Research for the AASHTO Standing Committee on Planning. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-07 is intended to fund quick response studies on behalf of the Standing Committee on Planning. The report was prepared by principal investigator Philip Meis, Utility Mapping Services, Inc. The work was guided by a technical working group that included:

Mr. Reed Adams, Virginia DOT
Ms. Victoria Bever, Arizona DOT
Mr. Eric Cimo, Delaware DOT
Mr. Kenny Franklin, Parsons
Mr. Rob Martindale, Colorado DOT
Mrs. Jennifer McCleve, Kentucky Transportation Cabinet
Dr. Michael Olsen, Oregon State University
Mr. Morgan Kessler, FHWA Liaison

The project was managed by Camille Crichton-Sumners, NCHRP Senior Program Officer.

Disclaimer

Contents

List of Figures and Tables

ABSTRACT

This research sought to illustrate the current state of practices within State Transportation Agencies (STAs) regarding collection of geospatially referenced as-built utility record data within public right of way. Also, barriers, both real and perceived, to collecting georeferenced utility as built data were discovered and explained. The research team investigated the costs and benefits of collecting and using georeferenced utility as-built data and determined that in almost all cases the benefits and long-term savings associated with georeferenced utility as-built data far outweigh the costs associated with collecting and maintaining it. The research conducted and analysis performed indicate that collecting true georeferenced utility as-built data on underground utilities before they are buried would result in potential savings of ~$384,000,0000 in future project costs, decreased utility outage time, increased safety of projects, and a host of untapped, proactive management practices which can enhance and optimize usage of public right of way space. Data collection methodologies, data management strategies, and legislative requirements currently in effect at some STAs were examined and recommended for expanded use at all STAs.

SUMMARY

Executive Summary

Historically, utility infrastructure has generally not been documented in a consistent, geospatially accurate, and useful format. The resulting lack of geospatially accurate utility data (or in many cases utility data at all) has caused countless project schedule and cost overruns, as well as news headlines detailing tragic utility dig-in accidents. This research sought to illustrate the current state of practices within State Transportation Agencies (STAs) regarding collection of geospatially referenced as-built utility record data within public right of way, as well as to quantify some of the costs and benefits of such practices.

The potential for cost savings is one of the main benefits to collecting georeferenced utility as-built data. This research estimates that $250,000,000 could be saved annually through damage prevention and another $384,000,000 would be saved annually through a reduction in the scope of Subsurface Utility Engineering (SUE) investigations. With the cost of as-built surveying being roughly 10-20% of the cost of SUE, it seems that collecting georeferenced as-built data as utilities are being put in the ground would be a common sense, non-controversial practice.

As the research progressed, real and perceived barriers to collecting georeferenced utility as built data were discovered through literature reviews, responses from STAs to a survey distributed by the research team, and interviews with STA and utility company representatives. The findings of the research confirmed that most STAs believe that collecting georeferenced utility as-built data could yield enormous benefits, and that they aspired to do so. However, the STAs cited many barriers to collecting this data such as worries about costs, concerns about data management, and pushback from utility companies citing security and competitive advantage concerns. Although these barriers have been sufficient to keep utility as-built data from being collected in the past, the research presented in this report shows that the benefits to collecting this data in the future far outweigh the costs. All the barriers cited can be overcome through an increased awareness of existing practices, a renewed sense of partnership and coordination between STAs and utility companies, better data management practices, and a forward thinking, proactive approach to infrastructure investment.

Examples of states where utility as-built data is being collected and data management practices have been implemented to ensure continued data applicability were examined and are presented in this report to highlight some of the ways that these above-mentioned barriers are being overcome.

CHAPTER 1

Background

The goals of this research include:

1) document effective practices (or lack of) used by state transportation agencies (STAs) for obtaining reliable, standardized utility record data ("as-builts") with required spatial accuracy from utility companies;
2) identify potential hurdles for compelling utility companies to install utilities as permitted and deliver reliable, standardized as-builts;
3) identify effort needed for utility companies and STAs to acquire and produce reliable, standardized as-builts; and
4) recommend a) legal and policy changes needed to overcome hurdles, and b) best practices so that STAs can gain access to reliable, standardized as-builts.

This research is to identify and investigate strategies for capturing, to a defined positional accuracy, standardized spatial and corresponding feature attribute data on utilities as installed. However, to fully understand, assess and appreciate the relevant elements required within an optimal approach, the background presented herein needs to include summaries of two influential factors: 1) known and growing impacts from not requiring this practice; and 2) known and perceived impacts for requiring such a practice.

Implications Resulting from Not Having Reliable, Standardized Utility As-Built Data

The 2017 American Society of Civil Engineers (ASCE) Infrastructure Report Card evaluated U.S. roads as having a "D" grade. They further indicate there is a substantial need for investment in America's roadways. (1) Additionally, the Transportation Research Board (TRB) 2nd Strategic Highway Research Program (SHRP2) Report S2-R01-RW indicates there is an estimated 11-million-mile underground network of utilities in the Unites States and this network is ever expanding. (2) In fact, the Common Ground Alliance estimates those numbers have doubled since that report was published in 2009. (3) With the telecom industry expansion, including new 5G mobile broadband systems, and connectivity being even more a part of daily life, those trends are likely to continue. Moreover, replacement of aging public works infrastructure and continual roadway expansion activities are exasperating the situation by leaving behind a gnarl of abandoned utility infrastructure. Current trends indicate both the transportation and utility infrastructure industries are currently entering periods of substantial growth and repair while both are vying for the same, and increasingly congested right-of-way (ROW) space.

Historically, utility infrastructure has generally not been documented in a consistent, geospatially accurate, and useful format. Often STAs are challenged by not having adequate resources available for inspecting and surveying utility infrastructure when installed in STA ROW. Instead, STAs must accept utility owner "as-builts", a misnomer frequently applied to an array of non-standardized records or drawings which are often in schematic, sometimes paper or image format, cannot be imported or easily transcribed into useful digital form, and typically fail to represent or accurately depict utility facilities with proper reference to a published geodetic datum and established geographic coordinate system. In-lieu of elevations, these "as-builts" sometimes represent utility locations at relative depths which can become imprecise with landscape alterations. To make matters worse, these "as-built" records may be lost over time due to sale or transfer of utility companies, or when there is a failure to hand off institutional knowledge as staff retire. It is not uncommon for records to be misfiled or discarded. Paper records may also be purposely destroyed or hopelessly stored away after information is transferred to a more user-friendly geographic information system (GIS) or computer aided drawing (CAD) format; unfortunately, these nicely formatted digital depictions are often of less accuracy than the paper originals.

Many civil engineers, contractors, STAs, cities, and counties, among others, can attest to the fact that **utilities have been the bane to many infrastructure projects as a direct result of inconsistent, inaccurate and deficient underground utility records**. Engineering performed with deficient utility data creates issues that must be addressed during construction, a reactive process that, under the best scenarios involves schedule delays, expensive field adjustments and emergency relocates, and under the worst scenarios may be compounded with outages, emergency repairs, property damages, and/or personal injury. Resulting litigation can not only be staggering for injuries, but also for outages in this digital age as the accidental severing of communication links supporting e-commerce and "cloud" based data management services can severely disrupt dependent businesses, airlines, public agencies, emergency responders, and the general populace.

As a result, project costs and claims have increased dramatically over the years. Three strategies listed below are currently employed to address deficient utility records. The first two listed are very costly, reactive in nature, and less than optimal. The third strategy, despite cost, is proactive and provides a positive return on investment which in turn gives some keen insight to even greater values that might be realized with having reliable, standardized utility as-built data recorded at the time of installation.

- **Wholesale utility relocations performed in advance of mainline construction.** This unsophisticated approach is often difficult to implement as mainline project designs, funding and schedules are often in flux. It's often unclear where, when, or even if utilities can be relocated prior to construction. To complete relocation designs, acquire easements, obtain permits, order materials, contract services, and schedule outages, utilities may need a year or more advance notice, adding complicating inertias to the strategy.
- **Using onerous contractual language to transfer effort and risk to the contractor with requirements to verify alignments, avoid damage, and use "force accounts" and change orders to deal with unanticipated delays and modifications.** This late stage approach causes contractors to contend with risk associated with poor utility information, and accordingly contingency costs for dealing with this risk are often buried in bids to the tune of a minimum of 10% of the total bid. To tolerate risk, contractors often implement large scale "potholing" campaigns in which all utilities marked out through Call Before You Dig / Call 811 notification services are exposed using vacuum excavation methods at intervals of about every 25-feet along each utility alignment through the project footprint. This approach is expensive, inefficient, disruptive to traffic, and results in inconsistent, non-standardized data which are not verified, not comprehensive, do not account for abandoned and unknown infrastructure, and can be misleading. Moreover, the information is acquired so late in the project that only reactive field fitting measures are invoked during construction which are by nature more expensive and less than optimal than proactive strategies that could have been implemented at the time when designs were being laid out.
- **Inclusion of Subsurface Utility Engineering** (SUE), a professional engineering utility investigation established to address the shortcomings of poor utility records for project development purposes) **along with other Utility Engineering (UE) best practices to analyze issues, engineer solutions, and integrate utilities into the mainline project as set forth by ASCE and advocated by the FHWA**. This strategy effectively reduces utility related project risk on projects at a fraction of the costs that would otherwise occur during construction if left to the contractor (as previously noted). UE practices yield more sophisticated resolutions which streamline project delivery and get utility impacts off the project critical path. Typically, SUE may add 1% to overall project costs, but produce a return on investment (ROI) on the order of $4.62 for every $1.00 spen (4) by enabling more sophisticated UE conflict analytics and engineered resolutions and project delivery tactics that reduce risk, enable tighter contract bids, and expedite construction. Anecdotal evidence with a recent 3D design project based on 3D ASCE 38-02 compliant data indicated the ROI to be greater than 10-fold. **The substantial ROI achieved on projects from investing in full utility investigations per ASCE standards provides direct insight to even greater values which can be realized through proactive, predictive asset management practices which include collection and management of accurate, standardized utility records as facilities are being installed.**

Because accurate, standardized record data essentially did not exist, there are many sophisticated strategies and value adding tactics for addressing, accommodating, and safeguarding utility infrastructure that to date have gone unexploited, such as the harnessing of emerging 3D technologies including 3D computer aided design and drafting (CADD), 3D building information modeling (BIM), virtual and augmented reality viewing, machine guidance, etc., that are now even more empowered through precision Global Navigation Satellite System (GNSS) navigation and 5G wireless broadband technologies.

Known and Perceived Hurdles for Obtaining Reliable, Standardized Utility As-Built Data

Most STAs are not requiring utility firms to acquire and submit standardized and spatially accurate records on utility infrastructure installations. The reasons cited vary from state to state and include:

- STA opinion that this is the utilities' responsibility, not the state agency, to acquire and manage their as-built data; quite often, in fact, the STA utility permit language stipulates this requirement. STA officials believe, often erroneously, that utilities know where their facilities are located and calling the utility or 811 will yield adequate data. If utilities fail to respond appropriately, then the STA believes it can force them with various hardball tactics including revoked permits, litigation and fines. This latter tactic uses negative reinforcement and often is not conducive to promoting a proactive, collaborative relationship between the STA and utility infrastructure owners.
- STA believes it lacks authority to compel and enforce such requirements; utilities are statutorily allowed within public right of way and the state agency cannot charge fees or force utilities to expend additional funds to survey and document their locations.
- STA believes it lacks labor force and funds to implement and manage an as-built data collection process and corresponding data.
- There hasn't been a published utility as-built standard for state agencies to use for specifying the data fields and spatial accuracy needed, and the format to which this data must be submitted.
- STAs lack a utility data repository and data management system to enable upload, access, and management of utility as-built data.
- STAs believe they are unable by law or policy to levy a fee through their utility permit process which can then be used to fund the implementation and operation of a utility data management system.
- STAs believe they are unable by law to require utilities to submit as-built data (as a result of strong backlash by utility companies in Las Vegas)
- STAs believe they lack staff, special procedures, equipment and practices for collecting utility as-built data during construction projects.
- STAs face bureaucratic inertia resulting from the separation power to purchase, develop and implement specialized software for managing utility infrastructure data (e.g., the state department of transportation must work through a separate department within the state that is responsible for all software and IT technologies).
- STA existing internal software applications for managing utility infrastructure are inadequate, and there hasn't been off-the-shelf (OTS) software technology available that is designed for managing complex utility infrastructure data.
- There is lacking cooperation from utility infrastructure owners because there are perceptions that:
  - additional costs will be prohibitive (to hire a surveyor, schedule the work, conduct the survey, and prepare submittals);
  - the data is proprietary and sensitive, and should not be made public for fear of competitors gaining knowledge or terrorist threat; and
  - the utilities submitting the data assume significant liability for incorrect data.
- There is a history of adversarial relations between STAs and utility infrastructure owners.

Perhaps, based on these observations, the two greatest barriers to collecting and managing accurate, standardized data on utility infrastructure installed within public right-of-way (ROW) can be distilled down to:

1. **the lack of a published, straight forward and easy to implement, utility "as-built" standard to accurately and consistently document installed infrastructure in a software-friendly format; and**

2. **the lack of a shared comprehensive vision and strategy for managing the existing and planned occupations of ROW space (above and below ground) in a manner that is proactive, productive, and mutually beneficial (symbiotic) for all stakeholders and the public alike.**

Over the past seven years ASCE and TRB have sponsored efforts to address these two specific needs. Summaries of ASCE efforts can be found in Appendix C, while summaries of TRB efforts can be found in the Literature Review Section and Costs to STAs Section of this report.

This research project was accomplished according to the research approach described in *Chapter 2: Research Approach*. The research team used a survey of 46 STA subject matter experts representing 36 states which included detailed follow-up interviews to capture information and data. In addition, identified literature and documents relevant to the research were reviewed. A snapshot of the state-of-the-practice was documented. Outside of the STAs, perspectives were captured through a subset of interviews with utility company representatives and informally collected information through:

- professional presentations at conferences hosted by AASHTO Committee for Right-of-Way, Utilities, and Outdoor Advertising (CRUO); Common Ground Alliance (CGA), Transportation Research Board (TRB), and the American Society for Civil Engineers (ASCE) Utility Engineering and Surveying Institute (UESI); and
- regular participation on conference calls and meetings hosted by AASHTO Utility Technical Councils (i.e., Utility Mapping, GIS & Information Subcommittee and Utility Accommodation and Safety Subcommittee), SHRP2 implementation participants, TRB AFB70 Utility Committee, FHWA Center for Accelerating Innovation Every Day Counts (EDC) Initiative, and the ASCE UESI Utility Risk Management Division (URMD).

The findings and information collected are presented largely in *Chapter 3: Findings and Applications*, however, relevant information is restated or reiterated throughout the report to support conclusions. The information presented in Chapter 3 is organized largely by collection approach (e.g., literature review, STA survey, interviews); however, more substantive findings are categorized by theme. For example, there is a theme category for costs incurred for collecting geospatial locations of utilities during their installation.

Although the data sources investigated for this work were broadly comprehensive, stemming from 46 survey respondents and 12 formal interviews, the data sources yielded few specifics on the actual costs associated with collecting utility as-built data geospatially. This result provides significant insight on the status quo for utility "as-built" data collection; simply stated, it's by and large not being performed as a standardized practice by STAs at the time of this investigation. Some cost data presented in the report is derived from an analysis of Common Ground Alliance's, 2018 *Damage Information Reporting Tool (DIRT) Report* and specific project reviews. Review of information obtained from these data sources, literature review, the *Homeland Security Act*, and the draft ASCE *Standard Guideline for Recording and Exchanging Utility Infrastructure Data*, formed the basis from which the research team developed conclusions, recommendations, and warranted additional investigations presented in *Chapter 4: Conclusions and Suggested Research*. To avoid distracting from the central findings of this research, some result elements are presented as summaries within the report body in lieu of full detail descriptions. For these cases, the complete data source is provided within the report appendices. Collectively, this report provides the main deliverable of this research as a guidance document focused on the objectives of the research as previously stated. STAs will be able to use this guidance to inform administrative officials of identified practices for requiring and obtaining standardized "as-built" data on utilities accommodated within STA ROW.

CHAPTER 2

Research Approach

The approach for this research project followed the general task descriptions of original request for proposals (RFP); however, the timing for early tasks to identify survey and interview needs for research panel review was delayed to allow the research team to conduct crucial interviews during the American Association of State Highway and Transportation Officials (AASHTO) Committee for Right-of-Way, Utilities, and Outdoor Advertising Control (CRUO) Annual Conference which was held April 28th – May 2nd, 2019 in Chattanooga, TN. This enabled efficient use of travel expense and time to complete required interviews with STA subject matter experts (SME). Further, the research team was able to direct attention to relevant literature review and data collection practices stemming from STA SMEs. Subsequent phone and email interviews allowed capture of relevant evolutions occurring over the past year within STAs with regard to utility as-built data collection, and also allowed SMEs to discuss and approve research findings pertaining to their current STA practices. With these minor alterations, the research tasks for the project are detailed further below.

Project Initialization

The project began with the research team presenting an amplified work plan, draft survey and interview questions, and an initial list of contacts for the interviewees to the research panel for review and feedback via web teleconference. The corresponding guidance and decisions provided by the research panel set the path for the research effort. The most critical decision made was the identification of the STAs to be interviewed in the study. The research team in collaboration with the research panel was familiar enough with the state-of-the-practice to identify the STAs that were actively pursuing and/or requiring geospatially acquired and accurate utility as-built plans from utility companies. An initial interviewee list was compiled, and survey interview questions were refined. Isolating the STAs to be interviewed for this study included consideration of those entities which were tracking and documenting information needed for deriving quantitative results required for the research initiative. The initial list of interviewees started with those states selected for SHRP2 R01A implementation funding for the *3D Utility Location Data Repository* and also included STAs involved as field users of those products. This list included California, Washington (state), The District of Columbia (D.C.), Georgia, Kentucky, Oklahoma, Texas, and Utah. Through review of recent legislation changes this interview list was expanded to include Colorado and Montana. Additionally, STAs from Michigan, Nebraska, South Dakota and Virginia were interviewed based on feedback from the survey.

Project initialization also involved the development and submission of several preliminary documents to guide the research effort: 1) amplified work plan that responded to research panel comments on the initial project proposal; and 2) draft survey and interview instruments and outlines for project deliverables.

Task 1

Task 1 was understanding current practices for utility as-built documentation at STAs. The research team conducted a review of relevant domestic research, guidelines, and current practices to identify and describe the current state-of-the-practice. This review involved several reliable sources of information including academic publications, STA/national research reports and manuals, and the Transportation Research Information Service (TRIS). After a preliminary literature review to address project initialization, the task largely involved a detailed review which in turn reduced the amount of information and time required for survey and interview respondents.

Within this task the research team initiated surveys and began connecting with the nominated STAs. The surveys were performed remotely and garnered state-of-the-practice information with minimal impact to the research team and respondents. The survey was designed to efficiently collect data on state-of-the-practice as well as information relevant to Task 2, Task 4, Task 7, and Task 9. The research team was able to use the AASHTO CRUO conference venue for promoting the survey and conducting several of the STA initial interviews. A few rounds of reminder notifications were sent to potential respondents of the survey; in the end, 46 responses representing 35 STAs were obtained. The research team prepared a technical memorandum to summarize the findings of the survey and used it to communicate the initial findings and potential list of additional interviewees to the research panel. A web teleconference with the panel was used to present findings of the survey and the initial interviews. By the date of this teleconference, the research team had conducted 8 interviews with STAs (Colorado, Georgia, Kentucky, Michigan, Montana, Texas, Utah, and Virginia). The research panel asked for minimal additional STA interviews, but instead requested the research team attempt interviews with utility companies. This research team contacted approximately 10 utility companies but were only able to interview three. The results of the survey and interviews are further detailed in *Chapter 3: Findings and Applications,* with access to the full research tools and data provided in the report appendices.

Task 2

The purpose of Task 2 was to identify implications for utility companies and STAs related to capturing, to a defined positional accuracy, standardized spatial and corresponding feature attribute data on utilities as installed. Data for investigating these implications (like several other tasks) was collected in Task 1. Relevant questions to the point of Task 2 were asked as part of the survey and interviews and are discussed in detail in *Chapter 3: Findings and Applications*. As discussed with the research panel, the feedback from the STA survey and interviews did not capture direct responses regarding implications to the utility companies; instead, utility company implications were presented by STA representatives as opinion or in second-hand form. Therefore, a select set of utility companies were contacted for interview. The interview questions were altered to capture only the data needed from the utility companies in order to use their time efficiently. Contact information for the utility companies for interview was requested within the survey but this garnered few responses. The final set of contacts came from a combined list from the survey, the research panel, and existing contacts of the research team. Again, these findings are discussed in *Chapter 3: Findings and Applications*. It is important to note that comments were provided by a diversity of STA and utility company representatives with varied experiences and technical knowledge; some of those interviewed are not specialists in state-of-the-art survey, mapping, data management, and IT technologies which are rapidly evolving, nor had specific knowledge of "utility as-built" standard development activities. This situation resulted in some responses which could be classified as inherently myopic perceptions and preconceptions.

Task 3

Task 3 involved cursory review and brief summary of the Homeland Security Act 2002, Public Law 107-296 as it applies to utilities occupying state ROW. Review of this legislation was intended to address utility representatives' common referral to it as reasoning for why geospatially accurate location data on utility infrastructure cannot be provided to STAs. The 2,135-page legislation was scanned to assess how the law may apply to utilities occupying STA ROW. Although not originally included within this task, the STA interviews included questioning to help determine:

1. potential barriers resulting from this law that can impact STA ability to require utilities to provide geospatially accurate as-built data when occupying STA ROW; and
2. effective policies or practices that enable STAs to require acquisition and submittal of geospatially accurate as-built data on installations within STA ROW as permitted within the confines of this law.

The findings of this summary and the interview questions are used as supporting elements in discussions in *Chapter 3: Findings and Applications*. The full summary of the law is presented in Appendix **E** of this report.

Task 4

Task 4 used specific examples to quantify costs incurred by STAs due to inaccurate geospatial utility as-built data. Both survey and interview responses were used to gather real project examples, but the results were disappointing as the information was insufficient for deriving quantified cost estimates. However, the research team was able to tap on professional experiences and media references to compile a few summaries in regard the costs associated with inaccurate geospatial as-built data. As mentioned in the proposal and to be discussed in *Chapter 3: Findings and Applications*, specific examples with quantifiable costs are difficult to pinpoint. As a perceived cost saving measure, conventional project development practices within many STAs and project owners do not include systematic and comprehensive Subsurface Utility Engineering (SUE) and other Utility Engineering (UE) best practices as developed by ASCE and promoted by the FHWA. For these STAs, the risk associated with inaccurate and incomplete utility depictions is passed along through onerous bid document specifications to the prime contractor who, in turn, schedule large scale "pot holing" campaigns and bury related contingency costs into their bids to tolerate and accommodate the risk. Resulting cost and schedule implications that are claimable are often buried with other project change orders. STAs are accordingly often oblivious of specific costs directly due to deficient utility record and as-built data. [Note: As a rule, STAs that utilize SUE and UE best practices do not incur unforeseen utility related construction costs as the utility depictions developed per the ASCE *Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data* (ASCE/CI 38-02) supersede deficient utility record and as-built data.]

The effort is complicated by the need for cost data on issues specifically tied to geospatially inaccurate utility as-built data, and not related to mismarked locations or location technology errors which occurred as part of the "Call 811" notification damage prevention process. As will further be discussed, costs associated with utility issues can involve and become entwined with numerous cost categories that are difficult to parse and assess. None-the-less, the research team has attempted to assemble costs associated with geospatially inaccurate utility as-built data. In addition, the research team presents a compelling case study in which geospatially accurate utility data was obtained through a SUE investigation and the engineering included UE best practices. The project owner and contractor, who were both new to SUE and UE, realized significant and unanticipated cost savings and schedule reductions which were quantified.

A related source of data used to quantify these costs was the Common Ground Alliance (CGA) Damage Information Reporting Tool (DIRT) Report covering the costs and frequencies associated with dig-in event damages. Further, the research team used media and presentations made at the 2019 CGA Excavation and Safety Annual Conference in Tampa, FL to support quantifying costs relevant to geospatially inaccurate utility data. Change order data from previous studies involving highway construction and utility specific issues were also assessed. The results of these analyses are presented in *Chapter 3: Findings and Applications*.

Task 5

To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed <u>*Standard Guideline for Recording and Exchanging Utility Infrastructure Data*</u> which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

Table 2-1. *ASCE Standard Guideline for Recording and Exchanging Utility Infrastructure Data* - Positional Accuracy Requirements

Positional Accuracy Level	Positional Accuracy[1] (English Units)	Positional Accuracy[1,2] (SI Units)
1	0.1 feet	25 mm
2	0.2 feet	50 mm
3	0.3 feet	100 mm
4	1 foot	300 mm
5	3 feet	1000 mm
0	Indeterminate	Indeterminate

[1] At the 95% confidence level, in accordance with FGDC-STD-007.4-2002. Level 1 generally coincides with requirements for vertical Positional Accuracy in ASCE 38-02 quality level A (QLA).

For purposes of this study the research team defined "geospatially accurate" to fall within the positional accuracy range of levels one through four in Table 2-1. The costs of collecting as-built data for three defined models of utility installations (small, medium, large per the following table) with survey points every 20 feet, and including joints, splices, tees, and inflection points for rigid lines, and every 10 feet for flexible lines were used in the study.

Table 2-2. Survey and Rediscovery Cost Estimate Parameters

Installation Method	Length (ft)		
Open Trench - Rigid	100	1,000	10,000
Open Trench - Flexible	100	1,000	10,000

Geospatially accurate utility as-built data collection costs were estimated based on: 1) the resources required for each model; 2) Accuracy Levels 2 through 4 (per Table 2.1); 3) urban vs rural site conditions; and 4) availability of adequate survey control which enabled referencing to the NSRS. Re-discovery costs (i.e., subsurface utility engineering (SUE) utility investigation (Quality Level B designating per ASCE/CI 38-02 *Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data*) costs to go back out and find buried infrastructure long after installation, when surface evidence, such as trenches, are no longer apparent) were estimated based on industry average rates. Cost estimates include field and office work. Because of the many variables that can affect costs that are project specific (local cost indices, access, weather, traffic congestion, traffic control, surface, mobilization distances, security clearance, permits, night operations, etc.), the research team used normalized cost averages to derive estimated costs for each georeferenced as-built survey scenario as well as each re-discovery scenario.

Task 6

Aligned with understanding the costs to require, acquire, and manage geospatially accurate utility as-built data, is the need to understand the benefits of such data. Task 6 sought to quantify monetary benefits associated with the risk reduction and safety enhancements derived from geospatially accurate utility as-built data. The research team analyzed the relationship of geospatially accurate as-built data to utility risks and safety using the Common Ground Alliance's (CGA) Damage Information Reporting Tool (DIRT) annual report. This data enabled assessment of the frequency and risks posed by utility strikes on known (not located properly) and unknown facilities. The project team then compared these factors against risks of utility strikes on known and properly marked facilities (per Call 811 notification services). The research team analysis included examining available data to determine if "accurate location" is a part of the reported data or can be implied. Based on the types of data available, the risk reduction and safety opportunities directly related to the availability of geospatially accurate data was summarized. The project team also contacted horizontal directional drilling (HDD) equipment manufacturers to identify technology used for tracking and recording HDD boring alignments (in 3D) and identified limitations. STAs were also asked through the survey of their requirements associated for obtaining and submitting this information. The STAs were also requested to identify technologies currently used or considered reasonable for acquiring geospatially accurate utility installation data.

Task 7

While the previous research tasks involved understanding costs and beneficial value for geospatially accurate utility as-built data, Task 7 focused on accountability for inaccurate or untimely utility records. Task 7 also sought to provide recommendations regarding how STAs might hold utility companies accountable for inaccurate or untimely record data, and for contractor claims when utilities have not been installed in accordance to permit criteria, or documented to geospatially accurate coordinates as required. The research team used the survey distributed in Task 1 to query STAs of efforts to hold utility companies responsible for deficient or geospatially inaccurate records of their facilities or for responsibility for contractor delay claims occurring because record data was deficient or inaccurate. Further details were sought from several STA representatives during interviews. Additionally, a recent legal case produced a finding of interest related to this task and was accordingly summarized. The survey and interviews were also used to determine if STAs were requiring professional stamping (PE or PLS) for utility as-built plans and prompted opinions of such practice. The results of this task are presented in *Chapter 3: Findings and Applications*.

Task 8

Very much related to the central objective of the research is an evaluation of the new ASCE *Standard Guideline for Recording and Exchanging Utility Infrastructure Data*, (a.k.a., "utility as-built standard"). The research team included leading members of the standard committee who could provide first-hand knowledge which aided evaluating implications associated with implementing it as policy for obtaining standardized and geospatially accurate utility data in a format that can be readily shared for facilitating design activities including CAD, BIM, conflict analytics and resolution engineering, utility coordination, agreements, bid document preparation. Moreover, the standardized data can enable enhanced damage prevention strategies including augmented reality viewing, machine guidance, and Call 811 marking activities which can leverage GNSS navigation technologies. A review was also made on the standard's scalable accuracy criteria and optional usage of professional certification. The research team used their personal knowledge and contacts to conduct this review, which included feedback from the Montana Department of Transportation and representatives of utilities involved with implementing the new standard as part of their ROW permitting process. The results are summarized where applicable within *Chapter 3* and also presented in full within report appendices. The research team also collected feedback on this standard through the survey tool to identify other STAs that are aware of this standard with plans to adopt it. The standard was further discussed in the STA interviews to evaluate and identify potential implementation barriers (real and perceived). The review of efforts by STAs that were recipients of SHRP2 R01A implementation funds provides support for these findings.

Task 9

Task 9 is the compilation of findings into a final report inclusive of potential policy recommendations for STAs. The recommendations involve data governance, storage, sharing, and legislation. These recommendations are the result of compiling the data and findings throughout the term of the project. Along with this final report, a Microsoft PowerPoint presentation with speaker notes is provided as a separate deliverable. There are numerous opportunities to report the findings of this project with one possibility being the 2021 AASHTO Committee of Right of Way, Utilities, and Outdoor Advertising Control Annual Meeting. Although this meeting will fall outside of the contract window for this project, the research team is committed to presenting the research at this venue if desired by the research panel.

Research Products & Outcomes

The objectives of this research was to document effective STA approaches for requiring utility companies to install or relocate facilities to known geospatial locations, identify the barriers to requiring utility companies to provide geospatially accurate as-built locations of their facilities, investigate the cost implications of these requirements to the STAs and the utility companies, and recommend policy and legislation changes needed to implement these requirements. The research team has compiled the research findings into this project report inclusive of resource appendices to meet those objectives. STAs should be able to use this report to navigate their practices toward improved requirements for geospatially located utility as-built plans with an understanding of the inherent impacts and value associated with those requirements.

CHAPTER 3

Findings and Applications

Research findings were produced through:

1. literature review (inclusive of research reports, presentations, policy manuals, and other references);
2. survey of subject-matter experts;
3. formal and informal interviews; and
4. analysis of openly available datasets.

This research effort is to gain an understanding of the value of requiring geospatially accurate and standardized data on utility infrastructure. But because acquisition and management of geospatially accurate and standardized utility as-built data is hardly ever performed at this time, none of the reviewed literature provided direct assessment of that value. However, inferences and analogies can be made from literature covering two distinct and separate categories of activities that are currently used to address and reduce issues with utilities on projects: 1) Subsurface Utility Engineering (SUE) investigations and Utility Engineering (UE) design analytics and resolution development which occur during project development; and 2) Damage Prevention (DP) practices utilizing One-Call (Call 811) notifications, contract locating services, and related damage incident reporting which occur at the time of excavation.

SUE and UE practices have been the focus of organizations including the American Society of Civil Engineers (ASCE), Transportation Research Board (TRB), and the Federal Highway Administration (FHWA). SUE and UE are predicated on acquiring accurate depictions of utility infrastructure through methodical engineering and geophysical investigative measures performed in accordance with the ASCE "Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data (ASCE/CI 38-02), and then integrating that data within the entire project development effort to mitigate issues and risk during planning and design stages of a project. DP services are the focus of organizations such as the Common Ground Alliance (CGA) and contract locating industries and are predicated on placing accurate marks and flagging ("locates") on the ground during construction to identify where utilities lie beneath. Both SUE/UE and DP practices are essential and were developed and are utilized to address the predominant lack of reliable utility records; moreover, both fields could achieve greater performance levels if geospatially accurate and standardized utility data were already available. SUE/UE literature provide insight on the value (i.e., reduced risk, better planning, lower bids, faster construction) that can be achieved through proactive and predictive engineering with accurate and standardized utility data. DP resources provide information on the quantity and nature of documented strikes occurring annually, as well as the myriad of direct and indirect costs incurred with utility strikes and damages.

STAs generally do not clearly track costs associated with issues resulting from poor utility data. Issues that arise are often late term (i.e., during construction with materials and equipment on site) and there isn't sufficient time to do anything but to quickly fix the problem with whatever reactive measure is fastest to implement and move on. Contractor claims are often muddled with other change order items and buried in construction budgets. In addition, costs that STAs do track are only those that are line items in the DOT budget, and do not account for other real and often significant utility related cost implications including:

- wholesale potholing campaigns and contingencies which contractors must build into bids to tolerate risk associated with poorly documented utilities,
- utility owner and ratepayer costs associated with having to clear out utilities in advance or conduct emergency relocates during construction,
- quantified public and commercial disruption (loss of time, loss of business) due to prolonged construction resulting from encountered late term utility related project issues.

Conversely, STAs which utilize SUE and UE practices also have a difficult time tracking the value achieved with having geospatially accurate utility data, as it is difficult to quantify and track savings which occurred for mishaps that were avoided. (Probably the best source for quantifying an average reduction on contractor change order fees resulting from the adoption of SUE practices will be in Colorado where the passage of SB18-167 in August 2018 essentially made SUE compliant with the ASCE/CI 38-02 standard for project design a law. However, this assessment will not be possible for several years, when the affected design projects are actually constructed.)

Accordingly, a review of the available literature, data, and responses from subject matter experts provided limited information; however, inferences are made and identified benefit line items along with estimates on associated costs and cost savings are listed, some of which are flagged as good candidates for future research.

The findings from these methods are summarized below, but results and conclusions are also reiterated where practical to align with the requirements of the research tasks. For example, a broad overview is provided regarding the STA survey, but specific findings are highlighted within applicable sections of this chapter to fulfill the objectives of individual tasks. In this way, the research established and presented state-of-the-practices, but then also present findings on identified costs and benefits specific to the implications of accurate or inaccurate utility location plans.

Literature Review

STAs unanimously recognize that both highway and utility facilities are important to the public and must share the public right-of-way. However, utilities located within and near road right-of-way (ROW) pose challenges as STAs must:

1) investigate the presence, ownership, specifications, prior rights, and correct coordinates of utility facilities within an STA project footprint;
2) assess direct (e.g., clash) and indirect (e.g., scheduling and constructability constraints) conflicts with proposed designs and construction activities;
3) optimize designs, utility adjustments, and construction activities to mitigate risk and impact to all stakeholders (e.g., STA, utilities and their dependent clients, contractors, commerce, and the public) and best accommodate highway system improvements; and
4) coordinate agreements, preparing bid specifications, and overseeing all project delivery activities associated with utility infrastructure.

With increasing frequency, conflicts with utilities have had significant negative impacts on transportation projects, and likewise transportation projects have had adverse impacts to utility infrastructure. Some STAs report conflicts between utilities and STA projects have become a leading issue in the design and construction of projects. FHWA has noted utility issues as one of the top three causes for project delays (6). As more and more assets are placed underground, the likelihood of these costly conflicts continues to grow.

Utility conflicts identified at the end of the design period or during construction are difficult to address with anything other than reactive, late term measures which are often less than optimal and disruptive to transportation projects. Addressing utility issues in this manner often extends construction time, pose safety concerns, increases costs for all parties, aggravates relations between stakeholders, and prolongs commercial and public discomfort. Attempting to address utility conflicts during project design stages is difficult because engineers lack reliable depictions of existing utilities from which to base designs. Accordingly, to avoid any utility conflicts, many STA design teams simply resort to tactics which are often overly conservative, unsophisticated, and draconian in nature in which utilities are forced to relocate with diminutive consideration, and quite often at utility owner expense.

However, experience has clearly demonstrated that identified and reliably depicted utility infrastructure can be leveraged during the early stages of design to invoke clever engineering and construction tactics which minimize or eliminate need to relocate facilities, or allow better coordinated construction strategies which better accommodate relocations and new utility installations with minimal disruption, risk, cost and impact to the project's critical path. States with statutes requiring STA participation in relocation costs, such as Texas, Utah, and Montana, have found very good return on investment from routine use of subsurface utility engineering (SUE) to develop reliable depictions and utility engineering (UE) in accordance with ASCE Utility Engineering and Surveying Institute (UESI) guidelines and best practices which include conflict analytics, utility coordination workshops, resolution engineering, and utility agreements that further allow contractor value engineering tactics which enable enhanced delivery methods with minimal utility impact.

The repeated investigating, surveying, and depicting, and subsequent analysis, accommodating, protecting, and relocating of underground utilities creates significant delays, costs, and complications to design and construction activities, as well as utility operations. This commonly understood fact provides immediate understanding of how geospatially accurate utility as-built data can significantly reduce adverse impacts for STAs and utility companies alike for transportation project development. In addition, there are also a host of other unexploited and far reaching beneficial uses from standardized geospatially accurate utility as-built data which include, but are not limited to: augmented reality viewing, global navigation satellite system (GNSS) aided locating, machine guidance, 3D modeling of utilities for building information modeling (BIM), resiliency analysis, civil defense and emergency response needs, etc. Such data will enable STA ROW managers to exercise more proactive operations and maintenance, planning, and asset management strategies. Moreover, utility owners can benefit from enhanced utility damage prevention, accommodation practices and proactive STA planning, and could also reduce risk, cost and schedules for their own maintenance activities and new utility installations.

Studies on Subsurface Utility Engineering Investigations

Kraus, et al., (2013) research team reviewed the state of the practice regarding utility investigations and developed recommendations for timing and use of utility investigation services in the Texas Department of Transportation (TxDOT) project development process (7). Kraus's research affirmed that accurate location and condition data on all utilities within the project footprint was needed early in the project planning and design processes, long before excavation activities, to assure minimal delays and cost overruns. Geospatially accurate and standardized record data are conceptually the most expedient and efficient means for enabling better coordination with the transportation. Quiroga, et al., (2012) in their research, pointed to two critical factors that contribute to inefficiencies in the transportation project development process (8): 1) lack of accurate and complete information about utility facilities that might be in conflict with the project; and 2) the resolution or overall management of those conflicts. Inaccurate or incomplete information about utility facilities can result in a variety of problems such as:

- disruptions when utility installations are encountered unexpectedly during construction, either because there was no previous information about those installations or because utilities were inaccurately depicted on the construction plans;
- damage to utility installations, which can disrupt utility service, damage the environment, and endanger the health and safety of construction workers and the public; and
- delays that can extend the period of project development or delivery and increase total project costs.

Studies on Damage Prevention and Costs Resulting from Damages

Sterling, et al., (2009) (9) and Makana, et al., (2016) (10) investigated utility damages occurring during transportation projects and means to mitigate damage events. Utility infrastructure are often located below the ground surface at shallow depth. Most transportation projects unavoidably require some level of excavation, such as for pavement replacement, vertical or horizontal alignment changes, and/or drainage system additions, as well as the relocation of existing utilities that were identified as in conflict with the project. Excavation work presents the possibility of puncturing or otherwise damaging existing utilities, as well as risk of death, injury, added costs, and project delays. Because of the seriousness of many utility and pipeline accidents and the high cost of disruption to some types of utilities (for example, fiber optic cables), much attention has been paid to this issue over the past 10 years. Efforts to promote damage prevention have fallen into the following major categories:

- Procedural mitigation: Improved "One-Call" (i.e., "Call 811") notification procedures; increased use of "One-Call" (public and contractor) education; tracking damage statistics (national and state utility offices); using damage statistics to prioritize actions, and moving the responsibility of the damage-prevention marking process to contractors or a single entity rather than individual utility owners.
- Technological mitigation: Improved locating and marking technologies; improved mapping; pipeline encroachment monitoring; leakage and mechanical damage detection; and "see ahead" technologies for excavation equipment.

This previously mentioned research highlights the potential to enhance damage prevention if more was known about the positions and alignments and sizes of existing utilities prior to excavation. The lack of accurate, reliable and standardized data on existing utility installations directly causes numerous levels of costs when damages do occur. Makana, et al., (2016) sought to further understand the impacts of utility damages (utility strikes) in the United Kingdom and quantified associated costs:

- incurred and paid directly by contractors (direct costs),
- those borne by third parties in the contractual agreements (indirect costs), and
- those costs of other parties not engaged in the contractual agreements (social costs) of the construction.

The study reported a 29:1 ratio of indirect and social costs to direct costs. In review of past utility strike example case studies, Makana, et al., (2016) was able to categorize the costs associated with utility strikes.

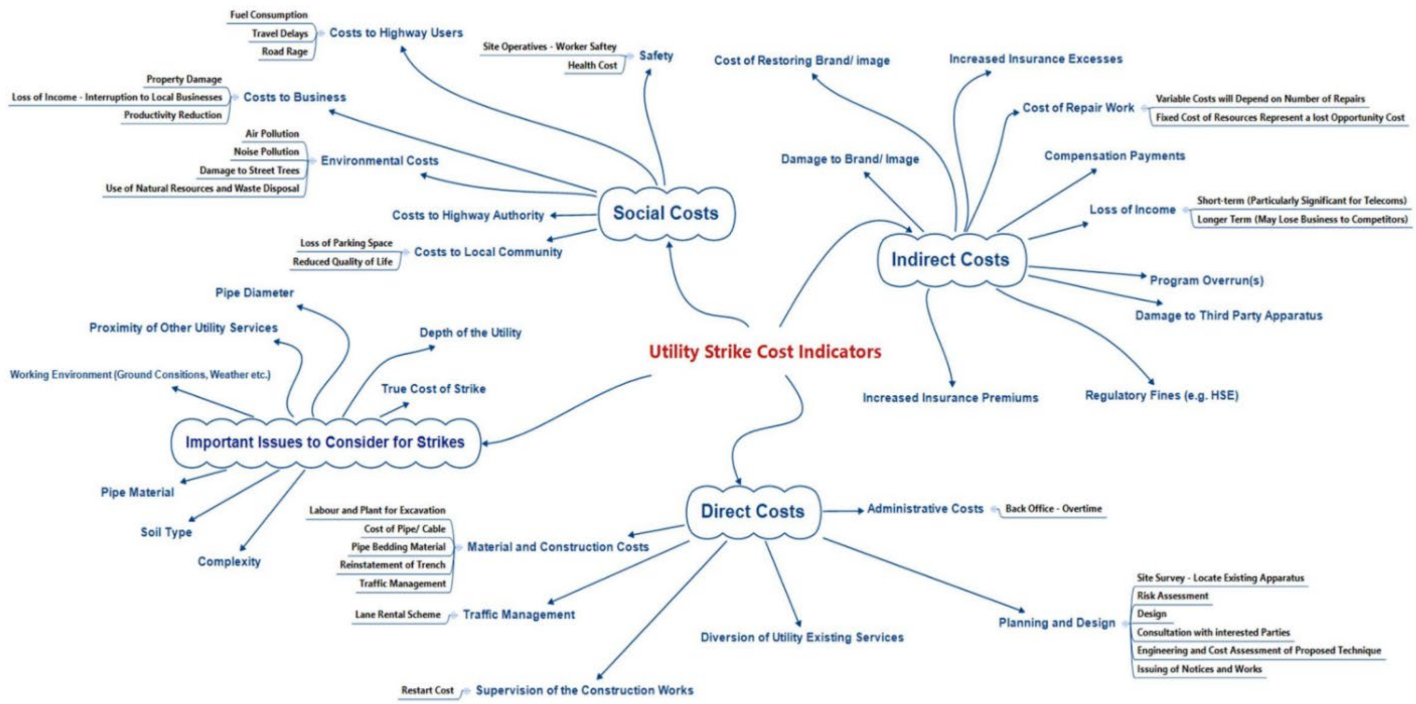


Figure 3-1. Examples of Utility Strike Cost Categories (Makana, et al., 2016)

Beyond the costs, Makana, et al. illustrated causal factors leading up to strike incidents. During excavation, a utility strike incident is triggered by inadequacies in one or more causal categories defined in Figure 3-2, in addition to human error. This figure systematically highlights contributing factors for utility strike events and illustrates the broad spectrum of the individuals involved with decision-making associated with utility infrastructure. The thematic analyses to produce this figure culminated in identifying four distinctive utility strike causal factor 'categories':

(1) Sequencing, Planning and Programming
(2) Competence and Training
(3) Physical Site Considerations
(4) Excavation Technique

(Makana, et al., 2016)

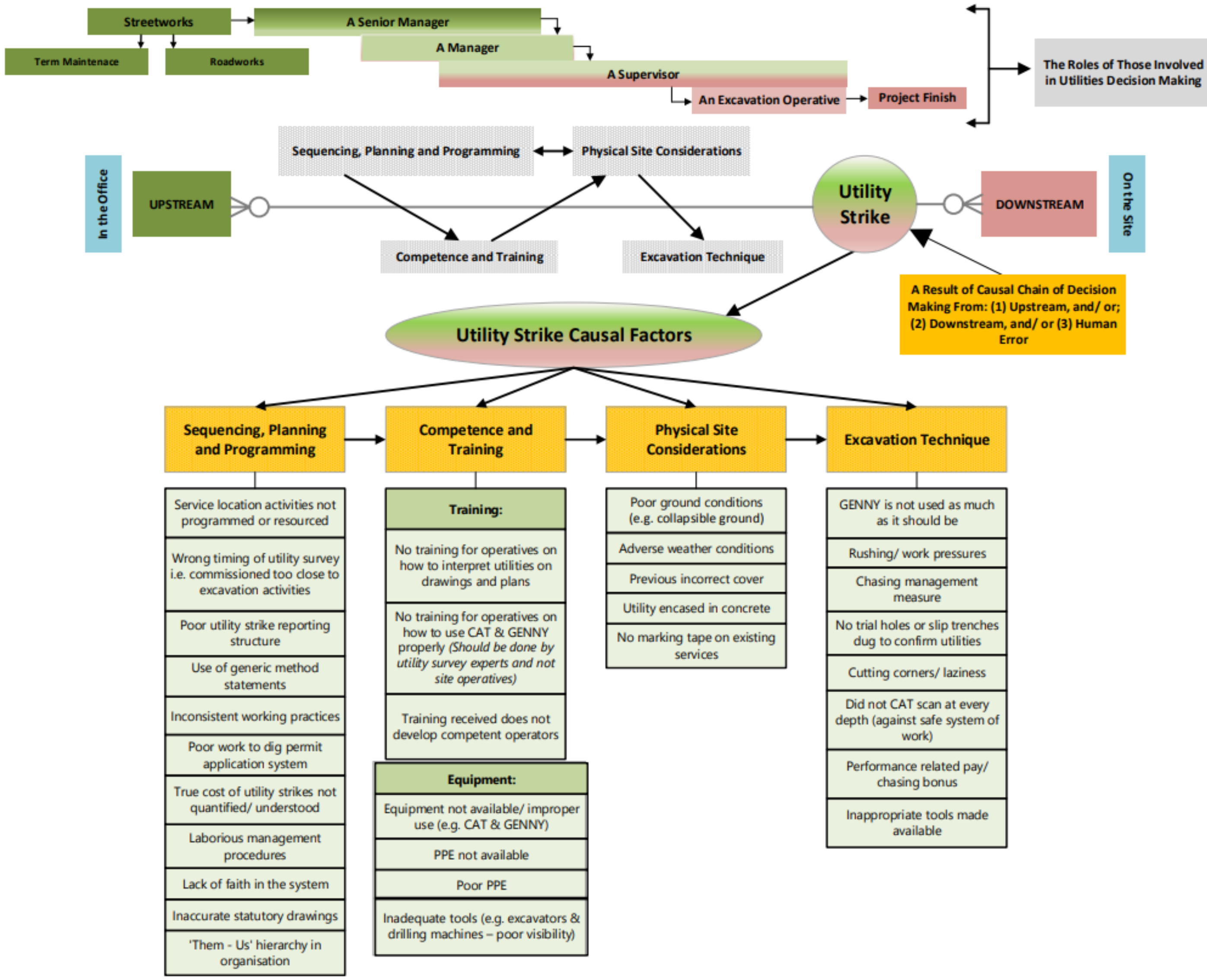


Figure 3-2. Utility Strike Causal Factors in Street Works (Makana, et al., 2016)

Makana, et al., (2016) also noted that some companies which were consistently involved with executed street works projects rarely experienced utility strikes. They found these companies exemplified the following key principles of effective utility coordination:

- consistent early and frequent consultation between all parties;
- regular input and attendance of relevant personnel at utility coordination meetings;
- disclosure of business development plans and the locations of upcoming projects; and
- pre-planning on a network basis.

Second Strategic Highway Research Program Initiatives

Domestically, there have been multifaceted efforts to improve utility investigation and utility coordination practices. The second round of the Strategic Highway Research Program (SHRP2), sponsored by the TRB and implementation partners the FHWA and AASHTO, developed a bundle of potential research products to improve the identification and management of utility conflicts (SHRP2 R15B), advance technologies for locating underground utilities (SHRP2 R01B), and approaches to developing and storing 3D models of utility as-built plans (SHRP2 R01A).

The final report for SHRP2 R01A sought to provide a prototype for a 3D data storage and retrieval schema that could influence utility coordination by having location information readily available. According to the research website, "The data stored will include the horizontal and vertical location of the utilities, as well as attribute data that is needed to ***effectively coordinate*** with utility owners." The framework for implementing such a system is provided as well as a framework for continuous updating of that system. While this is great information, there is no substantive discussion of cost regarding the implementation or operation of such a system. The project did not produce tangible, practical products, but instead yielded lessons learned, among which was the fact that the effort was not trivial and required a multi-discipline team with a variety of real-world experience and in-depth knowledge of utility infrastructure systems, installation methods, survey and geodetics, STA business processes, computer aided design and drafting (CADD), geographic information systems (GIS), and construction practices, among other expertise. The ASCE "Utility As-built" standard, which was developed independently of the R01A effort, provides a data framework and standardized domain values that supersede R01A prototype products. However, the SHRP2 program provided much needed funding for a few STAs willing to propose making serious foray into the practice of collecting and managing 3D utility infrastructure data. Montana and Colorado implemented utility data repositories compliant with SHRP2 R01A concepts, and data on the corresponding costs could subsequently be acquired and analyzed. Michigan also tested a web-based software using SHRP2 R01A funding, which could provide another source for further cost analyzation.

Another SHRP2 product, SHRP2 R01B *Utility Investigation Technologies*, report included a presentation of creditable nondestructive geophysical technologies for detecting buried utility infrastructure under a variety of real world geologic and physical constraints and characteristics. This research sought to provide engineers with more advanced multi-sensor tools that could be readily deployed for rapidly detecting and mapping utilities within the context of a SUE utility investigation. In the end R01B focused specifically on the use of two technologies: time domain electromagnetic (TDEM) induction and multi-channel ground penetrating radar (MCGPR). These types of "advanced geophysical technologies", which have been around for a few years, regularly applied for environmental and unexploded ordinance investigations, were queried for their use and effectiveness within a SUE utility field investigation. Subsequent SHRP2 implementation funding enabled several states to demonstrate the effectiveness of TDEM and MCGPR for SUE utility investigations. In general, the systems showed value for both providing 3D data for detectable infrastructure, and identifying undocumented or abandoned and forgotten buried infrastructure that could perceivably confuse and disrupt construction activities. R01B also demonstrated: 1) the value of having 3D data for project development, and 2) the growing need to collect and manage utility as-built data, as both active and abandoned infrastructure increasingly congest public ROW.

<u>FHWA Feasibility Study</u>

The Federal Highway Administration (FHWA) Report (FHWA-HRT-16-019, Quiroga et al, 2018), "Feasibility of Mapping and Marking Underground Utilities by State Highway Agencies," study (11) takes a step beyond the SHRP2 R01B products to conduct a detailed investigation of the feasibility and practical application of STAs capturing and warehousing the location data of utilities within their right-of-way. Additionally, the study delves into potential return-on-investment for having utility position information available along with supporting data such as positional accuracy. The return on investment (ROI) ratio presented was 4.0 based on generalizations from past 2D utility investigations for which depictions developed with SUE QLB and strategic QLA observations cost roughly 1% of the project design and construction costs, and the overall project savings realized from such an investigation is usually 3:1 to 6:1, stemming from previous studies (4.62:1—Purdue Study, 3.42:1—Ontario, Canada Study, and 22:1—PennDOT Study). However, these previous ROI estimates are based on 2D design efforts, and do not address added value that can be achieved with a plethora of untapped 3D development and delivery technologies along with improved engineering and coordination practices. The report does mention that there haven't been enough 3D projects involving utilities at the time of the research effort and that only anecdotal evidence was available. Although not mentioned in this FHWA report, a full 3D design and construction effort, detailed in the Extended Benefits section of this report, performed for a high-pressure gas main installation in Washington along a busy urban corridor in 2015 demonstrated an ROI ratio of approximately 10.

The report presents the perceived and actual challenges to implementing such an approach and provides a conceptual framework for doing so. The report also presents strategies that some STAs are trialing to achieve better information regarding the utilities in their right-of-way, such as the use of radio-frequency identification devices (RFID marker balls) and utility data management practices. Overall the report clearly demonstrated value from having utility data integrated with 3D design for project development and delivery, and trending efforts by transportation agencies at Federal and state levels to migrate toward 3D practices.

American Society of Civil Engineers Standards for Utilities

The American Society of Civil Engineers published in 2002 the ASCE/CI 38-02 *Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data* (ASCE 38-02). This fundamental document elevates utility investigations to a professional effort and is now considered the industry standard for achieving the level of care required for STAs to assess and appropriately address and mitigate risk for project development. ASCE 38-02 provides guidelines for collecting and designating, using professional judgment, the quality of utility information depicted on plans in a standardized manner. The ASCE 38-02 standard also describes relative costs and benefits.

ASCE is also developing a *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which is discussed in Task 5 and is intended to serve to compliment standard ASCE 38-02. This standard provides guidelines for documenting utility infrastructure, when it is being installed or is exposed, with standardized spatial data and feature attributes that provide the data required to produce virtual reality 3D renderings of utility installations tied to real world coordinates. Effectively, this latter ASCE standard is an “as-built” standard for documenting “newly installed” or exposed utility infrastructure, while ASCE 38-02 is a standard for documenting “existing” and already buried utility infrastructure.

Transportation Research Board Synthesis Studies

Several synthesis studies sponsored by TRB were reviewed to help develop the survey and interview questioning. The National Cooperative Highway Research Program (NCHRP) Synthesis 405, “Utility Location and Highway Design,” presented the fundamental challenges associated between utility coordination and highway design (12). STA procedures for identifying, locating, and resolving conflicts regarding utilities present the basis for the types and severity utility impacts. While the synthesis indicates there is little conformity on how this process should occur, it does provide as succinct list of best practices employed by STAs to mitigate utility and highway conflicts.

TRB's Airport Cooperative Research Program (ACRP) Synthesis 34, “Subsurface Utility Engineering Information Management for Airports” (13) reinforces the concept that utility management and utility coordination are important across various modes to properly address potential impacts utilities have on projects and operations. Numerous methods of identifying utility facilities are discussed, but early involvement of specialists, such as qualified SUE professionals, with knowledge on utility installations and proper investigative procedures, enables the best practice for identifying and managing utility conflict situations and reducing according risk.

NCHRP Synthesis 462 “Managing Longitudinal Installations on Controlled Access Highway Right-of-Way” (14) specifically investigates STA management of longitudinal utility installations on controlled access highway right-of-way. STAs often have procedures and practices to manage utility coordination and conflicts, but a void apparently exists with regard to a national standard of practice. The use of utility corridors, shared trench methods, and utility right-of-way accommodations are mentioned as practices, but procedures and policies guiding best usage of these practices are minimal. Managing utility locations is presented as a challenge, but there was little discussion on implementing practices to acquire and manage geospatially accurate utility as-built data. These resources were used collectively to develop the survey questionnaires.

State Department of Transportation Survey Results

The research team distributed the survey using multiple methods. The survey was distributed via email to the listserv for the American Association of State Transportation and Highway Officials Committee on Right of Way, Utilities, and Outdoor Advertising Control (AASHTO CRUO). The research team included their known contacts who were not on the AASHTO CRUO listserv but were involved in utility coordination and permitting in their respective STA. The final distribution method involved the use Quick Response (QR) code note cards widely distributed at the AASHTO CRUO Annual Meeting. A second email round was also used to bolster response numbers. The survey period began on April 23, 2019 and concluded on May 17, 2019 with a total of 46 responses representing 35 STAs. Five states submitted multiple responses reflecting views from the perspective of different subject matter experts within the STAs. The research team reviewed the states submitting multiple responses and determined the results were not biased by these submissions. The maximum number submitted by an individual state was three responses and most of the multiple respondents only submitted answers for a subset of questions. Presumably the questions for which they were the subject matter expert for their state. Figure 3-3 shows the regional dispersion of the responses.

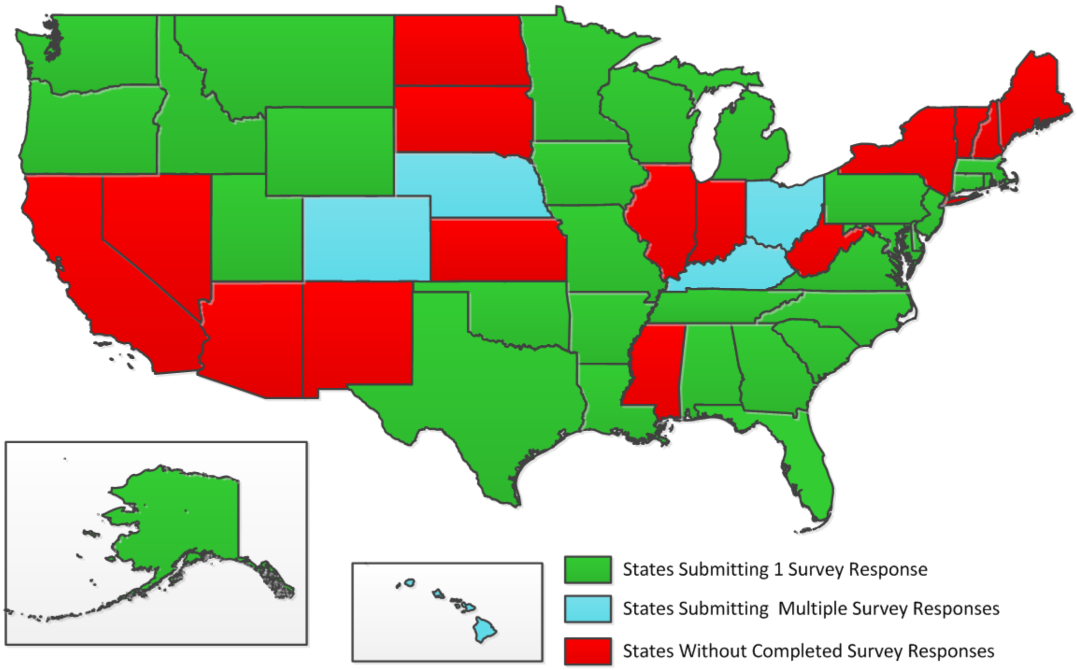


Figure 3-3.: Survey Response Dispersion

The survey results present some interesting findings and potential challenges for this research. Again, the objective of this research is to improve the understanding of the impacts and value in requiring geospatial locations within utility installation and relocation as-built plans. The survey results seem to indicate that the majority of STAs do not have documented processes for requiring or obtaining utility as-built plans. Additionally, the majority of those having a documented process for utilities to provide as-built plans do not stipulate accuracy or format requirements. In many cases, those managing as-built data requirements appear to lack understanding regarding what constitutes accurate data from a geodetic perspective. Further, the location information typically required of utility companies is associated with station and offsets for highway projects or with crude reference highway mile markers instead of geospatial coordinates properly referenced to an established geodetic datum such as managed by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). This would suggest that the information within the provided as-built plans lack standardization. This is reiterated by 81% of the responses to, "Are utility installation (or relocation) as-built plans required according to geospatial locations or accuracy levels?" was "No." The acquired responses led to the conclusion that the pool of STAs requiring utility companies to install or relocate facilities to known geospatial locations is low. The STAs which responded "Yes" to this question were Colorado, Georgia, Hawaii, and Utah. Interviews were conducted with three of these four STAs to review the underlying criteria for their required geospatial location data.

Another finding of interest from the survey concerns barriers to receiving as-built information from utility companies. Of the responses, 81% of the STAs indicated they routinely encounter barriers to obtaining utility as-built information from utility owners. The common barriers cited by utility owners to the STAs include: lack of resources, lack of information or record, protection of intellectual property, security protection under the Homeland Security Act, or that it was duplicating effort provided by the state One-Call (Call 811) system. The research team discussed these cited barriers and concerns during the study interviews and followed up with some utility companies to obtain their insight. The information obtained through the follow up indicates myopia and a resulting convolution of misperceptions and misunderstandings of responsibilities, purposes, requirements, efforts, and liability, which leads to mistaken fear and resistance by utility companies. The utility companies tend to dig in, using a myriad of excuses to thwart the perception that they are being targeted to assume substantial liability and take on high costs to produce precise high grade as-built plans.

However, an area of compromise between STAs and utility companies regarding acquisition and dissemination of as-built data seems easily attainable through:

- better communication between parties, and a fostering of mutual respect, concern and trust;
- educating on the myriad of proactive usages for reliable as-built data and how this is mutually beneficial;
- amicably addressing and resolving cited concerns with reasonable and effective solutions;
- implementing reasonable procedures and criteria regarding as-built data which are scalable and not burdensome; and
- establishing holistic accommodation policies that clearly reinforce joint usage goals which include asset management best practices for all infrastructure within public right of way.

Interestingly, and of significant relevance, the survey also revealed a stigmatic consensus among a number of STAs that the issue of obtaining and providing reliable as-built data on utility infrastructure is not the STAs problem, but rather it is the utility owner's problem. Moreover, the majority of the STAs felt that if issues result in STA right-of-way from lacking or inadequate utility as-built data, the resulting implications would fall to the utility companies in the form of litigation for damages, fines, revoked permits, delay costs, contractor claims, and required emergency relocations. Many STAs feel they have big hammers in their toolbox that can be brandished or employed to coerce utilities to respond to STA needs on projects. However, there is little documented evidence available to demonstrate that litigation, citations, or fines have been effectively imposed on utility companies as a result of their inability or failure to provide accurate as-built information. In addition, this strategy is reactive and not proactive or predictive, and results in otherwise avoidable costs to both taxpayers and ratepayers, who are effectively both the same and represent the public. This is another topic for future investigation.

From the responses gathered it was revealed that the STAs consider the issue of liability, legislation, and professional licensure as closely related with regard to utility as-built records. Most states (69%) currently do not require professionally sealed utility as-built plans; however, many (67%) believe they should. (Note: 10 of the 31 respondents indicated they do require professionally certified "as-built" utility plans; however, the researchers feel the majority of these confused certified "as-built" utility plans with professional subsurface utility engineering existing utility depictions prepared in accordance with ASCE/CI 38-02 standard guidelines, which require professionally sealed submittals.) For most STAs, legislative action is likely needed to require utility owners to provide professionally certified as-built utility plans. 63% of the respondent states noted they currently lack legal authority to require utility as-built plans to a specified accuracy level (which, to be compliant with existing state statutes and enforceable in courts would require appropriate and qualified professional certification). [Note: STA pursuit of legislative action to require utility companies to comply with certified as-built utility plans could create a backlash from the utility owners and their lobbyists. This happened when the City of Las Vegas tried to push legislation that would force utilities to comply with providing certified as-built utility plans. In the end the utilities cited homeland security reasons to reverse the legislation and prevent the City from ever requiring utilities to provide certified as-built drawings.] Very few of responders are pursuing damages resulting from inaccurate as-built data; the majority of STAs responding believe they lack appropriate legal authority to pursue related damages.

There were several themes that arose from the previously mentioned survey results which lead into the next stages of this research. The survey found that utilities are most often not required to design, construct or submit as-built plans according to geospatial location with any defined level of accuracy. Further, even where utility as-built plans are required, there is a lack of any standardization across all STAs. From the data gathered the research team is able to highlight the few states that have systems in place for collecting utility as-built plans to a defined accuracy or who are moving toward utility as-built plans with geospatially located features. Further investigation of these STAs will help to define the strategies they are implementing, lessons learned, and identify the effective practices which were successfully employed.

Interview Summaries

The completion of the survey highlighted state transportation agencies with varying levels of requirements for utility installation as-built plans. These findings were captured and summarized for the research advisory panel. With input from the advisory panel, transportation agencies of interest were highlighted for more detailed questioning in the form of interviews. The objectives of these interviews were to gain a more in-depth understanding of the implications departments of transportation might encounter by implementing utility as-built plan requirements involving geospatial level accuracy in the location of utility facilities. The research panel further highlighted a need to glean similar understanding from utility companies themselves. The response rate to interview requests from utility companies was much lower than that with the transportation agencies. However, the companies who did respond provided a much-needed perspective regarding the resource impacts they would face if geospatial requirements for as-built plans were implemented. The objectives of the interviews also entailed the desire to capture any associated cost or safety impacts regarding the lack of utility location data with geospatial accuracy. The interview questions for both the transportation agencies and utility companies are found in the appendices of this report. In the end, interviews were conducted with state transportation agencies in Colorado, Georgia, Kentucky, Michigan, Montana, Nebraska, South Dakota, Texas, Utah, and Virginia. Further, interviews were held with large telecommunications companies and a regional water company.

The findings from these interviews are summarized in the following. The questioning followed two distinct and separate scenarios for as-built plans data collection: 1) provided from the relocation of facilities during or as the result of highway construction projects; and 2) provided as part of permitted installations. The following interview summaries are arranged in alphabetical order.

Colorado

The Colorado Department of Transportation (CDOT) has very recently introduced an aggressive program for utility as-built data collection in regard to the level of detail and accuracy. This is driven by recent changes to their state legislation. Senate Bill 18-167, enacted in August of 2018, enhanced requirements for understanding underground facilities during design and prior to construction. The legislation incorporates compliance with the American Society of Civil Engineers (ASCE) Construction Institute's (CI) *Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data* (ASCE 38-02) during design stages of project development and **entails enforcement measures.** The legislation was in reaction to a gas line explosion in Firestone, Colorado (involving two deaths and additional injuries); the resulting investigation by the U.S. DOT Pipeline Hazardous Materials Safety Administration (PHMSA) noted existing laws did not include sufficient penalties for non-compliance with the One-Call (Call 811) System in Colorado. The new law drastically impacted CDOT's: 1) collection of information on existing utilities during the design phase of highway projects; and 2) approach to collecting as-built information from the utility companies with permitted installations and relocations on transportation right-of-way.

In terms of accommodating utilities, the Colorado Department of Transportation (CDOT) provides running lines or suggested alignments, locations, and sometimes shared (joint) trenches to which utilities can relocate during on highway projects; however, CDOT does not do this for newly permitted installations. **CDOT tries to incentivize utility companies for relocation activities by providing CDOT survey crews to assist with staking layouts when relocations occur prior to construction. They also have CDOT inspectors onsite to capture as-built data as the utility facility is relocated.** Although CDOT's goal is to complete most relocations prior to construction, some relocates must occur later as a coordinated effort with the highway contractor.

CDOT now collects geodetic coordinates, to specified horizontal and vertical accuracy, for utilities which are relocated as part of their highway projects. They also document relocations with digital photographs. CDOT also established a Construction Manager Utility Inspector role within their agency to collect this information, monitor the relocation plans and specifications, and provide coordination of the utility with the contractor. The location data collected is then provided to the contractor. They have been working toward a similar approach within their permitted utility installation process.

CDOT is implementing a GIS platform in which the collection of coordinate data is facilitated with an integrated software and hardware solution. The data is reportedly collected at survey grade accuracy and integrated with a GIS platform that can present information on 3D Google Earth®. This data collection effort is to be delegated to the utility companies and will be required for both utility relocations and permitted installations. CDOT has a goal to acquire data in this manner to meet QL B criteria in accordance with ASCE/CI 38-02 and the new statute (SB18-167) requirements for relocations; the required positional accuracy for this data is +/-0.15 feet horizontally and +/-0.3 feet vertically in reference to CDOT provided survey control points. These requirements will be firmed up in their state statute and policies which give them the authority to require as-built information on facilities installed within CDOT right-of-way.

Because the GIS platform allows for the collection of various types of facility metadata, CDOT is also collecting utility feature attributes such as pipe size, pressure, fiber count, or other details, all tied to one data set. One of the pieces of data that CDOT is collecting is the unit costs for the utility installation to conceptually be used to justify relocation estimates (something FHWA is pushing in their program review). However, CDOT currently does not have a system/policy/process in place that makes use of the unit cost data they are collecting. They also do not have established guidelines on data collection that specifies the details of everything that should be recorded.

The new platform data is anticipated to be used primarily by contractors but also possibly in planning and cost estimating of future projects, damage prevention, and future maintenance projects. There is a realization that without revisions, the data will degrade over time.

Because much of CDOT's new approach is mandated by law, they have not seen much hesitation or push back from the utility companies. The law also created a Colorado Safety Commission to rule on the gray areas of the law and deal with compliance complaints from contractors or utility companies. In terms of the utility companies providing data within the new platform (especially metadata), there have been concerns about propriety of information, data security, and liability of lesser quality data. CDOT is working with utility companies to achieve buy-in for the system because the objective of the approach entails benefits for all parties involved. As a final note on quality and liability, the Colorado statute now requires utility as-built plans to be stamped by a professional engineer or surveyor if the design of the utility was also stamped. While the original version of the bill required SUE QL A and a professional engineer's stamp, it was subsequently recognized that the objectives of the law could be achieved in a less restrictive manner than as originally prescribed.

Georgia

Georgia Department of Transportation (GDOT), like many of the other states interviewed, is actively working toward an as-built/permitted installation repository but there are many details to sort out. For traditional project relocations, there is not a system or guideline in place to collect utility as-built information to any kind of accuracy level. **They have implemented as-built requirements as part of their design-build specification and would like to compare those requirements to the anticipated ASCE standard for utility as-built plans** before moving to requirements on traditional projects. The hesitation comes from not knowing what information should be collected (especially in metadata) and how it would be used in the future. **A standard will help to provide clarity and consistency.**

GDOT has instituted a Georgia Permitting and Utility System (GUPS) that provides a portal for utility companies to submit permit applications, select locations of the permit from a GIS system, and upload planned alignments or as-built plans, but accuracy levels have not been defined for this repository. GDOT has found that utility companies vary in the level of data they collect about their own facilities. **In their experience, electric and gas amass good records while water, sewer, and to a degree, telecommunications companies collect poor quality data.**

GDOT has relied heavily on their SUE program to provide utility installation spatial and attribute information to roadway designers and contractors. They perform SUE on 70%-80% of their projects and most utility companies are receptive to this approach. The SUE providers are required to stamp the data provided; however, damages resulting from inaccuracies of locations are still found to be the liability of the utility company (assuming One-Call (Call 811) requirements are followed). The utility companies are less receptive to GDOT's utility as-built data requirements set forth in GDOT's design-build specifications. The utility companies want to know how the data will be protected and used in the future. GDOT has future goals for more detailed requirements of as-built utility plans but are awaiting the ASCE standard to help guide needs.

Kentucky

The Kentucky Transportation Cabinet (KYTC) is another transportation agency working toward improvements in the utility as-built information collected during their projects. Their current approach allows them to require as-built plans from utility companies performing reimbursable relocations. These as-built plans are usually provided as a PDF file without assigned levels of accuracy. The file is however uploaded to the Kentucky Utilities and Rail Tracking System (KURTS) and connected to the project file and alignment within a GIS database. Further, field inspectors have the ability to capture coordinates of the facility to be linked to the PDF file and pinpointed in KURTS. **Final billing can be withheld until the as-built plans are provided**. For no charge relocations however, there are times when final utility as-built plans are not submitted. KYTC also uses SUE as needed during highway project design. This data is used on the specific projects for which it was collected but is not usually stored in a fashion that is accessible for future reference.

As for new permitted utility installations, the Kentucky Encroachment Permit Tracking System (KEPTS) does not allow utility companies to upload their own information. Based on the permit application and any supplied plans or as-built plans (no specified accuracy requirements), a desktop derived geodetic point of reference is selected in the GIS system and attachment made to those supplied documents. In some cases, permit plans require professional stamping if the facilities installed require such stamping. These plans will later be called as-built plans, but the stamping is not certifying location accuracy.

KYTC is moving toward improve approaches to collecting, storing, and accessing utility related data. These initiatives started with the KURTS and KEPTS applications and they have been working toward a SHRP R01A system. **They have a 2D and 3D GIS database system setup, but utility companies have not been willing to provide their information stating their legal groups have advised against providing such information.** Unlike Colorado, their state legislation is not as firm in requiring this information and does not entail penalties for withholding the information. The data within the system have been collected in testing various technologies during relocation of utilities. The data has been collected by KYTC staff.

Michigan

In 2013, the Michigan Department of Transportation (MDOT) began a pilot approach to capture 3D geospatial utility information inclusive of system metadata. MDOT's Geospatial Utility Infrastructure Data Exchange system went through a successful pilot and recently completed a Proof of Program study in 2019. They also produced and refined a procedural manual through this process. **As part of GUIDE a utility that applies for a permit must also capture the location data of their facility to a survey-grade accuracy of +/- 5 cm as noted in the procedure manual.** The collected data is also required to be certified or stamped by a licensed surveyor and this is noted in the metadata. As a SHPR2 R01A approach, it is a very difficult product to implement due to a reliance on outside stakeholders, such as utility companies. The development of GUIDE has been a phased approach using various grants and consultant support while attempting to achieve buy-in along the development. The concept for GUIDE stemmed from Michigan's Utility Coordination Committee and was the suggestion of a utility company so location information could be provided upfront instead of through SUE. The idea was spawned from historic struggling with inaccurate utility data. The concept for GUIDE still has issues to overcome. The initial focus will be on new permitted installations (relocations will be added later) of larger more critical facilities (not service or minor lines). This focus is still expected to entail over 1,200 permits per year and likely require a full-time employee just for the quality control and review of the data input into the system. Utility data requirements are another concern as a published standard, such as that being developed by the ASCE, does not yet exist.

Other concerns are with the continued acceptance of the program from utility companies. While many utility companies have been supportive of the GUIDE initiative, there are companies with concerns about the security of the stored data, the intellectual property they want concealed from competitors, and the additional resources they would need to provide the data required by GUIDE. The pilot program utilized Federal funds to pay for associated survey operations; going forward the survey operations will either have to be funded by MDOT or the utility owners. MDOT is confident that the data security issues can be resolved but there is no question compliance will require additional resources for both the utility company and owner. It is believed the savings is in the enhanced safety and avoidance of underground facilities.

That said, the GUIDE approach is not fully adopted to date and the approach in-place does not entail the collection of utility as-built information to a geospatial accuracy. MDOT wants to be sure that prior to implementation the GUIDE system is vetted and as many programmatic issues as possible are resolved.

Montana

The Montana Department of Transportation (MDT) has recently implemented a very sophisticated approach and system for managing utility infrastructure installed within their right-of-way, while at the same time significantly enhancing their entire permitting application and review process. Through SHRP2 R01A implementation funding support, **MDT adopted their new and innovative Utility Permitting Administration System (UPAS) combined with a cloud-based Utility Location Data Repository Module (ULDR)**. By statutory requirement, MDT must participate in the costs to relocate public service utility infrastructure as required for MDT road and bridge projects; accordingly, MDT regularly spends a relatively large portion of their project development budget for SUE investigations and utility relocations. Although SUE is cost effective for providing accurate information which MDT uses to mitigate relocation costs, MDT recognized the added value of collecting and managing quantified utility location data and tying that to the permitting process. While SUE addresses the symptoms on a project by project basis, the routine collection of standardized utility as-built data on utility infrastructure as installed within MDT right-of-way will cure and resolve the bulk of the problem of not knowing where utilities lie.

Working with a consultant (Utility Mapping Services, Inc.) for this SHRP2 R01A implementation, MDT customized, configured and implemented a first of its kind commercial off the shelf system (GEO.works™) that: **1) streamlines the permitting, processing, and approval of utility installations and relocations, and 2) ties in, monitors and controls the right-of-way occupation, construction work, and collection of standardized as-built data on utility infrastructure as it is installed.** MDT uses the same general permitting process for both new installations and relocations which provides approximate locations of facilities installed in their right-of-way. In addition, they now have an online system for managing and tracking the status of an application that also facilitates the coordination, collection, management and sharing of as-built data as new and relocated facilities are installed. The ULDR metadata and attributes are based on ASCE's forthcoming "Standard Guideline for Recording and Exchanging Utility Infrastructure Data" (a.k.a., "utility as-built standard").

Initial thoughts were to require professional stamping of the data, but some utility companies noted significant resource constraints to meeting that requirement. This is one of several points where MDT and utility companies collaborated and came to compromise with a solution that was feasible for all. The ASCE utility as-built standard is a consensus standard designed to be scalable. Accordingly, MDT modified requirements so that when data are submitted a licensed surveyor **or** approved company representative attests to the accuracy of the horizontal and vertical positions acquired. The utility company than reviews the coordinate data and facility attributes (size, material, utility type, etc.) before submitting to MDT.

In accordance with the ASCE utility as-built standard, MDT's target accuracy is Accuracy Level 3 (+/- 0.3 ft) for horizontal positions and Accuracy Level 4 (+/- 1.0 ft) for vertical positions in congested areas. In more rural settings where there are fewer utilities and less potential for conflicts for newly installed or relocated facilities, MDT has elected to use less rigid accuracy levels for both horizontal and vertical positions. The annual cost of the system is largely supported by relatively minor fees paid by the permit applicants. The fee is considered worthwhile by utility owners as the application and approval process is much more streamlined and efficient, and paperless. It is anticipated that costs incurred by MDT for system implementation, operation, and data collection will be offset by improved application processing efficiencies, better management of new and relocated installations, advanced and improved coordination between adjacent and crossing infrastructure owners (instead of late term notification at the time of installation), more informed highway planning and design which allows engineers to avoid disturbance of underground facilities with future projects, and enhanced damage prevention during construction and maintenance operations.

Nebraska

The Nebraska Department of Transportation (NDOT, formerly Nebraska Department of Roads or NDOR) requires planned locations from utility owners as part of their permitting process and law. The level of detail submitted with these plans varies from simple schematic drawings to detailed and stamped plan sets as warranted by the type of utility facility to be installed. NDOT has been in conversation with their utility owner stakeholders on the topic of as-built accuracy and the responses have been varied especially in regard to the accuracy available for facilities installed by horizontal directional drilling (HDD). This is a point mentioned by many of the states interviewed. NDOT is expecting as-built plans from an upcoming installation of a large pipeline for which owner representatives stated would be highly accurate position data. NDOT is aware that as-built plan requirements are a concern which need to be addressed, but current focus is on their accommodation policy and the issues faced with small cellular and fiber optic installations.

South Dakota

The South Dakota Department of Transportation (SDDOT) by statute requires plans for permitted installations, but like other states the level of detail within these plans varies and there is not a requirement for geospatial accuracy. SDDOT does not specifically dictate where utilities should be located within their right-of-way, but in general, they are requested to installed as nearly as practical to the right-of-way boundary. For utility relocations, utility companies are to provide exhibit drawings without accuracy or geospatial requirements. These drawings are not considered plans but a representation for use in coordination with the highway project. The as-built plans or exhibit drawings collected are stored in permitting files for later reference in highway design projects. On an as-needed basis, the SDDOT utility coordinator, project designer, surveyor, or SUE consultant will collect geospatial utility location data to be incorporated into the highway plans.

SDDOT has had varying attempts to collect more accurate geospatial as-built data for utility installations. They attempted a pilot project in 2016 to collect utility as-built information to survey-grade accuracy in horizontal and vertical geospatial alignment. The utility companies were initially receptive to the concept but began to have significant concerns regarding proprietary data security and the costs of providing the data to the accuracy level desired. In the end, the pilot was ended before any data was collected as it was believed to be cost prohibitive. SDDOT additionally tried the collection of utility data using pipe and cable locating equipment (Vivax-Metrotech Spar 300™) which are integrated with global navigation satellite system (GNSS) survey instruments. This approach was also not long term. These attempts stemmed from a successful data collection effort performed by a SUE consultant for the Rosebud Sioux Tribe Water Line on Tribal Lands' right-of-way. The SUE plans were sealed by a professional engineer. Although test holes results did not match these the Spar 300 data in every case, they are still considered to be of fair (QL B) accuracy and effectively revealed where the water main lacked sufficient depth of cover along the alignment.

Texas

The Texas Department of Transportation (TxDOT) collects utility as-built information through a statutory requirement, but not to a specified accuracy or standard; the "as-built" files are typically submitted as a PDF. The locations of the facilities are typically referenced to project stations numbers or mile points and not geospatial accuracy. TxDOT often does not require utility as-built data to be stamped or certified, but it is an optional requirement as set forth within the permit statute. TxDOT's main concern is that by current practice there is not a repository for this information. Current practice entails the filing for the utility information drawings within permit files. There are occasions where location data is collected in a coordinated effort with highway project surveys or

SUE processes. Again, this data on existing utilities is not in a practical format for storage or access, but rather merely a plan depiction that is stored within permit or project files. TxDOT regards their SUE program as very beneficial and foresees the collection and management of accurate, standardized, accessible as-built data as being very useful. However, some previous attempts by TxDOT to request accurate location data from utility companies have been met with resistance due to stated concerns regarding security and liability.

Utah

The Utah Department of Transportation (UDOT) has been working toward an as-built utility data repository for some time but they currently have not made much progress with regard to implementation. In 2017, they revised their survey standards to include accuracy level requirements for utility as-built data. The approach loosely follows the draft ASCE "utility as-built" standard by specifying multiple accuracy levels which are defined to also align with ASCE 38-02 quality levels used for SUE investigations. UDOT is requiring accuracy and quality level specifications for all new installations and relocations, but they are still working through details regarding which party is responsible for collecting the data. They are also to provide a quality report for the collected data which includes verification of the corresponding survey observations, which technically and statutorily could require professional land surveyor involvement. The utility companies have noted that the level of detail and accuracy required is not useful to them (the utility companies) so there is concern that the accuracy of the data submitted will be less than desired. If UDOT will need to perform substantial quality assurance on the data that is collected, the situation could evolve to where it might be more appropriate for UDOT to simply collect the utility as-built data; however, that would entail substantial resources. For some fiber optic networks, UDOT has hired a consultant to collect the as-built data. Within UDOT design-build (DB) projects, the design-built team is responsible for collecting utility as-built data, though there have been situations for which the utility companies are not properly notifying UDOT DB contractors of their installation operations. Many utility representatives have noted that mapping grade data is sufficient in lieu of survey-grade data; however, this is a myopic assessment from an inventory and operations perspective. The concept of enhanced damage prevention, predictive 3D design, and expedited, cheaper construction with less risk for their own installation efforts in the future is getting completely overlooked.

To force things along, **UDOT implemented an administrative ruling that now allows UDOT to perform SUE investigations for collecting utility as-built information and back charging the utility companies if they do not provide compliant accurate 3D data themselves.**

UDOT's primary concern is not having a data repository in place. It is believed that the repository would be a great asset for permit and project planning, project scoping and alignment alternatives, and planning and validating SUE processes. Without the repository, collected data is not easily accessible and there are concerns the data would degrade (utility or highway maintenance and alterations) too quickly to be useful. The utility companies are also concerned about liability associated with their data. The survey manual does require the utility as-built data to be certified by a professional land surveyor, so there is question of whether the purported accuracy of the data has any meaning and can be accordingly utilized as desired. UDOT is considering the relaxing of certification criteria to ease liability and cost concerns professed by utility representatives. UDOT's current goal is to collect the most accurate data possible; liability is not their primary concern at this point.

Virginia

The Virginia Department of Transportation (VDOT) attempts to have a strong partnership with utility companies who occupy their right-of-way. When possible, they acquire easements for the utility companies requiring relocation due to their highway projects and suggest locations within their right-of-way where feasible. The relocation plan and estimate is provided to VDOT. Some utility companies include high-quality information, even cross-sections, while some struggle to deliver even CAD produced plans; sometimes only hand drawn as-built plans are provided. VDOT consolidates all of this information into their highway plans. They also perform survey staking to help utility companies perform their relocation construction.

VDOT requires utility owners to submit both initial plans and as-built plans for newly authorized and permitted utility installations, but these are much less detailed than the requirements for relocation as-built drawings. For underground relocations, VDOT has utility inspectors who perform vacuum excavations along identified underground facilities at 25-foot increments. The data is provided on an informational plan set to contractors, and not as formal SUE submittals or certified records that are sealed by a professional land surveyor or engineer of record. Also, while initial existing utility depictions are on plan sheets provided with bid documents, utility as-built plans for relocated utility infrastructure are not provided to the highway contractor until after the project is awarded. The utility "as-built" data collected varies and is without defined accuracy. For horizontal directional drilling (HDD), VDOT inspectors collect observation information at the bore entry point and from the bore head at regular intervals. The inspectors also collect positional data on overhead facilities to a purported accuracy of +/-1 foot.

VDOT also is well-known for their radio frequency identification (RFID) marker ball program. The expense for this program has shifted from VDOT to the utility companies in recent years. The data has been an asset to both VDOT and the utility companies. All of the data is collected and stored in VDOT enterprise filing system (Bentley ProjectWise). There has been some resistance from utility companies to provide data with concerns of security and competitive advantage. **Most utility companies have been willing to provide data under confidentiality agreements with VDOT and VDOT maintains anonymity of facilities on plan sets as much as possible**. VDOT has been successful procuring utility company data based on the relationships they have built with utility company partners. **The remaining concern utility companies have in providing as-built data is in resource constraints** based on the number of projects requiring relocations; VDOT accordingly tries to assist by prioritizing projects for them as much as possible.

Overall Department of Transportation Feedback

The consensus from the STAs in regard to collecting and managing geospatially accurate and standardized utility as-built data is that it would provide many beneficial uses. These benefits are contingent upon a standardized approach (potentially a solution provided from the forthcoming ASCE standard), a repository system for collecting and easily accessing the data, and an approach to update, revise, or understand the quality of the data. This data could be used in planning, design, utility avoidance, utility coordination, construction, and maintenance among other functions. The key concerns highlighted are the resource requirements (cost and staff) and potential resistance from utility companies with data security, proprietary nature, and liability cited as concerns. Many of the DOTs noted that utilities had concerns of security, their own resource requirements, protection of the intellectual property or facility details, and many have cited restrictions by the Homeland Security Act. However, this research effort included a review of the Homeland Security Act which yielded the conclusion that there aren't any restrictions within the Act which preclude STAs from collecting and managing utility as-built data for infrastructure located within their right-of-way other than taking appropriate measures keep the data to secure. Subsequent interviews with utility companies were conducted to learn more about the identified hesitations to providing geospatially accurate as-built data.

Utility Company Feedback

Several utility companies representing varying services were contacted for interviews; however, only three representatives agreed to discuss details associated with this research. The interviews were conducted with two large telecommunication providers and one regional water company.

Telecommunications Company 1 (T1) noted they do not collect facility "as-built" information with geospatially accurate coordinate data. They also do not employ CAD technicians to depict facilities on their plans or highway plans. Their above ground facilities are mapped and connected by vector representations between the above ground points which identify connectivity, but not necessarily correct alignment orientation. This is the information input for the One-Call (Call 811) system polygons. T1 uses a spatial viewer software to access utility records with rough geospatial referencing, but it is not considered to be spatially accurate or even a GIS asset management system. **Their most accurate data has been collected by the DOTs themselves through SUE or other means and**

provided back to T1. T1 is able to store SUE and other utility information acquired and provided by others within their spatial viewer. T1 voiced several concerns regarding the prospect of DOTs requiring geospatially accurate as-built data. First, there were minor concerns regarding data security and that some secure lines could not be shared due to the Homeland Security Act. However, **the biggest concern T1 had was in the cost and staffing resources it would require to collect and manage geospatially accurate as-built data**. T1 simply does not have staff, let alone staff with appropriate skills, available to acquire geospatially accurate survey data on their utility facilities. Based on their current understanding, T1 feels providing such information would require them to incur significant costs. However, T1 did believe geospatially accurate as-built data could be useful and, with more and more fiber optic installations, could eventually become a necessity.

Telecommunications Company 2 (T2) has recently transitioned to a software platform for depicting installation positions. They were representing their locations on hand drawn plats but now are manually creating digital depictions of their facilities. However, the system is not GIS, and the depictions do not include geospatial coordinate information. Drawings are not to scale, and spatial referencing made to their own above ground facilities. They avoid reference to the road or other surface features as those can change without their knowledge. The drawings are marked-up in the field with actual footage of material, but that information is not supplied to the DOT. If geospatially accurate as-built data becomes a requirement, T2 cites their main concern to protect their proprietary information. The telecommunications industry is very competitive, and they do not like sharing details of their facilities. The cost of collecting and providing the information is also a concern due to the expense of surveying. T2 also believe geospatially accurate as-built data for their facilities is beneficial, but the perceived costs to achieve that are considered high. T2 also stated they would require significant assurance that data on their facilities shared with an STA will be kept secure and protected from competitors.

The Water Company for the past 10 years has used a GIS system for managing as-built data. They collect asset data which includes lengths and fittings; the spatial component of their as-built data is non-survey grade GNSS coordinate data observed at regular intervals and junctions or turns. Their primary focus is to record horizontal coordinate data; however, noted depths or elevation data is documented as deemed important. Their GIS system also provides access to as-built drawings that could be CAD produced or hand drawn. They have attempted pilot efforts for capturing vertical information (i.e., depth or elevation) of facilities, and achieving improved spatial accuracy; however, the company is not seeing the benefit from collecting and managing this additional and more highly accurate data. The Water Company also feels that a requirement to collect standardized and geospatially accurate as-built data will require them to incur substantial cost in equipment and staff. However, The Water Company believes having such data could be of benefit to many stakeholders. Their main concern is the expense to them. They are comfortable providing their location data assuming it would be exempt from open record requests through the National Freedom of Information Act.

Barriers and Implications for Utility Companies and STAs in Requiring Utility As-Built Plans at Specific Geospatial Accuracy

The investigation of barriers and implications to the possible requirements for installing utilities to specific geospatial accuracy evolved through the course of this study. The survey and interviews pointed to a need to better understand the utility as-built development process and what implications or barriers geospatial accuracy might include for requiring as-built plans to this accuracy. In terms of STAs requiring locations or relocations in specific areas according to a geospatial accuracy, the research found most STAs did not take such actions, and that the most an STA would do is suggest locations for new installations or relocated facilities. **In short, STAs are doing very little to actively manage and control a wide variety of utility infrastructure which exist or are being installed within their right-of-way, and yet utilities are documented as a leading cause for project risk, escalated costs, and unplanned project delays.**

The STA representatives interviewed are of the belief that simply knowing a utility's final location as submitted in as-built documents is of the greatest importance. A central goal to this research was the identification of barriers and implications faced by STAs to require utility as-built plans with geospatial accuracy. A host of sources including the project survey, formal and informal interviews, and analysis of public datasets (as well as some company internal data) was used to achieve this goal. The following presents implications and barriers along various categories for consideration.

The survey found that 81% of the respondents noted difficulties in acquiring as-built information of any level of accuracy from utility companies. The issues cited are summarized in Figure 3-4.

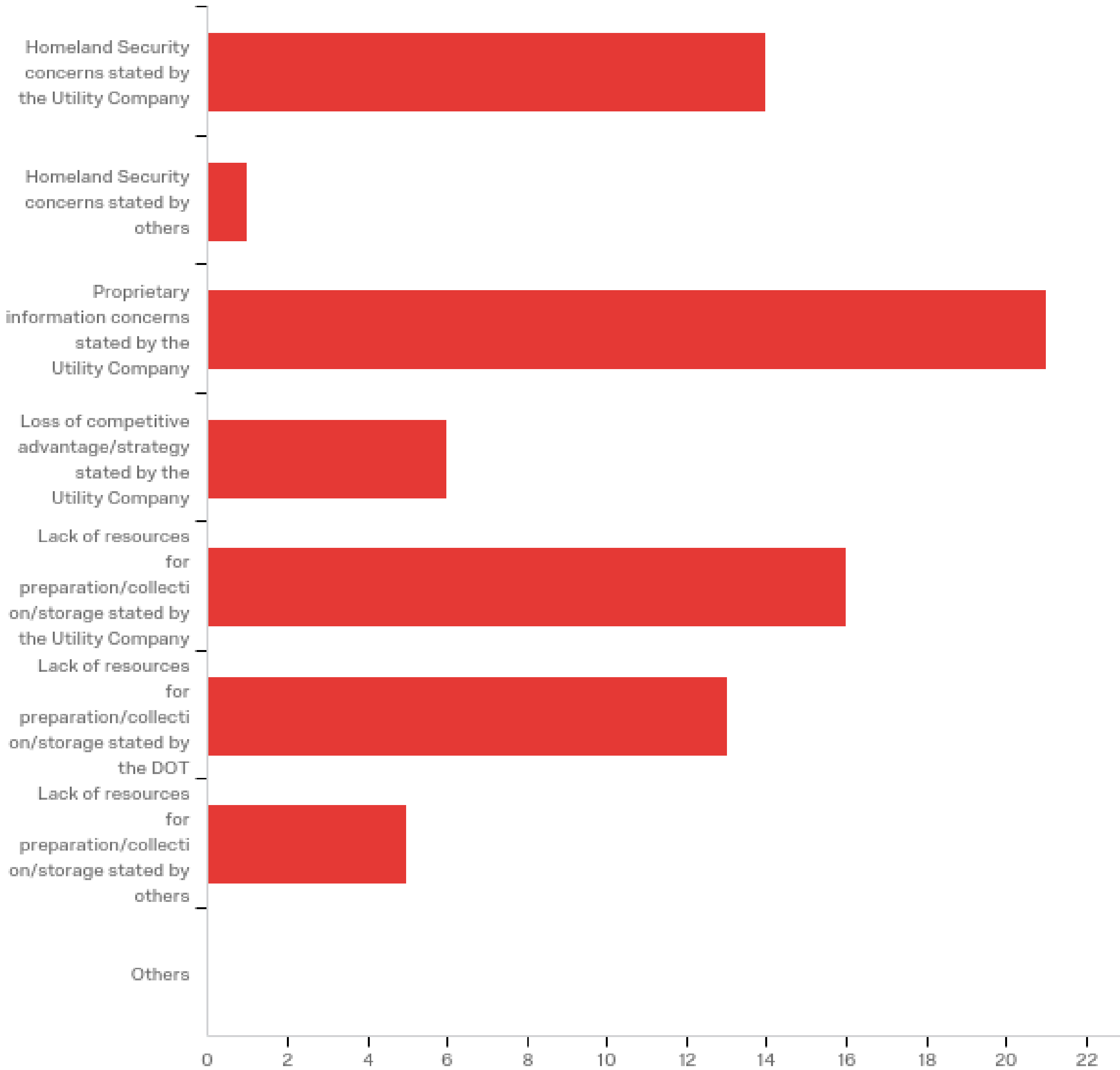


Figure 3-4: Survey Responses for Cited Barriers to Acquiring Utility As-Built Data

Top three barrier areas, ranked from the survey, are proprietary information concerns (top), resource concerns, and concerns of Homeland Security Act infringements. These align with the feedback of the interviews with the utility companies, though the ranking of concerns seemed to vary based on the competitive nature of their services. The telecommunications companies, a very competitive industry, were quick to note concerns of the proprietary nature of their systems, while they were minimally concerned about Homeland Security Act infringements. The water company, with very little if any competition, had less concerns about the proprietary nature of their system but were slightly concerned with the Homeland Security Act. Informal discussions with gas companies, a semi-competitive industry, revealed their concerns were more in regard to security of their system and some proprietary information concerns. They did note that they felt the Homeland Security Act supported their concerns regarding security. However, all companies noted that the concerns of proprietary information and the Homeland Security Act could be resolved through agreements with STAs that would protect their information from public information requests and contractual assurances for the security of the information. A noted concern of all interviewees for collecting geospatially accurate utility as-built information is the cost and resources necessary to collect, store, manage, and update that data.

Personnel and Resource Implications

As just mentioned, one of the most concerning implications for collecting geospatially accurate utility as-built information is the additional personnel and technology required for this collection. These concerns were highlighted in formal and informal interviews with not only utility companies but also STAs. The concerns were also not only about the resources needed for collection, there were also storing, managing and updating this information.

In interviews with utility companies, their top concern was the personnel and technology needed to collect this information while completing their installation. They believed they would essentially need a survey crew to accompany their installation crews which would be extremely costly. While at some accuracy levels this might be the case, there are many technology alternatives capable of allowing field installation staff to collect reasonable and useful levels of accuracy with minimal training. Additionally, the purchase of this type of equipment is becoming much more reasonable, in the range of several thousand dollars for mapping grade capability, and several hundred dollars for uncorrected GNSS grade data, which, in the scheme of things, is a relatively minor incidental cost. Even if an equipped professional survey crew was required at $120-$150 per hour, the costs are merely one side of the equation.

Geospatially accurate as-built utility plans would be extremely beneficial for quickly locating facilities (within the One-Call notification process), as well as communicating positions to STAs, engineers, and contractors alike. Accurate and readily available location data will enable STAs to execute better asset management strategies, accommodation practices, and planning which in turn will result in fewer relocations. There is a wealth of studies on SUE practices which prove that accurate as-built data provided early in design phases of projects enables designers to avoid conflicts within design, and moreover reduces project risk and enhances damage prevention during construction. Geospatially accurate data in a standardized format can also lower costs for One-Call (Call 811) location services during design stages, and will help contract locators do their work more efficiently during construction. Further, in-terms of technology, SUE firms are already providing data repository services which simplify the collection, storage and upkeep of location data. The resources needed for storing this information are relatively small and are often cloud based, offering flexibility and ease of sharing with STA partners and others. Guidance on implementation of these systems or other approaches for collecting geospatially accurate utility as-built data is a topic for subsequent study.

The added personnel resources needed to collect, store, maintain and update utility as-built data is believed to be minimal as off the shelf technologies can enable existing staff to perform this work during installation operations. While a discussion of resource costs will be provided in a subsequent section of this report, it is important to note that most experts in this subject matter concur that benefits from having geospatially accurate utility as-built data dramatically outweigh costs. This sentiment is agreed upon by Quiroga et al, (2018) who likened the approach's ROI to that of SUE implementation, for which five independent studies have documented between 3:1 and 6:1 ROI.

Additional research is needed to investigate and develop guidance for the collection, storage, and management system to present an approach that meets the needs of both utility companies and STAs. This need is highlighted from discussions with STAs who don't grasp or are leery of their need to be involved in collecting and storing asset management data for other companies (utilities). The approach borne to date by STAs is inadequate and due to: 1) poor, non-standardized, spatially inaccurate records collected by utility companies occupying public ROW, and 2) a belief STAs lack authority to require utility companies to help fund, implement and sustain a utility as-built data management system. This discussion is evidence for needed guidance, and also points to a need to understand costs currently borne by STAs as a result of current practices, or lack thereof, for managing utility facilities within STA ROW. However, this study did reveal that STAs unanimously believe there is value in having geospatially accurate as-built data on utilities located within their ROW.

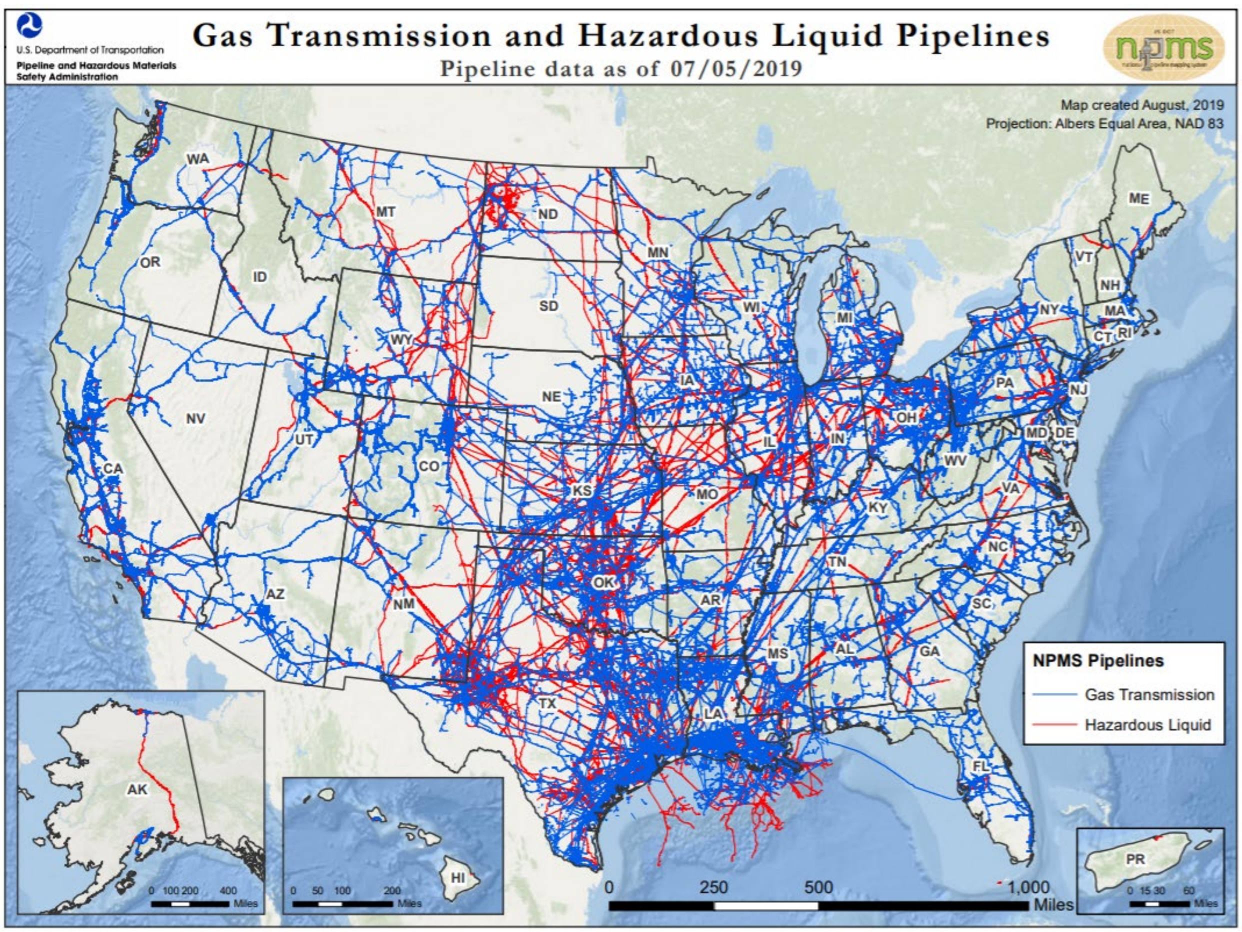
As achievable from acquired information, a quantifiable comparison of costs and benefits is discussed in the Discussion of Costs and Benefits in Regard to Requiring Utility As-Built Plans at Specific Geospatial Accuracy section of this report, yet from a qualitative standpoint, considering the costs (collection, storage, management, and updating) and benefits (avoidance, better designs, reduced relocates, advanced coordination, reduced risk, tighter bids, expedited construction schedules, less public and commercial disruption, enhanced damage prevention, implemented asset management strategies, improved and more efficient Call 811 contractor locates, etc.), there is value to be reaped with collecting utility as-built information with geospatial accuracy.

Security Implications

Security concerns of utility locations often are reported as potential infringements of the Homeland Security Act. As noted in Appendix E, a review of the Homeland Security Act was conducted within this study. There is no question that the security of our utility infrastructure is vital to our national security, just as our highway infrastructure is; however, the sharing of location records with STAs is not an infringement of this Act. Measures can be taken to ensure the security and protection of this data within the STAs. Waivers can be put in place to protect this data from being shared publicly or with other entities without permission of the utility owner.

Beyond these protections, many facilities already have their locations publicly available to some level of minimal accuracy as found on water distribution websites and the Pipeline and Hazardous Materials Safety Administration, Figure 3-5 (https://www.npms.phmsa.dot.gov/). The fact is, as was confirmed with conversations with utility companies, utilities can be provided assurances from STAs through written data agreements that alleviate data security concerns. Utility representatives quietly noted that the Homeland Security Act is cited as an excuse rather than a legal constraint. Utilities are primarily concerned with the security of their own facilities and the proprietary nature of some of their systems.

Figure 3-5. Pipeline and Hazardous Materials Safety Administration Gas Transmission and Hazardous Liquid Pipelines Map



Proprietary Information Protection Implications

The proprietary nature of their facilities was highlighted as the top concern for utility companies in regard to providing geospatially accurate as-built plans to STAs. This was of extreme concern to the telecommunications companies as they are leery of the additional metadata that might be collected with their location and how that could be inadvertently shared with competitors during projects. While the proprietary nature of telecommunications, and some other facilities, is a concern, most felt it could be resolved with proper data agreements, limiting sharing of information, and limited the metadata collected. Further investigation of this implication is needed to develop guidance around these concerns.

Cost Implications

The crux of this study is to determine if requiring utility companies to collect geospatially accurate as-built data on their facilities is a value adding effort. To make this determination, one must synthesize relative scenarios of qualitative reasoning and quantitative observations. It is difficult to determine and assess all the beneficial applications in which geospatially accurate utility as-built data could be utilized for highway and utility industries. It is also challenging, albeit less complex, to determine and assess all the impacts and costs entailed in requiring such data. The next sections of this report will attempt to delve into several scenarios regarding the costs and impacts of requiring geospatial as-built plans from utility companies. This assessment will begin with a discussion of damage prevention potential and follow with costs associated with collecting geospatially accurate utility as-built data. First, to assess damage prevention potential, it is important to understand the current data on utility damages and strikes reported through the Common Ground Alliance’s Damage Information Reporting Tool (DIRT report).

Damage Prevention Implications

Originally formed in 2000, Common Ground Alliance is a voluntary association of 1,700 organizations (including many utility owners), individuals and sponsors in every facet of the underground utility industry. The 2018 Damage Information Reporting Tool (DIRT) report published in August 2019 reviewed 440,749 reported damages in the United States and Canada. DIRT data entry forms for reporting incidents include check boxes to indicate if locating was a root cause and to describe why locating was not performed or was not executed inaccurately. (15)

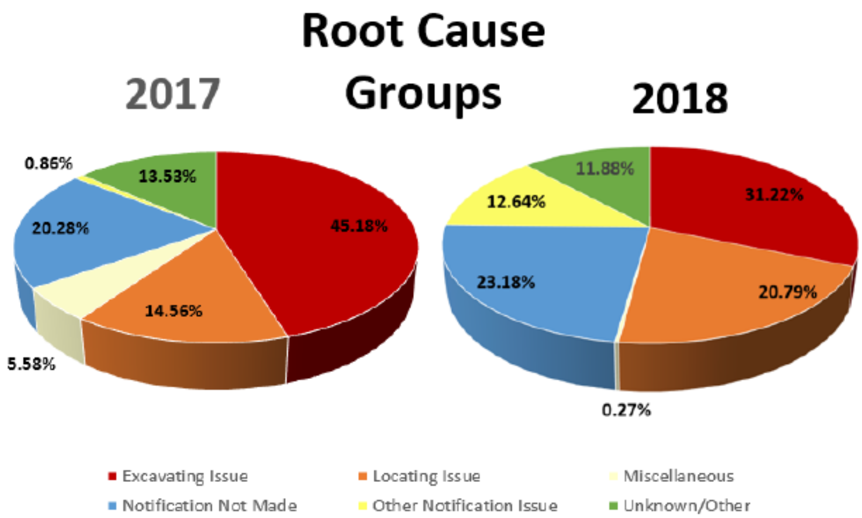
In the 2018 DIRT Report, the Root causes for damage to utility infrastructure are divided into six “Root Cause Groups” shown in figure 3-6. “Locating Issues” caused nearly 21% (70,859/year) of the strikes on utilities; it is reasonably conceivable that access to spatially accurate utility as-built data could greatly eliminate these strikes. The “Locating Issues” identified include:

- operator error
- unidentified “bleed off”, secondary inductive currents, EM distortion, or errant tracer current flow along common/bonded ground line
- undocumented and misleading abandoned facilities
- crude, schematic level records which lack geodetic referencing
- inaccurate or incomplete records
- tracer wire damage
- poor signal to noise conditions resulting from facilities that are too deep or hidden within or beneath a congestion of other buried infrastructure

The “Root Cause Groups” categories, while not literally identical, generally align with those discussed in Tables 3-1 to 3-5. **If geospatially accurate as-built data were acquired at the time of installation, the contract locator responding to the Call 811 notification could use survey technologies, such as GNSS, along with augmented reality to navigate to where the pipes and cables that require marking are supposed to be buried to help verify locating efforts. In addition, new technologies which record locator field marks can enable others, such as supervisors, to verify field locating efforts. Moreover, contractors could utilize augmented reality and other**

technologies to further check locator efforts, and use machine guidance technology to prevent accidental strikes on known buried infrastructure. In short, new technologies which can utilize accurate utility as-built data will eliminate many if not all of these "Locating Issue" incidents.

Figure 3-6. DIRT Report Root Cause Distribution



Another "Root Cause" that could potentially be addressed by having geospatially accurate as-built data is the "No Notification to One-Call (Call 811) Centers" at 23% or 79,179 reports. Many projects are first designed by engineers who try to obtain record data for all identified facilities within the project area to avoid conflicts with existing utilities during design development. These records are nearly always two dimensional line drawings, non-standardized, often simply photocopies or scanned images of large scale printed plans, not updated and incomplete, crude schematic format that lack real geodetic referencing and coordinates, and often mis-leading for design and subsequent construction use. Geospatially accurate as-built data properly depicted in CAD reference files would allow engineers to develop designs and specifications which: 1) avoided conflicts or risk prone situations; 2) enabled engineered solutions and advanced coordination that assured appropriate protect-in-place measures are included in special provisions and detailed drawings for work in close proximity of existing infrastructure; and 3) clearly presented existing utilities and proposed construction activities in the Plans, Specifications, and Estimates (PS&E) documents so contractors could appropriately plan, bid and execute the work with minimal risk of strikes. Moreover, as mentioned earlier, contractors could check Call 811 field markings against plans (or increasingly utilized 3D BIM models) to verify facilities have been properly flagged.

"Root Causes" associated with "Excavating Issues" and "Other Notification Issues" would also be reduced by the availability of accurately georeferenced as-built data for developing proactive designs and including on plans, 3-D CADD and BIM models, and other reference documents supplied as part of preliminary engineering plans and documents.

In conjunction with the most recent release of Common Ground Alliance's DIRT Report, there was a release of their raw data for 2017. This dataset allowed for a slightly deeper analysis of the information collected through the DIRT and included a summary according to the number of dig-in events, repair costs, excavator downtime costs, outage durations and customers affected, the facilities affected, work involved, and other factors. This data is organized along the practices identified as the root cause for the dig-in event. The data provided spanned between 2007 through 2017. Through analysis of this data, the following tables report the number incidents, repair costs, excavator downtime costs, and hours of service interruption. The research team focused on the "Root Cause" of "Locating Practices Not Sufficient" because these incidences would largely be eliminated if geospatially accurate as-built data was available.

Table 3-1. Number of Dig-In Events with a Root Cause of Location Practices

No. of Incidents Due to Location Practices	2017	Avg 2007-2017
Markings/location not sufficient	28,491	18,571
Facility not found/located	1,889	2,635
Incorrect facility records/maps	5,932	2,698
Facility not located/marked	10,361	6,775
Locating Practices Not Sufficient (Subtotal)	46,673	30,679

Table 3-2. Estimated Repair Costs for Dig-in Events Resulting (Location Practices)

	2017		*Average 2007-2017*	
	Min	Max	Min	Max
Markings/location not sufficient	$ 11,706,311	$ 38,668,168	$ 8,539,449	$ 26,251,524
Facility not found/located	$ 776,226	$ 2,564,021	$ 1,211,673	$ 3,724,861
Incorrect facility records/maps	$ 2,437,220	$ 8,050,602	$ 1,240,453	$ 3,813,335
Facility not located/marked	$ 4,257,002	$ 14,061,685	$ 3,115,343	$ 9,577,025
Locating Practices Not Sufficient (Subtotal)	$ 19,176,759	$ 63,344,475	$ 14,106,918	$ 43,366,745
Average Per Reported Incident	$ 410.87	$ 1,357.19	$ 459.83	$ 1,413.57
Average Per Incident with Damage above $0	$ 848.72	$ 2,803.50	$ 933.41	$ 2,869.43

Table 3-3. Estimated Downtime Costs for Dig-in Events Resulting (Location Practices)

	2017		*Average 2007-2017*	
	Min	Max	Min	Max
Markings/location not sufficient	$ 293,953	$ 799,200	$ 2,934,744	$ 8,250,331
Facility not found/located	$ 19,492	$ 52,994	$ 416,414	$ 1,170,650
Incorrect facility records/maps	$ 61,200	$ 166,391	$ 426,305	$ 1,198,455
Facility not located/marked	$ 106,896	$ 290,629	$ 1,070,647	$ 3,009,868
Locating Practices Not Sufficient (Subtotal)	$ 481,540	$ 1,309,214	$ 4,848,110	$ 13,629,304
Average Per Reported Incident	$ 10.32	$ 28.05	$ 158.03	$ 444.26
Average Per Incident with Damage above $0	$ 1,637.06	$ 4,450.85	$ 862.77	$ 2,425.47

Table 3-4. Estimated Service Interruption Hours for Dig-in Events Resulting (Location Practices)

	2017		*Average 2007-2017*	
	Min	Max	Min	Max
Markings/location not sufficient	25796.9	48967.2	36004.6	64011.6
Facility not found/located	1710.5	3246.9	5108.7	9082.7
Incorrect facility records/maps	5370.8	10194.8	5230.1	9298.4
Facility not located/marked	9381.0	17806.9	13135.1	23352.6
Locating Practices Not Sufficient (Subtotal)	42259.3	80215.9	59478.6	105745.2
Average Per Reported Incident	0.9	1.7	1.9	3.4
Average Per Incident with Serice Loss	2.5	4.7	4.8	8.6

These tables reveal that rectifying just one "Root Cause" for utility strikes provides highly significant reductions in damages and outages. Most relevant to the cost assessment are direct costs associated with repairs for the "dig-in" (i.e., utility strike) events (Table 3-2). There is apparent validation in these numbers based on the study by Metje (2015) (16) in the United Kingdom. Table 3-5 presents those findings converted to US $s.

Table 3-5. Estimated Direct Repair Cost of Dig-In Events by Facility Type

Utility Facility Type	*Estimated Average Direct Cost of Strike*
Electric	$1,300
Gas	$650
Telecommunications	$550
Fiber Optic	$3,800
Water	$400-$1,350

Further, Makana et al (2016), found the **actual total costs of a dig-in events** (direct, indirect, and social) **are roughly 29 times the direct repair costs**. According to these estimates, the DIRT report data would suggest **average dig-in events associated insufficient location practices cost between $12,000 to $82,000**. **If the practice of collecting geospatially accuracy utility as-built data could reduce the location related dig-in events by even 10%, it could save the industry up to $250,000,000** (10% x 30,000 events/year *Table 3-1* x $82,000). Being that Makana et al (2016) noted one company saw a reduction in dig-in events by 45% just from using active locating technologies, a 10% reduction stemming from geospatially accurate as-built records seems conservative.

Several large contractors have noted that 70% of their utility strikes are on new infrastructure that they themselves had installed during large construction efforts, but for which geospatially accurate as-built data was not acquired. Accordingly, records were not available for One-Call notified contract locator services to use for their field marking efforts, and as-built plans were not available for contractors to utilize within the duration of the project construction effort. This highlights the need to collect accurately georeferenced as-built data during project construction, as well as the need to have an ever-evolving project plan set that is referenced before digging.

Michigan's GUIDE program offers additional supporting information on construction projects in their 2014 Pilot Initiative report that is directly applicable to the above discussion (17). These cases are detailed in the following:

The AT&T project on M-17 included only 125-feet of fiber cable installation. Prior to construction, AT&T had a contracted "utility-locating" company to mark the existing AT&T communication line in response to a ticket request through Michigan's One-Call notification system, MISS DIG. Using locating equipment, the locator marked the AT&T facility in the field; however, the utility was marked incorrectly. It has not been determined if the incorrect markings were the result of operator error or inaccurate readings from the locating equipment; however, because of lacking accurate geospatial as-built data, there was no way to identify before starting construction that the utility was improperly "located" and marked out in the field. Construction crews relied on the field markings and proceeded with excavation activities; consequently, the mismarked utility was hit by the contractor.

An AT&T claims group will now expend resources to investigate the circumstances leading to the cable cut. If the cable was located incorrectly, then a claim will be filed against the contracted "utility-locating" company. If it was determined that the contractor was at fault, a claim will be filed against the contractor's insurance for AT&T's additional cost and lost revenue due to service outages. It is conceivable that AT&T may be at fault for not "accurately" documenting their installations in accordance with Michigan DOT permit requirements. Currently for this project, it is unknown what these additional costs are in real dollars, but it can be speculated that a significant amount of personnel resources, contractor resources and the potential for lost revenue due to service outages could have been avoided if the utility-locating company had access to and made available accurate geospatial information on the utilities it was field locating. Had the locating company been provided accurate geospatial information, conceivably the field-located utilities would have matched the known position of the utility as it was depicted on the design plans, and all parties would have had a high-level of confidence that all the utilities were marked and marked accurately in the field.

Similar to the AT&T project, the DTE Gas Company gas main relocation project at Fort Street and Gibraltar also had additional construction time added to the project due to the lack of accurate geospatial data on the existing gas main. The problem with much of the existing utility records data is that it is generally referenced by measurement data to an existing land base feature (e.g., distance from curb), as was the case with the Fort Street project. This is a common scenario with the internal records of most utility companies. The specific problem is attributed to land base information changing because records are not proactively maintained to accommodate land base changes (e.g., street widening), and land base changes occur without the knowledge of the utility company's records group. DTE has internal records that showed the 12-inch high-pressure gas main relative to the Fort Street right-of-way; the right-of-way at Fort Street had changed, but DTE's land base had not been updated to reflect this change. As a result, the contractor spent one additional day on site simply trying to find the 12-inch high-pressure gas main that he was contracted to relocate per the design plans. This is a common problem with records systems based on land base information. For this report, we were not able to obtain the actual additional cost to the project that was incurred because additional time spent by the contractor. However, it is relatively easy to foresee a much larger issue arising from other excavation work, unrelated to the gas main, which could have been carried out in that proximity.

The DTE Fort Street project is a very good example of the value achieved with obtaining geospatially accurate coordinate data (e.g., geodetic coordinates tied to the NOAA NGS National Spatial Reference System) for utilities instead of relative land base feature referencing. Accurate absolute geodetic coordinates essentially do not change and provide reliable referencing year after year; moreover, with today's technologies, referencing to a published and maintained geodetic datum is relatively simple and inexpensive.

The previous discussions examined costs for not having accurately georeferenced utility as-built data; the following will estimate costs associated with collecting this coordinate data with geospatial accuracy.

Cost of Collecting Geospatially Accurate Utility As-Built Information during Installation

The question of costs to collect geospatially accurate utility as-built data requires a deeper discussion of the typical underground installation methods used by utilities. For the purposes of this study, the research team considered two versions of open trench installation (flexible versus rigid) and horizontal directional drilling (HDD). The open trench installation entails a threshold of surveying skills to collect accurate observation data. These approaches and methods involve survey grade GNSS equipment to record direct observations or involve a combination of GNSS and LiDAR or photogrammetric methods for remote observations (e.g., utilizing drone or mobile platforms).

Costs to Utility Companies

Table 3-6 shows a comparison of land survey costs at the time of installation (which can generally provide +/- 0.1 feet accuracy in 3D / x,y,z coordinates) versus the costs of a SUE provider to perform investigative work long after the installation effort to reestablish the facility alignment, largely in 2D, through SUE Quality Level B data. Due to inherent limitations of geophysical methods and other uncertainties, QL B is not always achievable, moreover, cannot be assigned a statistical accuracy tolerance, but, as a rule of thumb, is generally within +/- 1.0 feet in 2D / x,y coordinates.

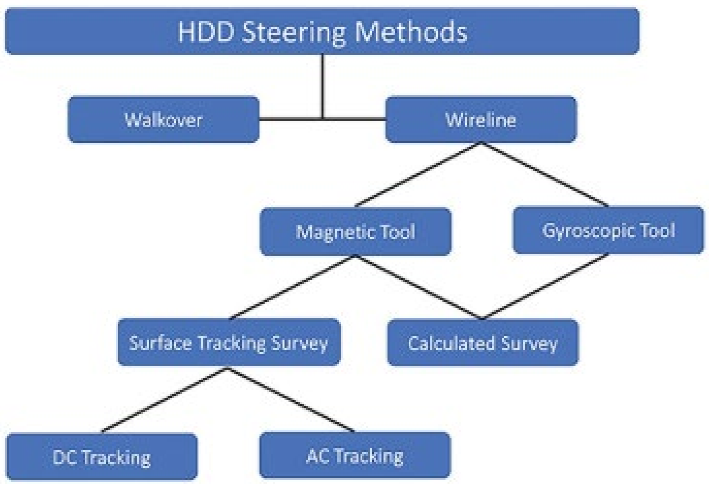
Collecting the statistically very accurate (+/- 0.1-feet) 3D survey grade data at the time of installation requires 10 to 20% the cost of collecting the less "accurate" SUE 2D Quality Level B data after installation; this is just for data collection efforts and does not account for all the untapped value from just having standardized, geospatially accurate utility as-built data always and readily available. If uncorrected handheld GPS or cellular phone technology devices were used in lieu of traditional survey methods, the cost to collect geodetic coordinates could be significantly less, although there would be varying and likely undocumented losses of accuracy, especially in "urban canyons" and beneath tree canopies where satellite coverage is limited. Still, the value of this lower grade geodetic coordinate data is far superior to not having any geodetic data. Regardless of who is paying for SUE or for survey services, it is much more efficient, accurate, cost effective, and with greater ROI to survey utilities at the time of installation; moreover, because the rate payer and taxpayer are the same, it is from a community perspective and public welfare and safety stance, much more responsible for ROW agencies and utility owners to have utility facilities surveyed at the time of installation. Please note, just as geospatially accurate utility as-built data can enhance, **but not replace**, One-Call (Call 811) damage prevention efforts, SUE investigative efforts should not be replaced; however, SUE can be improved and costs significantly reduced as the SUE engineer can readily import the data, employ a variety of geophysical and vacuum excavation testing methods to validate the data, and then use professional judgement to designate and depict facilities.

Table 3-6. Estimated Generic Survey and Rediscovery Costs

Line Type	Length (feet)	Cost to Collect Survey Data	Price per Linear Foot to Collect Survey Data	SUE Rediscovery Costs RURAL	SUE Cost per Lineal Foot RURAL	SUE Rediscovery Costs URBAN	SUE Cost per Lineal Foot URBAN	% Saved by Collecting As-builts RURAL	% Saved by Collecting As-builts URBAN
Rigid	100	$ 20.14	$ 0.20	$ 106.00	$ 1.06	$ 110.00	$ 1.10	81%	82%
Rigid	1000	$ 168.00	$ 0.17	$ 1,050.00	$ 1.05	$ 1,080.00	$ 1.08	84%	84%
Rigid	10000	$ 950.00	$ 0.10	$ 9,500.00	$ 0.95	$ 9,900.00	$ 0.99	90%	90%
Flexible	100	$ 20.14	$ 0.20	$ 106.00	$ 1.06	$ 110.00	$ 1.10	81%	82%
Flexible	1000	$ 168.00	$ 0.17	$ 1,050.00	$ 1.05	$ 1,080.00	$ 1.08	84%	84%
Flexible	10000	$ 980.00	$ 0.10	$ 9,800.00	$ 0.98	$ 9,900.00	$ 0.99	90%	90%

While this data refers to open trench installations, a similar analysis can be made for Horizontal Directional Drilling (HDD). In review of HDD equipment resource guides and brief discussions with some manufacturers, HDD equipment has relatively accurate means to track boring tip location both horizontally and vertically. HDD has two primary methods for tracking a boring tip during the drilling process: Inertial Navigation System (gyroscopic or "gyro steered") and Electromagnetic (EM) sonde. The EM sonde can be located and tracked along the surface with a standard EM pipe and cable locator receiver. Both the gyro steered and EM sonde can be used in conjunction (best results) or individually to obtain 3D (x,y,z) "as-built" coordinate data of the boring. For liability reasons, equipment suppliers are careful to not provide specifications on achievable positional accuracy with either method; however, conversations with HDD equipment suppliers infer that these tools can provide positional accuracies of about +/- 1-feet horizontally and vertically if proper methods are employed during the boring and post processing effort. Because direct survey observations are not possible other than at the bore pits and test pits, HDD boring observations made with gyroscopic or EM tools are considered geophysical observations that cannot be statistically analyzed for accuracy and should appropriately be designated as SUE QL B per ASCE 38-02 standards. Figure 3-7 (18) helps to illustrate the technologies available for mapping borehole trajectories.

FIGURE 3-7 HDD Steering Methods Flow Chart (English 2018)



The research team surveyed STAs on requirements for obtaining information on HDD installations. The answers varied greatly and indicated only 7 of 35 STA respondents require as-built plans to be acquired and submitted for HDD work. A few STAs provide staff on-site, either Design Team members or Inspectors, to acquire the installation data. Other STAs require utility representatives to submit bore logs and georeferenced information. One STA requires HDD information to be submitted only for Design Build projects. Because bore tip position data is generated and readily available during HDD operations, the cost for collecting this data with georeferenced accuracy appears negligible.

Costs to STAs

The SHRP2 R01A implementation program succeeded in enabling several states to implement effective programs which in turn provided cost data that could be reviewed. Eleven STAs received SHRP2 R01A implementation funding; however, three of those recipients didn't respond to the survey distributed for this report. All but one of the STAs that received funding and responded are aware of the ASCE's proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data*. (a.k.a., ASCE's new utility "as-built" standard). Six of the seven STAs that received funding and responded said they are definitely or probably going to implement the ASCE Standard to facilitate their recording and exchanging of data. Using funding from R01A implementation program, several STAs are building spatial database platforms with standardized attributes which vary in complexity from basic GIS applications for storing the data to full blown data repositories for complete data management.

The questionnaire responses as part of this project and references in the SHRP2 report indicate that numerous STAs have difficulty requiring and enforcing "as-built" submissions due to numerous issues including: 1) current laws; 2) lack of control through their current permitting processes; 3) breakdown in control and procedures, and resulting data loss, at the end of projects; and 4) lack of concern within STAs about retaining the data.

The ability to integrating utility as-built data into a Utility Conflict Matrix (UCM) for project development is a primary desire of all the surveyed STAs. Utilizing the data for STA utility coordination on STA projects is important; however, consideration must be extended to enhanced safety and damage prevention, better usage of public ROW, and enhanced facilitation of utility installation projects.

Table 3-7. SHRP2 R01A Funded State Transportation Agencies

California	Develop and test a spatial database platform with a standardized set of data attributes to ensure the accurate identification of utility infrastructure during project planning and for conflict resolution during design and construction.
DC	Develop utility data repository and integrate with existing District transportation systems. Use utility data repository with the PLUG (https://dcpsc.org/DCPLUG) system to underground electric lines.
Kentucky	Design structure of spatial database to store utility data. Populate database with sample data. Provide training in collection and use of the data. Evaluate future implementation activities.
Texas	Develop 3D model of utilities for one of the R15B pilot projects. The model includes existing utilities and design of utility relocations. Develop library of 3D objects for transition from 2D to 3D design and construction.
Utah	Conduct trial implementation of commercial system to handle a wide range of applications at USTA. Utility data management is one of the modules included in the trial implementation.
Indiana	Develop a pilot inventory of utility facilities within the right of way.
Michigan	Use existing consultant to provide knowledge transfer on the use of the Geospatial Utility Infrastructure Data Exchange (GUIDE) system. Conduct data collection at MDOT transportation service centers (22 around the state) that review permits.
Montana	(Includes R01A and R15B) Develop business case for the implementation of commercial off-the-shelf (COTS) software to manage utility permits and utility inventories using cloud-based services. Select consultant for COTS implementation. Customize COTS to address MDT's needs and requirements in three areas: Notification module, permitting module, and utility location data repository (Fully implemented in 6 months, training completed, and went live January 1st, 2020).
Oregon	Develop enterprise GIS database to store utility data. Develop module to import CAD data. Develop module to import utility investigation deliverable data. Develop module to import survey data.
Pennsylvania	Develop an IT business case and system requirement plan to develop a spatial database to store utility data. Data sources include final design plans, utility permit data, and as-built data.
Washington	Evaluate available utility investigation data. Develop prototype utility data repository database. Test data repository with sample 3D data collected for pilot project.

Comments from the recipient states were included as part of survey responses (see Appendix A). The following constitutes feedback from a select number of the recipient states that is especially germane to the discussion of utility as-builts.

The **Michigan Department of Transportation** (MDOT) had begun work in 2014 on the GUIDE (Geospatial Utility Infrastructure Data Exchange) which utilized STIC (State Transportation Innovation Councils) funding to begin a process to obtain and store standardized geospatial data. During this process MDOT created a data standard for collection and storage of data which included an effort in 2016 to align with the draft ASCE *Standard Guideline for Recording and Exchanging Utility Infrastructure Data*. Additional funding was obtained through the R01A program which allowed MDOT to finish the project and to conduct demonstration projects to trial the data collection processes. At the time of this report MDOT has not implemented the GUIDE program as statewide policy.

Caltrans identified the following benefits resulting from the pilot utility data repository (R01A) implementation: *Caltrans' vision is to have a spatial database platform with a standardized set of data attributes to ensure the accurate identification of utility infrastructure during project planning and for conflict resolution during design and construction. Caltrans' implementation plan is based on CAD and GIS practices and procedures that are already largely in place at the agency*. At the time of this report Caltrans has not implemented a program as statewide policy

In 2019, **Montana Department of Transportation** (MDT) completed the installation, customization and configuration of an online utility permitting system integrated with a 3D utility location data repository with an "Off-The Shelf" (OTS) software solution. The utility permitting process is the starting point for utility installations within the right-of-way managed by MDT. The previous process was a paper-based application; applicants submitted supporting documents via email or paper and used different systems to look up information required by MDT (roads, mile markers, section, etc.). At the end of the project, when as-built data were required, MDT previously lacked a standard data format for data submission and exchange or a viable method for storing, managing, updating and leveraging that data for future projects.

The OTS solution is a web map based permitting and utility data repository based on the Open Geospatial Consortium standards. The utility data repository has been built on and is compliant with the American Society of Civil Engineers' standards for as-built utility data and utility rediscovery. The system allows user to submit applications online and leverage already available GIS data for permit routing and automatic data population. The utility data repository captures, stores and manages all the utility location data provided by the utility owner which can then be downloaded for use on future projects. As the data include information about the accuracy and quality of the data it allows engineers to make more informed decisions during a projects design phase. The solution is fully implemented and has been operating since January 1st, 2020.

In response to the survey completed by the STAs, 69% of the respondents indicated that they are not currently utilizing any technology to collect as-built information or implied this by not responding to the question. This is indicative of the number of STAs which are acquiring as-built information. Four STAs indicated they are utilizing tools available for positioning utilities for "as-built" collection including:

- Global Navigation Satellite System (GNSS, which includes Global Positioning System or GPS satellites) Handheld Device (Consumer Grade)
- GNSS Handheld Devices (Mapping Grade)
- GNSS Rover with real-time kinematic (RTK) or post-processing corrections (survey grade)
- GNSS enabled digital single-lens reflex (DSLR) photography
- Light Detection and Ranging (LiDAR)
- Unmanned Aircraft Systems (UAS) or drones
- Aerial Photogrammetry

One STA, however, stated they only use these tools on Design Build projects. The bulk of the respondents that utilize tools for positioning utilities to collect "as-builts" are using consumer or mapping grade GPS handheld devices, not survey grade GNSS.

There are advantages and constraints to every technology listed above. For example, cost versus accuracy, such as the use of GNSS Handheld Devices (Consumer or Mapping Grade) in lieu of RTK GNSS. A GNSS RTK Rover (Survey Grade) with the proper correctors acquired in real-time or post-processed can yield better positional accuracy (e.g., +/-0.2 feet) than GPS Handheld Devices (e.g., +/-10 feet or more) but the equipment is more expensive and the acquisition and processing requires surveying training and knowledge. **However, the cost to achieve significantly higher resolution and accuracy is significantly less at the time of installation; moreover, in nearly all cases, the higher accuracy is never again achievable after installation.** Much more costly SUE investigative measures employed long after installation involve geophysical and test hole methods can only achieve limited observations that are assigned "quality levels" as defined by the ASCE 38-02 standard. SUE investigations can never achieve the same definitive, highly accurate and contiguous geospatial observations possible at the time of the utility installation. Additionally, the higher-grade geospatial as-built data will have more functional use over time for damage prevention, planning, design, etc., than cheaper lower-grade positional data.

Spending more to collect reliable and more accurate data up front at the time of installation in almost all cases yields far greater value over time. The fact that SUE investigations are cost effective (providing an ROI of 3 to 6 times based on studies of 2D SUE, and in excess of an estimated 10 times for 3D data) for STA projects certainly supports the argument that utilizing RTK GNSS to survey installations at the time of installation is many times more cost effective and provides much greater value. For a typical SUE operation, the survey component (typically using GNSS RTK methods) for the field operation is typically 10% to 20% of the total SUE investigation utility designating cost. Therefore, this implies performing RTK GNSS "as-built" survey at the time of particular utility installation could provide an ROI on the order of 5 to 10 times of SUE; **in other words the cost of the "as-built" survey for a new utility installations will provide a net ROI in the range of 15 to 60 times just for a single future STA project**. This postulation of course assumes a single survey event is required to document all the utilities within an STA project limits; in reality, there will be multiple mobilizations and setups required to collect an as-built survey for each utility installation over time. However, each "as-built" survey event performed at installation time for each individual utility is considered to:

- be a singular and rather trivial effort, and with current technologies and established procedures, can be performed in an incidental manner concurrent with the installation work with minor, if any, additional labor requirements;
- provide a yield quality that is 3D and many times superior than SUE 2D QL B data (i.e., the "as-built survey would be roughly five times more "accurate", and essentially continuous and in 3D along the entire alignment); and
- in a format and readily available for a myriad of other value adding, proactive uses such as damage prevention, asset management, civil defense, emergency response, permitting, ROW planning, and advanced coordination.

These factors are anticipated to offset and dwarf actual survey costs. With this in mind an "as-built" survey is still conservatively speculated to provide an ROI of at least 15 to 60 times over the lifecycle of the utility asset, and likely much more.

"As-built" positional information, however acquired, needs to be properly documented with observation methods and quantified accuracies so future users readily understand data reliability and make appropriate use of the recorded information, and avoid grave misuses. Costs can escalate if data is collected by a professional surveyor, but, as mentioned, the increased cost will result in having more accurate data which is certified, and therefore statutorily useful for a variety of future uses, including many sophisticated uses that are currently untapped because this data does not currently exist. Utility as-built coordinate data collected and certified by a professional land surveyor at the time of installation technically does not require a SUE professional to reinvestigate, and by ASCE 38-02 standards would be considered Quality Level A data at every direct survey observation point. Professional land surveyor certified "as-built" observations do not revert to QL D after a project is completed as do SUE investigation results per established statutes which regulate "engineering surveys".

No new utility "as-built" field technologies were revealed during the interview process but there is significant effort afoot by the STAs to understand various software, programs, and applications to manage the "as-built" data for future projects. It is commonly understood by STAs that collecting accurate and qualified data at the time of installation of a utility will virtually eliminate future rediscovery costs and enable a host of value adding management, accommodation, damage prevention, planning and construction strategies. Potential reductions of SUE, utility strikes, project delays, reduced relocations, better use of limited ROW, and the untapped benefits of new 3D virtual technologies clearly far outweigh the costs.

<u>Case Studies for Estimating STA ROI for Standardized and Accurate Utility "As-Built" Surveys</u>

Colorado's recent passage of Senate Bill (SB) 18-187 provided a unique opportunity to compare existing utility depictions for project bid packages that were developed using:

1. non-standardized record data and pickup surveys of Call 811 notification field markings; and
2. SUE investigation data collected in accordance with ASCE 38-02, which reflects what could be provided with standardized and accurate utility "as-built" data.

One example project originally had 102,425 lineal feet of existing utilities depicted based on utility company discussions, records research, and survey of One-Call (Call 811) markings. The SUE costs for this work were estimated to be $53,079. During field investigations of the facilities, 151,081 lineal feet of utilities were discovered (nearly a 50% increase) with an actual SUE cost of $85,310. In addition, some utility alignments that were previously identified shifted by eight feet or more. Key observations from this example are:

- current record data is insufficient to accurately depict what is in the ground and where it lies;
- damage prevention One Call (Call 811) notification field markings appear to be limited based on inadequate utility records;
- in this case the SUE investigation likely provided an ROI of 4.5 times during construction (based on the Purdue study), which means the $85,310 spent saved $383,895; and
- the cost to perform just the GNSS RTK field survey of the utilities for the SUE investigation was about $10,000.

If the utilities had been surveyed when they were installed, the cost to survey those installations, assuming multiple local mobilizations and setups over time to pick up all the utility installations, is speculated to be at $20,000. This would yield an estimated ROI of about 19 times (383,895/20,000) for project savings. Additional value for enabling 3D technologies and GNSS navigation aided damage prevention tactics is currently un-estimated, but likely substantial.

A separate example project from another state involved a 10.5-mile corridor with an estimated 527,000 lineal feet of utilities with 900 utility structures (vaults, drop inlets, etc.) based on discussions with utility companies and records research. Two other estimates for the same corridor and project were developed by different and nationally reputable SUE firms; these firms respectively estimated the corridor contained 300,000 and 400,000 lineal feet of existing utility infrastructure. The actual amount discovered during the SUE investigation is currently over 1,000,000 lineal feet and growing with over 3,600 utility structures. The projected cost for the SUE investigation will be over double the initial SUE budget, to over $1.5M, and has required five months of field operations to complete. The key observations from this example are:

1. Current record data is insufficient to know what is within public ROW; and
2. Even reputable SUE firms with years of experience have difficulty estimating how much infrastructure exists beneath our roads.
3. If performed, the total cost to perform standardized and accurate utility "as-built" surveys of these utilities at the time of installations is estimated to be under $200,000.

These two recent examples represent rather common situations; as more utilities are placed in the increasingly congested ROW, these problems are expected to only become more frequent and exasperate further if corrective measures are not taken now.

Liability Implications

Another area of implications is in regard to liability for the entity providing utility "as-built" data. Some conversations with utility companies highlighted a concern of accuracy and maintaining the accuracy of the data collected. Recently the court system of Iowa made a ruling on this matter and confirmed a ruling in a previous case in Illinois. The Southern District Court of Iowa, Docket number 3:2018-cv-00020, in Allied Manatts Group, LLC et al versus Question Corporation (CenturyLink), found the CenturyLink breached its legal obligations to provide accurate information to the Contractors. The court entitled payment from CenturyLink to the Contractors for extra costs including idle equipment, idle labor, extra work, and unabsorbed home office overhead. This case represents the second case in the country which recognized a contractor's direct cause of action against a utility for negligent misrepresentation of facility locations. (Tom Olson, 2019 Presentation at the Iowa AGC Summer Meeting). Stemming from these findings, it would appear to be on court record that utility companies are bound to provide the most accurate information possible regarding the location of their facilities to STAs and contractors.

There could be liability concerns over data provided for a repository. The liability risks, however, could be controlled through contractual agreements between utility companies and STAs to stipulate that accuracy level for coordinates provided with as-built data, and define that such data is for the STAs use in planning and designing future work, and that damage prevention for excavation is still controlled through the One-Call (Call 811) law.

If an STA maintains a utility "as-built" data repository for preliminary design purposes, the utility company stands to benefit from supplying more accurate georeferenced as-built data, which in turn results in fewer interruptions to customers from relocations and dig in events. Initial feedback from most utility companies in Montana after implementation of MDT's Utility Location Data Repository (ULDR) seems to support this conclusion.

Extended Benefits

In addition to obvious damage prevention enhancements for design and construction, numerous untapped value adding tactics that can be realized by both STAs and utility companies with standardized and accurate utility as-built data, including conflict avoidance during highway design stages, less relocations, more efficient planning and use of public ROW, resiliency analysis, civil defense and emergency response uses, and improved asset management by utility companies.

If STAs have accurate as-built plans of utility facilities in project footprints, they can take measures very early in project timelines to avoid utility conflicts and relocations. For non-reimbursable utilities, relocations are viewed by STAs as a justifiable cost to the utility companies for being allowed to be installed within public ROW at minimal costs and avoiding the need to acquire private easements. However, given the cost and disruption caused by relocating utilities, it is apparent that avoiding even a few relocations through increased accuracy and standardization of utility data would more than cover the costs incurred by utility companies to survey utilities at the time of installation.

STAs, on the other hand, must realize that allowing utilities to be installed within public ROW is also a value to the taxpaying public and commercial businesses which utilize these utility services. As custodians of the public ROW, STAs are obligated to serve commercial and public welfare interests because: 1) the ratepayer and the taxpayer are the same, 2) utilities serve the public and commerce, 3) the public ROW is a logical corridor for utilities; and 4) utilities, commerce, and the public generate the taxes that support the roadway and ROW development and maintenance.

As utility infrastructure are increasingly installed within public ROW, often haphazardly, there is mounting risk of utility strikes and intensified need for utility investigations. Often the disorganized nature of installations is due to not fully understanding the utilities currently existing in the ROW. With better records, STAs and utility companies can both plan, design, construct and operate with greater efficiency while optimizing usage of limited ROW space. The alternative to available public ROW is private easements that are expensive, time consuming, and challenging to acquire. Improved use of the more economical public ROW is a logical and practical approach.

A recent (Spring 2015) high-pressure gas main installation project along a heavily traveled urban corridor utilized a 3D model of existing utilities which was developed from ASCE 38-02 data acquired through a SUE investigation. This data set, analogous to what would have been possible if all utilities were documented with spatially accurate as-built data, enabled the natural gas company, contractor, and STA to realize the following:

- The installation was so clearly and well designed in 3D, and the work so well planned, that the STA which owned the ROW granted the gas company a permit with waivers to allow an open cut and shallow depth variance.
- 193 conflicts with existing utilities were identified and resolved in advance, including 23 previously unknown facilities that were identified through the SUE investigation.
- Contractors at the Prebid Meeting stated this was "the most complete and best bid package we've ever seen" and were provided the 3D digital CADD model from which to prepare their bids.
- The awarded bid was 10% below engineer's estimate.
- Project was scheduled for 10-weeks and 2 crews, each working from opposite ends of the project; but data and design were so good that the contractor could, without surprises or issues, lay 300-feet of pipe per night, which is as fast as a crew could go. The contractor accordingly called off a crew and the entire pipeline was actually installed in 7-weeks using just 1 crew.

- The project did not encounter any utility damages, nor any delays, nor require any changes or field adjustments. This is unprecedented in this industry for a project of this nature.
- The STA responsible for the ROW did not experience any traffic flow disruptions or unanticipated issues from the project. Even signal light sensors were kept operational. A senior official for the STA that commuted along the project corridor daily stated the project was not even perceptible by the traveling public.

The natural gas owner, the contractor, and the STA responsible for the ROW all experienced tremendous value on this project, which exemplifies what could be an everyday experience along all public corridors if spatially accurate as-built data were acquired when utilities are installed.

A final example of savings provided to utility companies by collecting spatially accurate and standardized as-built data is improved asset management of their facilities. Utility system maintenance, operations, and upgrades for utilities could be better planned and facilitated. Potential savings may also be realized in One-Call (Call 811) notification field locates as follows: 1) work zones could be analyzed more efficiently and as-built data used to determine when facilities are clear and field locates not required; and 2) when field locates are necessary, they could be marked more efficiently due to better location accuracy.

A cost savings cannot be readily quantified for all these items, but they nonetheless add value for the utility company and their service dependent clients, the STA, construction industry, commerce, and the general public.

A Discussion of Costs and Benefits in Regard to Requiring Utility As-Built Plans at Specific Geospatial Accuracy

The costs and benefits in requiring spatially accurate utility as-built data have been highlighted in the paragraphs above both qualitatively and quantitatively. A central point presented and concluded by the research team is money spent to collect accurate as-built data will be generously offset with a multitude of savings including SUE investigations. Established to treat the symptoms resulting from the absence of accurate as-built data, SUE investigations are documented to provide an ROI of between 3:1 to 6:1 in project construction costs; similarly, accurate utility as-built data acquired at the time of installation would cure the problem and is estimated to provide an ROI of 15:1 to 60:1 just for STA project development alone.

From a damage prevention standpoint, the research team believes that an annual savings in reduced damages could be $250,000,000 once systems have geospatially referenced as-built plans. As some have estimated, utility strikes represent a $50 billion total cost to the United States economy (19). Based on the root cause breakdown, 21% of this cost ($10.5 billion) is the result of utility strikes that could potentially be reduced with geospatially accurate utility as-built plans. A reduction of just 20% of those specific dig-in events would represent a total savings of $2 billion per year. Further, according to the Common Ground Alliance, there are more than 20 million miles (possibly up to 33 million miles) of underground utilities in the United States. The cost of surveying that amount of utilities at an estimated cost of $1 per liner foot would be $106 billion. Given how far behind the system is to date, a 50-year breakeven point ($106 billion/$2 billion) does not seem all that bad. Of course, with system replacement and conservative nature of these estimates, the breakeven point nationally would be much less than 50 years. Considering that underground installation of facilities began in earnest in the 1960's, spreading the $106 billion cost over the past 60 years would be about $1.75 billion per year. Using the $2 billion cost savings from above, the resulting return on investment could be estimated to be more than 13%.

From a return on investment (ROI) standpoint of the STAs, the ROI of SUE is estimated to be between 3:1 and 22:1 for money spent on SUE and saved for the project overall. Surveying is considered to be 10-20% of the cost of performing SUE Quality Level B. Since SUE investigations would still be warranted (only in reduced quantities) even with geospatially accurate utility as-built plans, one might assume that, for a period during which accurate as-built data becomes increasingly available, such as perhaps over the next 10 to 20 years, surveying utility installations to develop accurate as-built plans could save STA projects conservatively 80% to 90% of their SUE cost. The FHWA also estimates that a SUE investigation for a project is less than 0.5 percent of the total construction costs (19). Extending these inferences, we can conceivably conclude the following:

$0.20 surveying = $1 SUE Investigation or $1 surveying = $5 SUE Investigation (a postulated 20:1 ROI based on the 4:1, most commonly cited, ROI of SUE)

If surveying utility as-builts reduces SUE costs by 80%, that is a savings of 0.4 percent of total construction costs

Annual Construction Spending for roads and streets, according to the U.S. Census is averaging nearly $96 billion. The reduced SUE work savings according to these figures would alone be $384 million (0.4 % of $96 billion).

There are many implications of cost and savings regarding a requirement for utility as-built plans at a specific geospatial accuracy. However, looking at these costs and benefits from various angles, the potential requirements still seem like a strong long-term strategy. In considering these requirements a John Wooden quote comes to mind, “If you don’t have time to do it right, when will you have time to do it over?” If we consider those words and that above mentioned costs and benefits the approach to more toward geospatially accurate utility as-built plan collection seems appropriate.

CHAPTER 4

Conclusions and Suggested Research

Geospatial Locations for Utility Installation As-Built Plans: Costs & Benefits Overview

This research set out to document effective practices used by state transportation agencies (STAs) for obtaining geospatially accurate and standardized utility as-built data, identify hurdles and needed efforts to collecting utility plans at that level of accuracy, and develop recommendations for overcoming these hurdles in the form of best practices and any needed legislation changes. To achieve these goals, the research began with conducting reviews of literature, legislation, STA policies, manuals, practices and standards. These reviews guided the research team in the development of a survey distributed to STAs to collect feedback on the current state-of-the-practice in regard to development of as-built data and plans for utility installations. The practices in place vary considerably and only a few states are experimenting with methods that would collect the as-built data with identified geospatial accuracy. To gain a depth of understanding, the research team conducted interviews with STAs and utility companies willing to provide their perspective. The crux of the research question involves the costs and benefits of a utility as-built process that would entail the collection of utility as-built data according to known geospatial locations. Unfortunately, the data required to perform a thorough cost-benefit analysis is not being collected nor available from the STAs or other resources investigated. The resulting recommendation in this regard is that strategic improvements to data collection would not only help answer the questions of this study, but many others dealing with costs incurred on highway projects as a result of utility installations or relocations. The research team also investigated more abstract sources of data and sources that could be correlated to the desired cost-benefit understanding. This analysis investigated the costs of utility strikes and the costs of collecting utility installation data by performing subsurface utility engineering (SUE) utility investigations or standard survey of utility infrastructure as it is installed. A cost and benefit comparison showed that proactive practices of collecting utility installation coordinate data as facilities are installed clearly provides benefit over more reactive measures including SUE investigations. An intuitive line of reasoning is as follows:

- The costs for a SUE investigation are typically around 10% of the design costs of a project
- Typical survey practices are 10% to 20% of a SUE investigation
- With the assumption that the survey data would provide benefit equivalent to the SUE investigation ($1 spent resulting in $4 of savings), the return from developing utility as-built plans through survey practices would save STA projects at least $20 for every $1 spent on surveying the utilities as installed.
- Survey provides a one-time shot at collecting an accurate as-built record. Survey data quality of an exposed facility at the time of installation is in 3D and at least 5 times more accurate than SUE QL B data.

While this is considered the central conclusion of the research effort, the research completed also highlighted other conclusions of note.

Conclusions

In compiling the conclusions of this study, the research team assembled these conclusions along the research questions posed by the research panel within the original request for proposals. While this is not an entirely inclusive list of the findings collected with the study, these were those originally deemed the most important at the origination of the study. Through the multiple research methods used, there were several other conclusions captured; some of which are mentioned below. Chapters two and three provide the most thorough listing and explanation of the findings of the study.

What effective practices are STAs requiring for utility companies to properly install or relocate facilities to known geospatial locations?

The research found that most STAs are not collecting and maintaining georeferenced utility as-built data. In fact, the data collected when not georeferenced is typically not even to scale if installed by a new installation permit. Relocations as part of a highway project are often captured to project coordinates but their depiction on plans can be suspect. The relatively few STAs collecting as-built plans to georeferenced locations are doing so in pilot stages and typically as part of using SHRP2 R01A implementation funding for the effort. These implementations are showing promise for the approach but until the data they are collecting is used for future projects, their value will not be fully realized by all stakeholders. Two examples of note for further examination are Colorado and Montana because both are requiring as-built data be collected and are storing and managing the data in repositories.

What are the potential barriers to requiring utility companies to properly install utilities and deliver reliable as-built plans?

Most STAs have a desire to collect and maintain spatially accurate, georeferenced utility as-built data, but have the perception that barriers are currently too great to overcome. The barriers mentioned by the STAs varied but many did not know where to begin. They did not know if they had legislative authority to request these types of as-built data, or how the data would be collected, stored, or used. The states piloting the SHRP2 R01A program are leading the way in this regard and as they become more advanced, other STAs will mimic their efforts if value is realized. Most felt that an industry standard would help and that there is a need to further educate STA personnel about the proposed ASCE "Standard Guideline for Recording and Exchanging Utility Infrastructure Data (a.k.a., ASCE "Utility As-built Standard").

The utility companies interviewed cited their own reservations about moving to georeferenced as-built data. Common barriers they perceived to collecting georeferenced utility as-built data are in providing proprietary information to the STAs and concerns of possible losses in their competitive advantage. This concern is easily rectified as STAs have processes in place to protect proprietary data and data shared could be limited by the utility company. Typically, the only information necessary for sharing consists of owner, facility type, material, geometric dimension and location. If more information is needed, the designer or contractor can contact the utility company for details. Another concern mentioned was in security of the utility facilities. The Homeland Security Act, often cited as prohibiting utility companies from providing their data to STAs, in fact does not preclude data from being shared if there are provisions to safeguard data security.

Utility companies interviewed admitted most of the reasoning used to not provide georeferenced as-built information to the STAs could be overcome through data agreements. Their major barrier was actually in that they do not feel that they have sufficient resources (personnel, equipment, funding and time) to collect georeferenced as-built plans of their facilities. They also do not have a resolution to this without total company buy-in to a change in process. To overcome this barrier, the value of having the data needs to be demonstrated. As shown through this study the costs of collecting this data at the time of installation are relatively small relative to the benefits; especially when compared to having to collect the data years after installation. In many cases utilities are already being crudely mapped by contractors using low grade GNSS tools; a relatively minor improvement in technology and procedures could enable systematic and standardized data that is accurately georeferenced and suitable for STA needs.

What are the cost implications for project development for both state transportation agencies and utility companies to install and provide accurate geospatial as-built plans?

As previously mentioned, the cost implications for capturing georeferenced utility as-built data are significantly lower (10% to 20%) when capturing the information during installation in lieu of collecting the similar data through subsurface utility engineering (SUE) investigations. Not only is the data more cost effective to collect but it is considerably more accurate (typically 5 times more accurate and in 3D). Even crude coordinate data collected using low grade GNSS equipment by non-licensed technicians is still more accurate than the data that is typically exchanged in current practice; moreover, technology improvements are reducing costs and improving data accuracy dramatically every year. The utility records currently in use for design purposes are incomplete and, in many cases, both incomplete and inaccurate. Some utility companies even admit that the best records they have are those given to them by the STAs after SUE investigations in the right-of-way. On a project-by-project basis, georeferenced as-built data is higher quality and more cost efficient that SUE investigations. Further, it is believed that collecting georeferenced utility as-built data would demonstrably decrease the number of dig-in events every year when thinking on an industrywide basis. So much so, that even conservative estimates demonstrate that collecting georeferenced utility as-built data has the potential to save $250,000,000 through damage prevention and another $384,000,000 in decreased SUE costs.

What legal and policy changes are needed in order to effectively implement the research findings?

Through the research no significant legislative barriers were encountered. Most STAs have current legislation allowing, if not requiring, them to collect as-built information from utility companies as part of permitted installations or relocations. With the legislative authority to require utility as-built data, the requirement for georeferenced as-built data becomes a change to the permitting process. With the 2020 anticipated ASCE utility as-built standard forthcoming, these permitting policy changes could soon only require the adoption of this standard into practice. This standard, as previously described, references varying levels of georeferenced accuracy and could be incorporated into permitting policies by STAs to require specific levels of accuracy. The Utah Department of Transportation and Montana Department of Transportation have already adopted language from a draft of this standard into their permitting policy to require georeferenced as-built data.

Suggested Research & Recommendations

Based on these conclusions and findings, the research team formulated several recommendations. First and foremost, it is evident to the researchers of this study that there is value in requiring standardized utility as-built data that is georeferenced to a specified accuracy. This practice can promote savings in project development costs, reduce costs for SUE investigations, and allows for a well-informed project initiation regarding potential utility conflicts. Moreover, this data enables a myriad of emerging 3D digital technologies and practices that will remarkably enhance design, construction, coordination, damage prevention, as well as emergency response, civil defense, resiliency analytics, and asset management practices. In addition, both STA and utility owner project risk, costs, and construction schedules can be substantially reduced. Responsibility for data collection may end up varying state to state, but STAs and utility owners everywhere need to foster better partnerships moving forward in order to be able to collect and manage this data properly. Educating both STA and UC personnel of the mutual benefits of collecting true utility as-built data would be a good first step towards fostering this partnership, as well as generating support for funding for future efforts.

The study also highlighted the need for improved accounting of costs associated with utility issues and dig-in events. Currently, dig-in event data is seemingly only available through the Common Ground Alliance. While the data collected is valuable, it is collected and analyzed according to their central goals and beliefs which focus on damage prevention during the time of construction. For STAs to be able to analyze data according to their questions and along their desired research, they need to perform independent data collection of dig-in events, emergency relocates, change orders, project delays, claims, etc. from an industry perspective. The STAs themselves should collect data that allows for determining the costs and benefits of having accurate utility information, including consideration of a myriad of practices, methods and technologies that are currently not tapped and utilized because this data is lacking. This is becoming possible in a small number of states that have developed electronic systems for utility coordination and conflict management, but more data collection and analysis are needed. There is also a need for more in-depth case studies of states that are collecting as-built data and storing in repositories (for example Montana and Colorado) once these systems are more advanced and the data has demonstrated value in the project development process. Since both are fairly new, time will be needed to collect best practices and implementation lessons learned.

Concluding Summary

In conclusion, the central question of this study was, *is there value in collecting utility as-built data to geospatially known locations?* While the data to easily answer this question does not seem to be readily accessible, the research team is confident that the answer to the question is a resounding, *yes!* The support for this response comes in multiple forms at both the project and industry level. At the project level, readily available location data of utility assets stands to inform and allow better early project decision making with minimal or reduced expenditures on SUE investigation. On an industry basis, better location information can easily cause reductions in dig-in event and improve utility designation through One-Call (Call 811) services. The practice of collecting utility as-built information to georeferenced accuracy provides benefits to multiple stakeholders and potentially enhances the security or protection of the facilities, thereby providing benefits to the utility companies themselves.

Implementation

One implementation area of this project is in providing model permitting language for requiring utility companies to provide their as-built data to geospatial accuracy. Appendix D provides examples language from Colorado DOT.

At the time that this research project (NCHRP Project 20-07 Task 418) is concluding, several STAs (e.g., Montana, a SHRP2 Implementation Assistance Program Round 7 funding recipient, and Colorado) appear to have newly implemented ROW asset management approaches which seem to embody key elements of a shared comprehensive vision and strategy for gathering reliable utility as-built data and managing the existing and planned occupations of ROW space (above and below ground) in a manner that is proactive, productive, and mutually beneficial (symbiotic) for all stakeholders and the public alike. While it is still too early to understand cost/benefits and practical limitations, these STAs appear to have implemented effective programs by successfully adapting and harnessing: 1) existing business practices, policies, permit language, and statutory regulations; 2) the new ASCE utility "as-built" standard framework; 3) existing internet technologies (IT); and, lastly and equally as important, 4) proactive relations with utility infrastructure owners. Key to the implementation efforts at these STAs were:

1) strong STA implementation managers with proper background to champion the development and implementation and buy-in within the STA;
2) strong STA division or bureau managers with proper understanding of needs and vision to secure implementation funding and back the efforts;
3) IT developers with in-depth understanding of STA operations, survey and geodetics, utility infrastructure operations and installations, utility infrastructure construction;
4) approaches and applications which fit within existing business practices, organized and streamlined procedures, and effectively eased burdens while improving performance within the STA; and
5) proactive outreach to both STA staff and utility infrastructure owners to clearly convey the purpose and mutual benefits of the new approach.

Through a memorandum of understanding the Montana Department of Transportation (MDT) has already implemented the draft ASCE "Utility As-Built" standard within its new Utility Permit Application System (UPAS) and Utility Location Data Repository (ULDR) which went into full use on January 1st, 2020. To date the response from stakeholders, including utility infrastructure owners, has been positive and MDT is now obtaining utility "as-built" data from utility owners in a standardized, useful digital format. The ASCE "Utility As-Built" standard is scalable with regard to spatial accuracy, so MDT is adjusting requirements for various installations and locations at this time to encourage participation by all utility installation owners, large and small. Required accuracy criteria may gradually be tightened as submittal practices become established and routine, and GNSS and survey technologies continue to evolve making it easier and less expensive to obtain accurate coordinate data.

An additional area for implementation would be in creating agreements with UCs regarding data security in order to alleviate any concerns over facility security and proprietary information being overshared. A minimal amount of utility metadata is usually required during the design phase of projects. Agreements could be made to ensure sharing of fields such as geospatial locations, ownership, size, and material in some cases. If additional data were required a project specific request could be made by the STA.

References

1. American Society of Civil Engineers. 2017 Infrastructure Report Card: Roads. March 2018.
2. Sterling, R.L., Anspach, J., Allouche, E., Simicevic, J., Rogers, C.D.F., Weston, K., Hayes, K. *Encouraging Innovation in Locating and Characterizing Underground Utilities*. SHRP2 Report S2-R01-RW. Transportation Research Board of the National Academies, Washington, D.C., 2009.
3. Common Ground Alliance. Dig Risk Reduction. <website accessed: August 11, 2018> http://call811.com/before-you-dig/risk-reduction
4. Purdue University Department of Building Construction Management. *Cost Savings On Highway Projects Utilizing Subsurface Utility Engineering*. Prepared for the Federal Highway Administration.1999. FHWA Contract Number DTFH61-96-00090
5. American Society of Civil Engineers. White Paper on ASCE "Standard Guideline for Recording and Exchanging Utility Infrastructure Data". <Website accessed April 20, 2020 >https://www.asce.org/uploadedFiles/Technical_Areas/Construction_Engeering/Content_Pieces/as-built-standards-whitepaper.pdf
6. Federal Highway Administration Office of Infrastructure. *National Utility Review: Utility Coordination Process Final Report rev. Oct 2018*. FHWA-HIF-18-039
7. Kraus, E., Li, Y., Overman, J., & Quiroga, C. (2013). *Utility Investigation Best Practices and Effects on TxDOT Highway Improvement Projects.* Texas A&M Transportation Institute, Texas Department of Transportation. Texas: Texas A&M Transportation Institute. Retrieved December 18, 2019, from http://tti.tamu.edu/documents/0-6631-1.pdf
8. Quiroga, C., Kraus, E., Scott, P., Swafford, T., Meis, P., & Monday, G. (2012). *Identification of Utility Conflicts and Solutions - SHRP 2 Report S2-R15B-RW-1.* The National Academies . Washington, D.C.: The National Academy of Sciences Engineering and Medicine. doi:10.17226/22819
9. Sterling, R. L., Anspach, J., Allouche, E., Simicevic, J., Rogers, C. D., Weston, K., & Hayes, K. (2009). *Encouraging Innovation in Locating and Characterizing Underground Utilities.* National Academy of Sciences. Washington, DC: The National Academies of Sciences Engineering and Medicine. doi:10.17226/22994
10. Makana, L., Metje, N., Jefferson, I., & Rogers, C. (2016). *What do Utility Strikes Really Cost?* University of Birmingham.
11. Quiroga et al, 2018), *Feasibility of Mapping and Marking Underground Utilities by State Highway Agencies*, FHWA-HRT-16 019
12. Anspach, J.H., Utility Location and Highway Design. NCHRP Synthesis 405. Transportation Research Board of the National Academies, Washington, D.C., 2010.
13. National Academies of Sciences, Engineering, and Medicine 2012. *Subsurface Utility Engineering Information for Airports.* Washington, DC: The National Academies Press. https://doi.org/10.17226/22751. ISBN 978-0-309-22367-6
14. National Academies of Sciences, Engineering, and Medicine 2014. *Managing Longitudinal Utility Installations on Controlled Access Highway Right-of-Way*. Washington, DC: The National Academies Press. https://doi.org/10.17226/22356. ISBN 978-0-309-27139-4
15. Common Ground Alliance. Member Webinar Presentation of Mar 1, 2018. <website accessed: Aug 10, 2018
16. Metje, N., Ahmad, B., & Crossland, S. M. (2015). Causes, impacts and costs of strikes on buried utility assets. Proceedings of the ICE - Municipal Engineer, 168(3), 165-174.
17. Michigan Utility Coordination Committee. *Geospatial Utility Infrastructure Data Exchange 2014 Pilot Initiative*. <website accessed nov. 8, 2019> https://www.michigan.gov/documents/mdot/GUIDE2014_510082_7.pdf
18. English, J., Lead, Follow or Get Out of the Way: A Challenge to the HDD Industry, 2018 <website accessed: Sep 25, 2019> https://uconline.com/magazine/2018/september-2018-vol-73-no-9/features/lead-follow-or-get-out-of-the-way-a-challenge-to-the-hdd-industry
19. Zeiss, G. https://geospatial.blogs.com/geospatial/2018/07/towards-a-digital-twin-of-infrastructure-on-the-cusp-of-efficient-reality-capture-of-underground-utilities.html

Appendices

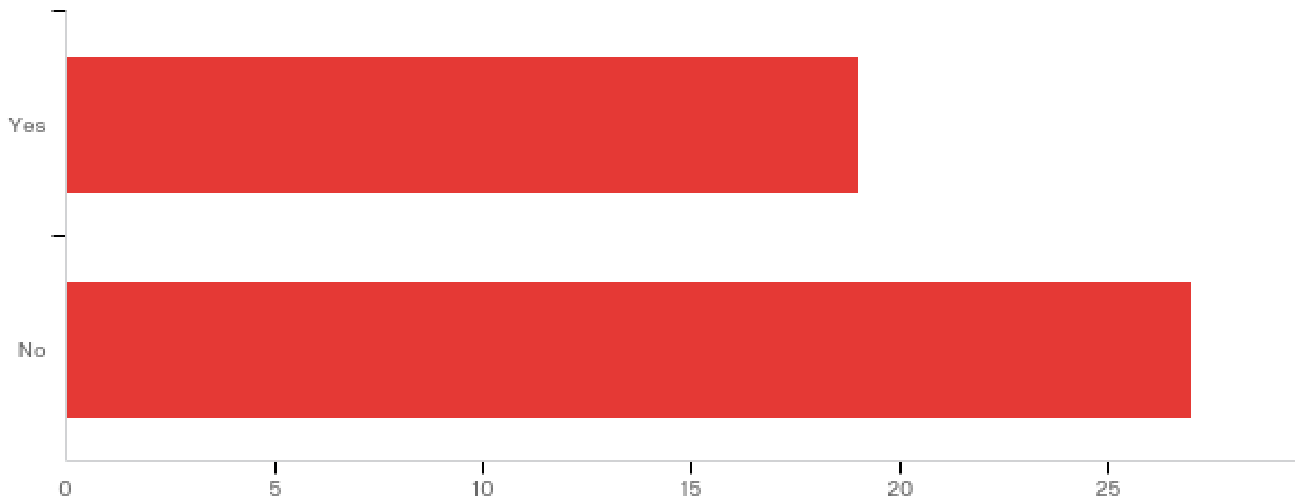
Appendix A: Full Survey Response Data

Data Report

NCHRP 20-07/Task 418 Survey

June 5th 2019, 1:18 pm MDT

Q5 - Does your DOT have a documented process for collecting the proposed or installed locations of permitted utilities during new installations or relocations within DOT right-of-way?



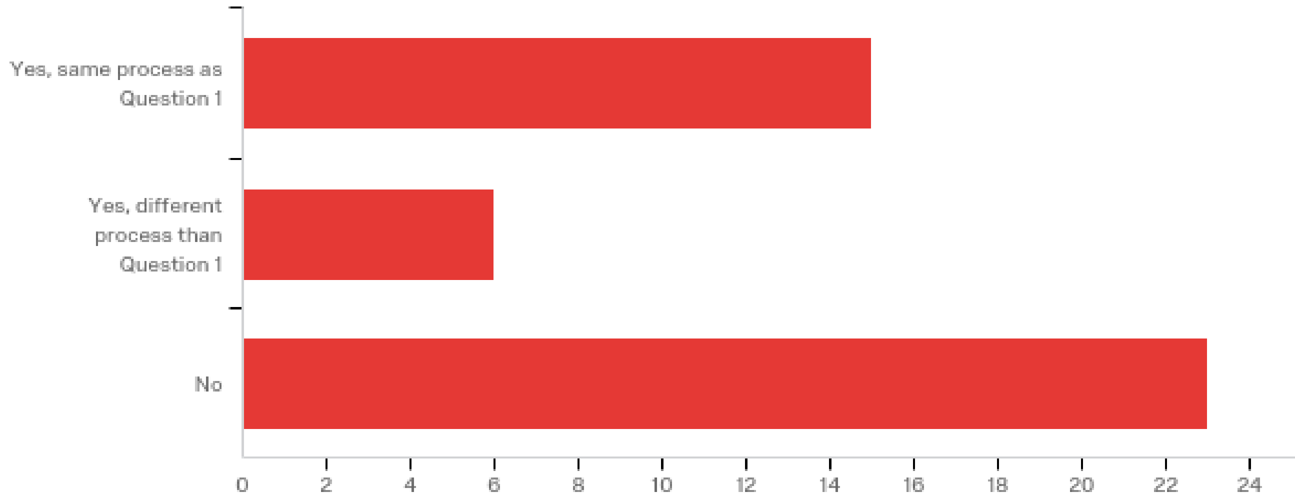
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT have a documented process for collecting the proposed or installed locations of permitted utilities during new installations or relocations within DOT right-of-way?	1.00	2.00	1.59	0.49	0.24	46

#	Answer	%	Count
1	Yes	41.30%	19
2	No	58.70%	27
	Total	100%	46

Q6 - Would you provide a link or access to that documentation?

Would you provide a link or access to that documentation?
As Built Plans- Highways Design Branch
https://www.udot.utah.gov/main/uconowner.gf?n=21971224353070596 https://rules.utah.gov/publicat/code/r930/r930-007.htm
https://www6.modot.mo.gov/ElectronicPermitting/ElectronicPermitting.html#
https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=3222
New process not published to date. Old process is contained within Section 3.3.4.5 within CDOT's Utility Accommodation Code: https://www.codot.gov/business/permits/utilitiesspecialuse/utility-accommodation-code
Transportation.ky.gov/organizational-resources/pages/policy-manuals-library.aspx
https://www.tn.gov/tdot/right-of-way-division/utilities-office/utilities-forms.html Use & Occupancy Permit Collecting longitudinal lat/long since 2000
UAM
https://dot.nebraska.gov/business-center/permits/row/
No
https://www.doa.la.gov/Pages/osr/lac/books.aspx
NOTE: At this time, this process is only draft and not a policy of Michigan DOT. https://www.michigan.gov//documents/mdot/GUIDE_Procedural_Manual__2017_Draft_547744_7.pdf
It's an application and Maryland State employees website, iMap. Arc GIS Survey123. Currently updating the Utility Procedures Manual. I can share after.
https://www.dot.state.al.us/rwweb/util/utilitiesgrid/UtilitiesManual.pdf. We say we require it, but don't have much in the way of what we want. It is implied that we want a hard copy of plans, only if what was installed differs from the relocation plans. We need to update the requirement to state an electronic format (CADD), preferably MicroStation. Our goal is to create a GIS as a repository for that as well as relocated underground utilities.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/programmanagement/utilities/docs/uam/uam2017.pdf?sfvrsn=d97fd3dd_0

Q7 - Does your DOT have a documented process for collecting the proposed or installed location information of new utility installations or relocations occurring during a DOT construction project within right-of-way?



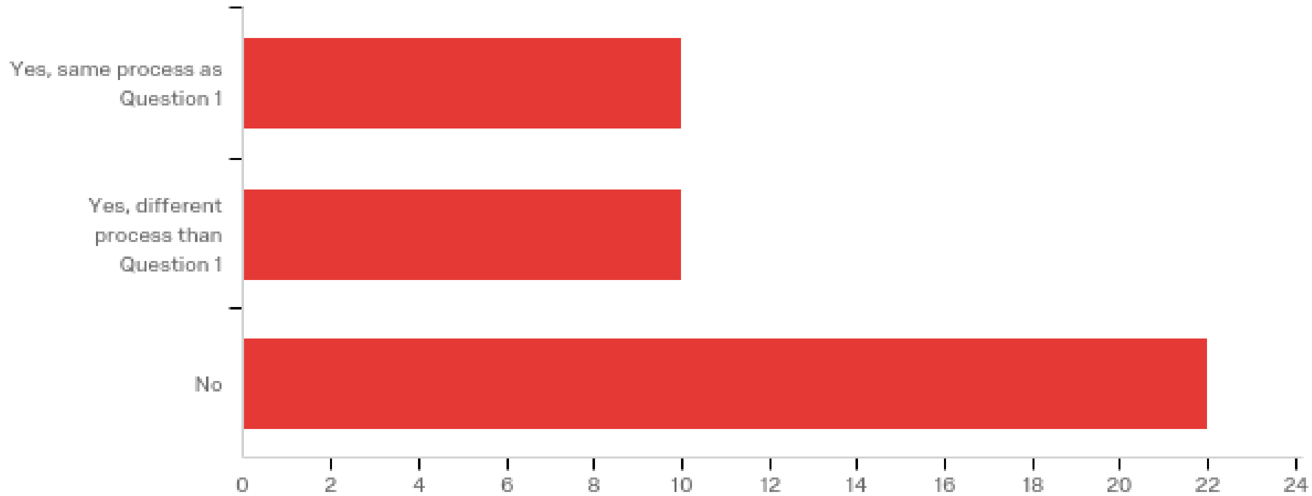
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT have a documented process for collecting the proposed or installed location information of new utility installations or relocations occurring during a DOT construction project within right-of-way?	1.00	3.00	2.18	0.91	0.83	44

#	Answer	%	Count
1	Yes, same process as Question 1	34.09%	15
2	Yes, different process than Question 1	13.64%	6
3	No	52.27%	23
	Total	100%	44

Q8 - Would you provide a link or access to that documentation?

Would you provide a link or access to that documentation?
https://hidot.hawaii.gov/highways/s2005-standard-specifications/2005-standard-specifications/
Same
Majority of utility relocations are MOVE IN state contract whereby the utility relocation is performed by the highway contractor/sub. The utility provides "detailed" proposed utility relocation plans. TnDOT does not currently maintain AS BUILT plans.
Currently, we are only requesting as-built utility information on Design-Build type projects as part of the contract items.

Q9 - If utility installations are constructed by a DOT procured contractor, is there a documented process for collecting the proposed or installed location information of new utility installations or relocations?



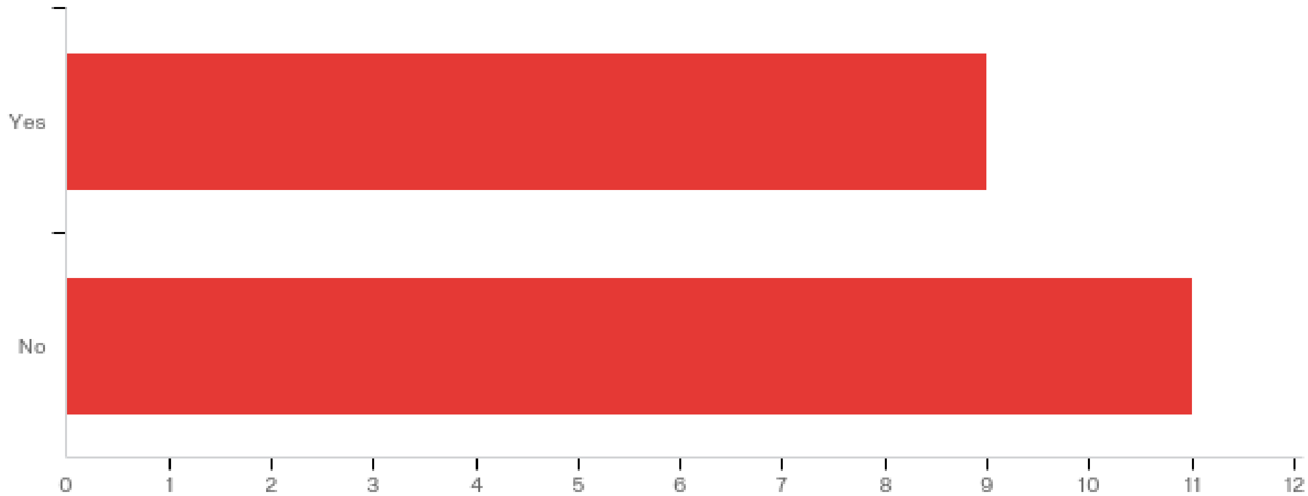
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	If utility installations are constructed by a DOT procured contractor, is there a documented process for collecting the proposed or installed location information of new utility installations or relocations?	1.00	3.00	2.29	0.82	0.68	42

#	Answer	%	Count
1	Yes, same process as Question 1	23.81%	10
2	Yes, different process than Question 1	23.81%	10
3	No	52.38%	22
	Total	100%	42

Q10 - Would you provide a link or access to that documentation?

Would you provide a link or access to that documentation?
If the utility relocation work is done within the roadway construction contract the plan of adjustment is part of the contract plans. The actual construction alignment is incorporated in the final As-built plans.
Engineering document unit
http://www.dot.state.ak.us/stwddes/dcsspecs/assets/pdf/hwyspecs/sshc2017.pdf Section 105-1.02 In addition we will add additional survey criteria via special provisions to our standard specifications. GIS data collection is not required as the State of AK does not have resources in place to manage the data.
Same
Majority of utility relocations are MOVE IN state contract whereby the utility relocation is performed by the highway contractor/sub. The utility provides "detailed" proposed utility relocation plans. TnDOT does not currently maintain AS BUILT plans.
UAM, Specs
No
See last response.

Q11 - Are there accuracy requirements for the location information within your processes?



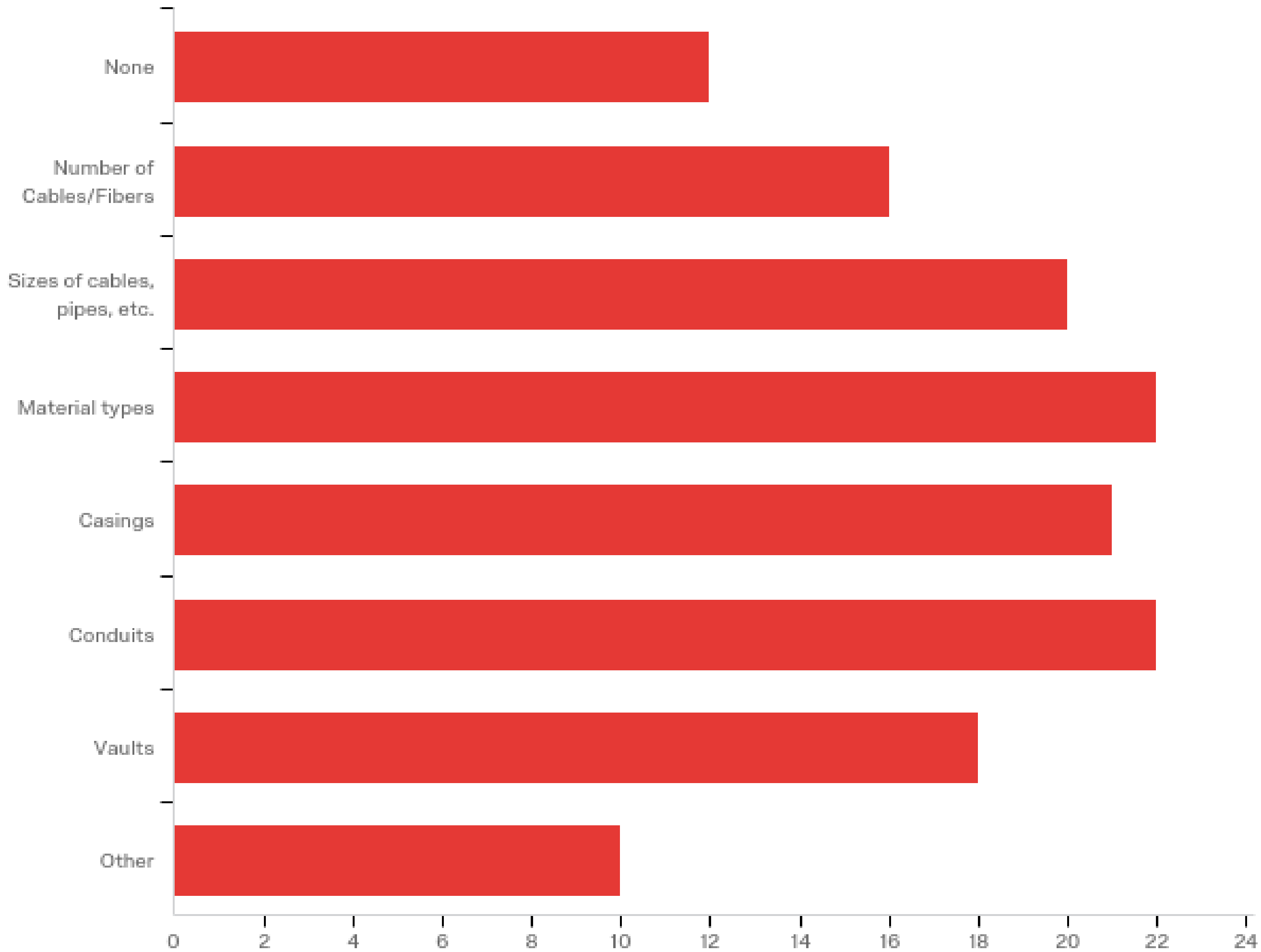
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are there accuracy requirements for the location information within your processes?	1.00	2.00	1.55	0.50	0.25	20

#	Answer	%	Count
1	Yes	45.00%	9
2	No	55.00%	11
	Total	100%	20

Q12 - Would you describe the accuracy requirements?

Would you describe the accuracy requirements?
See Table 105.10-1 in the following link: https://hidot.hawaii.gov/highways/files/2013/01/105E__Control-0f-Work__Print.pdf
As Built Plans confirmed with metes and Bounds descriptions.
Refer to Chapter 15 of the UDOT Survey & Geomatics Manual here https://docs.google.com/document/d/1dF_8qQHczpiN4J6_ZOGhLh74b2eM0uf0hEbi0l7yNik/edit
with in 3 feet
only when added by special provisions. Below is an example for a water line system. The Contractor shall prepare asbuilt drawings as the work progresses and final record drawings as described below. Acceptable record drawings will be prepared on copies of the project construction drawings to depict all lines, grades, locations, materials, and other elements of the work as actually constructed with clearly marked final elevations and locations with actual dimensions. Noted stations, elevations, slopes and other design dimensions shall be shown on the construction drawings with “ASB” if no change occurs in the field. The Contractor shall survey the work and all utilities and obstructions encountered during construction in a manner producing an accuracy of 0.03 feet vertically and 0.5 feet horizontally, and reference that as-built information to both project survey control and to pipe stationing.
Must be placed within the specified location and depth or the permit becomes void.
Please reference the DRAFT procedural manual.
Elevations with an accuracy of +/- 0.05 ft. and certified accurate to the benchmark(s) used to determine elevations Horizontal data accurate to within +/- 0.2 ft. or applicable survey standards, whichever is more precise

Q13 - What attributes of utility facilities are being collected?

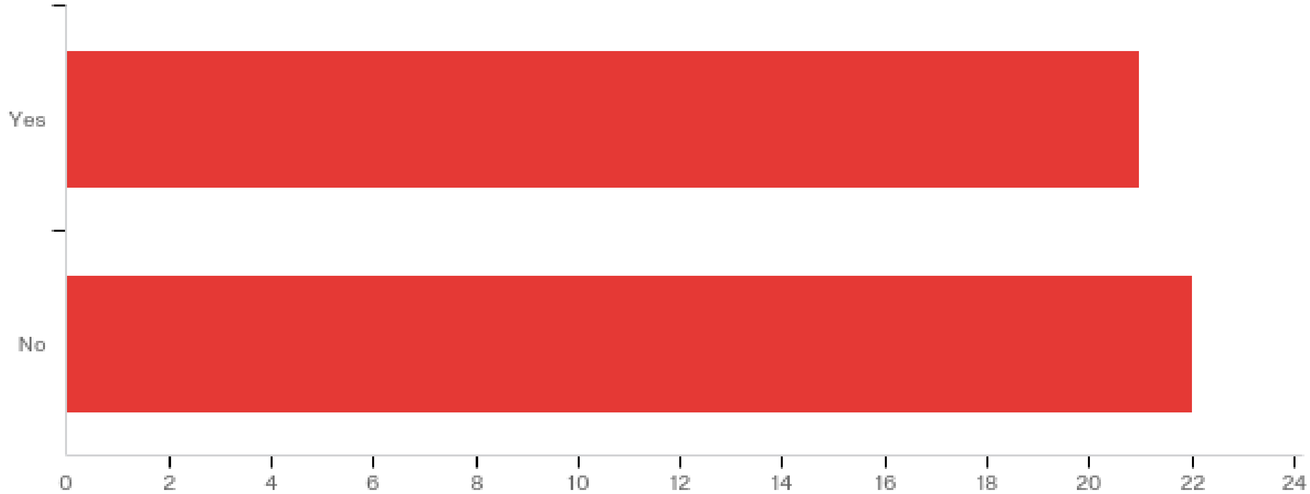


#	Answer	%	Count
1	None	8.51%	12
2	Number of Cables/Fibers	11.35%	16
3	Sizes of cables, pipes, etc.	14.18%	20
4	Material types	15.60%	22
5	Casings	14.89%	21
6	Conduits	15.60%	22
7	Vaults	12.77%	18
8	Other	7.09%	10
	Total	100%	141

Q13_8_TEXT - Other

Other - Text
Currently we do not collect this information. However, we are in the process of changing our Utility Accommodation Code to get better as-built information.
"Out of Service"
Not on a constinent basis
Anything required for payment
Other information required by process in UAM
Please reference the DRAFT procedural manual.
Steel Plates, backfilled patches

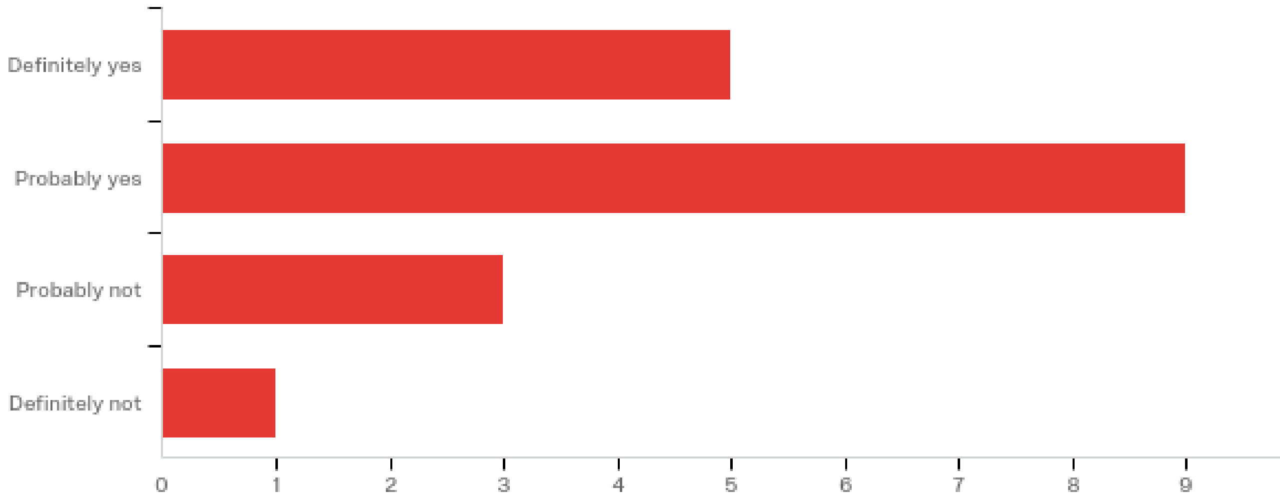
Q14 - Are you aware of the new ASCE Utility As-Built Standard?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are you aware of the new ASCE Utility As-Built Standard?	1.00	2.00	1.51	0.50	0.25	43

#	Answer	%	Count
1	Yes	48.84%	21
2	No	51.16%	22
	Total	100%	43

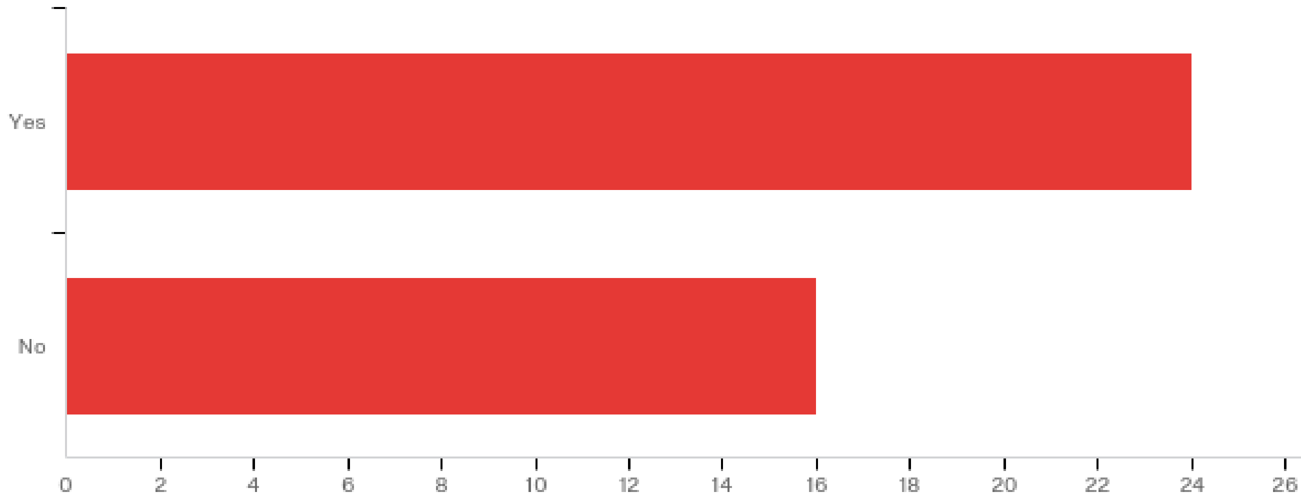
Q15 - Do you plan to incorporate the ASCE Utility As-Built Standard into your as-built requirements?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you plan to incorporate the ASCE Utility As-Built Standard into your as-built requirements?	1.00	4.00	2.00	0.82	0.67	18

#	Answer	%	Count
1	Definitely yes	27.78%	5
2	Probably yes	50.00%	9
3	Probably not	16.67%	3
4	Definitely not	5.56%	1
	Total	100%	18

Q16 - Does your DOT inspect new utility installations or relocation placements for location accuracy?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT inspect new utility installations or relocation placements for location accuracy?	1.00	2.00	1.40	0.49	0.24	40

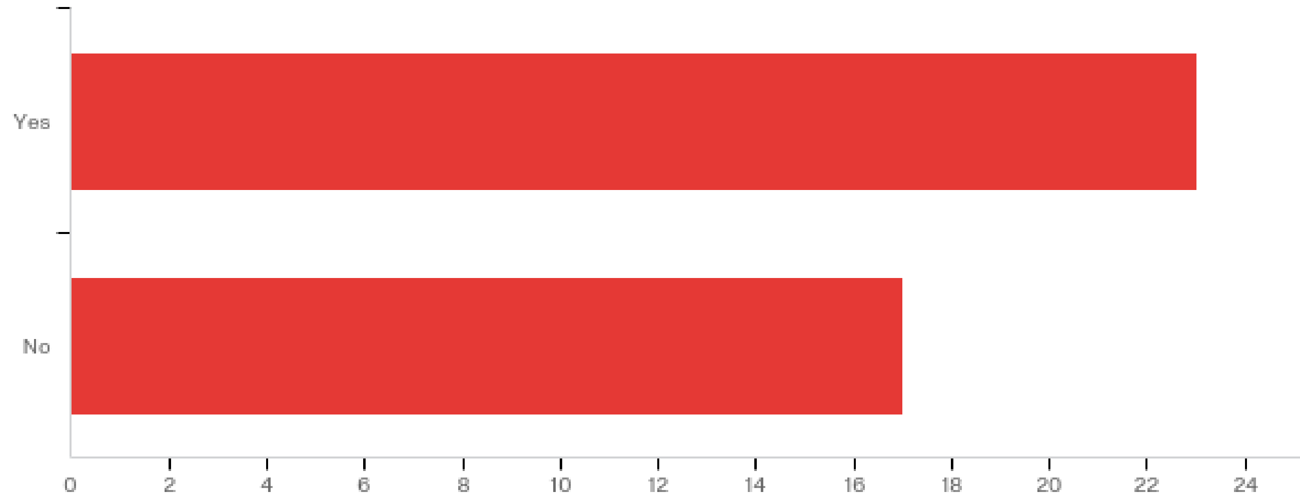
#	Answer	%	Count
1	Yes	60.00%	24
2	No	40.00%	16
	Total	100%	40

Q17 - Comments (Please specifically comment on any geospatial inspection that occurs):

Comments (Please specifically comment on any geospatial inspection that occurs):
Conventional Total Station and Scanning methods are used. GNSS, LiDAR, handheld GPS methods are not used due to insufficient accuracy.
On site inspectors.
See Table 105.10-1 per the following link: https://hidot.hawaii.gov/highways/files/2013/01/105E__Control-0f-Work__Print.pdf
We are working on a Utility Information data repository that will capture this information in the future. We are currently testing new software so that will be ready to go when the revised Utility Accommodation Code rules go into effect around early 2020.
Not all are inspected due to staffing
All new utility installations are collected with a positional accuracy that is verified by positional intelligence built into our software. For example all data collected with survey grade GPS systems provide an electronic record of the location, VDOP, PDOP, Horizontal and Vertical accuracy that is captured with every point collected and is included in our database.
Relocation is collected sporadically spatially. As a single point of data per inspection. Very low accuracy data, can be many meters off.
Location accuracy to station / offset. Not to a surveyed accuracy.
Each Field Division has a Utility Coordinator that is onsite to monitor installation. No geospatial inspection/documentation.
Inspection is performed on select improvement projects, and randomly on utility permits.
Field inspection per UAM
sometimes but not all the time on every job because most of the time the companies have installed and left before it can be inspected so no one was aware of the installation other than the approved permit.
We do field inspections for requested permits, but no geospatial information is documented.
Only field observation, no data gathered.
Some regions collect data with a GNSS tablet and download it into a database.
No geospatial inspection occurs.
Survey 123 application from ArcGIS
The Project Engineer verifies the work of the utilities, in particular those who are reimbursed, in order to allow payment for the work. The extent of the verification of proper location of the install is unknown.
Our current permitting system does not capture as-built information and staffing is an issue.
We inspect work but the intent of the inspection is to ensure proper installation techniques, MOT, restoration, etc. Facilities are not inspected for placement accuracy but our inspectors

will try to ensure they are roughly being placed in accordance with plans, especially when the work is a result of a highway project.

Q18 - Does your DOT require utility companies or contractors (installing utilities) to submit as-built plans?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT require utility companies or contractors (installing utilities) to submit as-built plans?	1.00	2.00	1.43	0.49	0.24	40

#	Answer	%	Count
1	Yes	57.50%	23
2	No	42.50%	17
	Total	100%	40

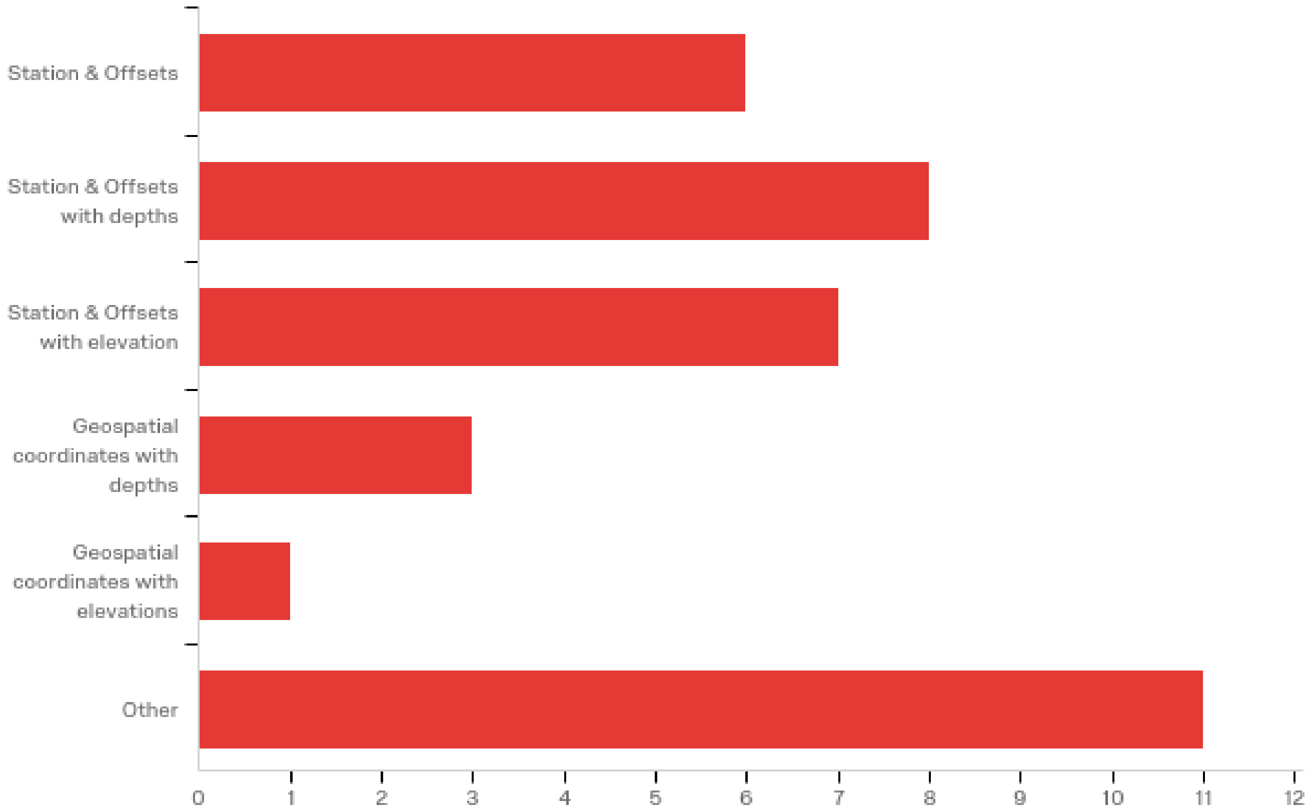
Q19 - Comments:

Comments:
See Section 930-7(11)(6) for GPS requirements https://rules.utah.gov/publicat/code/r930/r930-007.htm
Occasionally this is done depending the utility facility being constructed and the necessity to ensure that the facility was constructed as planned due to potentially impacting other construction work and activities within the right of way.
Our permitting process "requires" utility companies to submit as-builts, but they rarely do and most often they simply submit the permitted location as the as-built. Any as-builts received are filed in an electronic records system and not incorporated into road as-builts nor utilized in future design.
The requirement has always been there for as-built plans. However, this has not been consistently enforced and there has not been a place to put this information. We are working on a Utility Information data repository that will capture this information in the future. We are currently testing new software so that will be ready to go when the revised Utility Accommodation Code rules go into effect around early 2020.
Not always received
Only required if a requirement by the utility company.
They are not geospatial. Paper is accepted and we suspect as builts may not be accurately depicting field changes
ITD requires As-built plans, but doesn't always receive them. ITD is inconsistent in following-up with Utility Companies to obtain the as-built plans. Further the quality of the as-builts vary greatly in quality/accuracy.
The format of plans and the level of detail vary widely since we don't currently have standards, but this will quickly change with the release of our online utility location data repository.
Receive bore logs.
WisDOT has required this in rare cases on utility permits-- usually associated with a highway improvement project.
Some installations require submittal of as-built plans, some do not.
yes but I do not know where they are stored. and not sure if it is enforced
As-built are only required for utilities that were reimbursed.
However, we do not receive them all of the time.
the accepted practice has been - that if the Utility installs within no more than 2 feet from the proposed installation on the application - they do not need to submit an as-built and the maps provide with the application are considered the as-built
Case by case basis for new permit installations.
For underground, strongly required especially if a payment is involved. For aerial, a little more relaxed and use PS&E submissions if the company does not stamp or certify.

We say that we require As-Built Plans, but since we are not presently doing anything with As-Builts, we have not held the contractors accountable to doing it If all we are doing is filing it, seems like a practice without benefit.   As part of creating a GIS, we will specify format and accuracy standards.

Again, this as-builts are only a requirement on Design-Build type projects. On the permitting side, we are requesting lat/longs for small cell installations and working with our GIS team to map them; the utilities are not required to provide as-builts for encroachment permits.

Q20 - Which of the following describes the location information required of utility companies or contractors (installing utilities) regarding utility installations (or relocations)?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Which of the following describes the location information required of utility companies or contractors (installing utilities) regarding utility installations (or relocations)? - Selected Choice	1.00	6.00	3.50	1.89	3.58	36

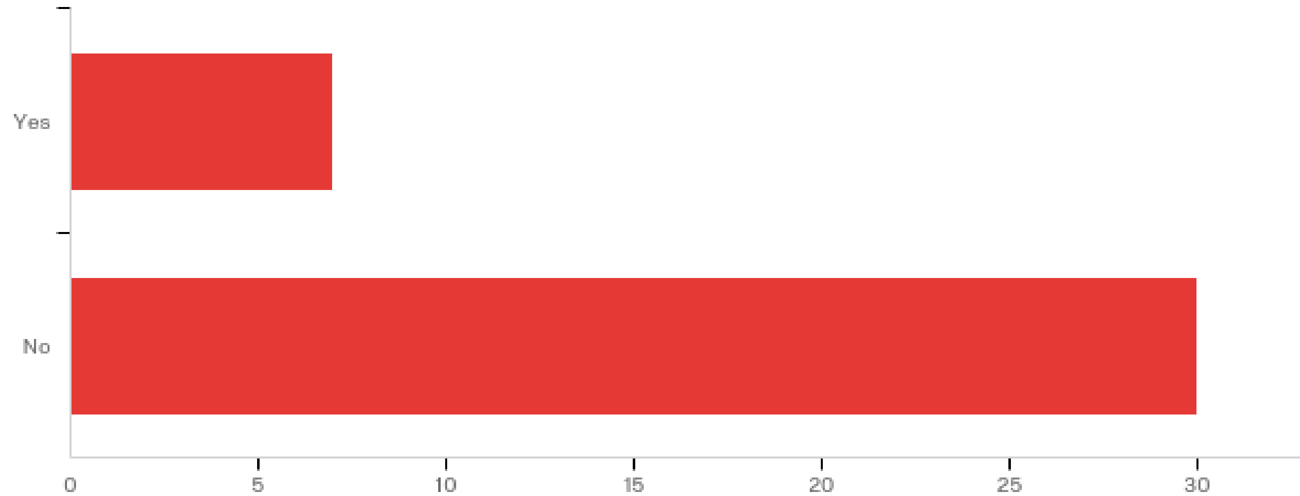
#	Answer	%	Count
1	Station & Offsets	16.67%	6
2	Station & Offsets with depths	22.22%	8
3	Station & Offsets with elevation	19.44%	7

4	Geospatial coordinates with depths	8.33%	3
5	Geospatial coordinates with elevations	2.78%	1
6	Other	30.56%	11
	Total	100%	36

Q20_6_TEXT - Other

Other - Text
This is done on an as needed basis.
drawing/sketch
WisDOT typcially utilizes station and offset, but in rare instances has required geospatial information.
Station & Offsets with depths and/or elevations
Mile posts and offsets with depths
Distance off right of way.
Mileposts and Offsets from centerline or fogline
Geospatial X and Y, no Z axis.
All underground utilities that were relocated, adjusted or newly installed within the Project limits will be surveyed by a certified licensed surveyor at the time of installation to determine the exact location and position of the utility line.
None of this is required

Q21 - Are utility installation (or relocation) as-built plans required according to geospatial locations or accuracy levels?



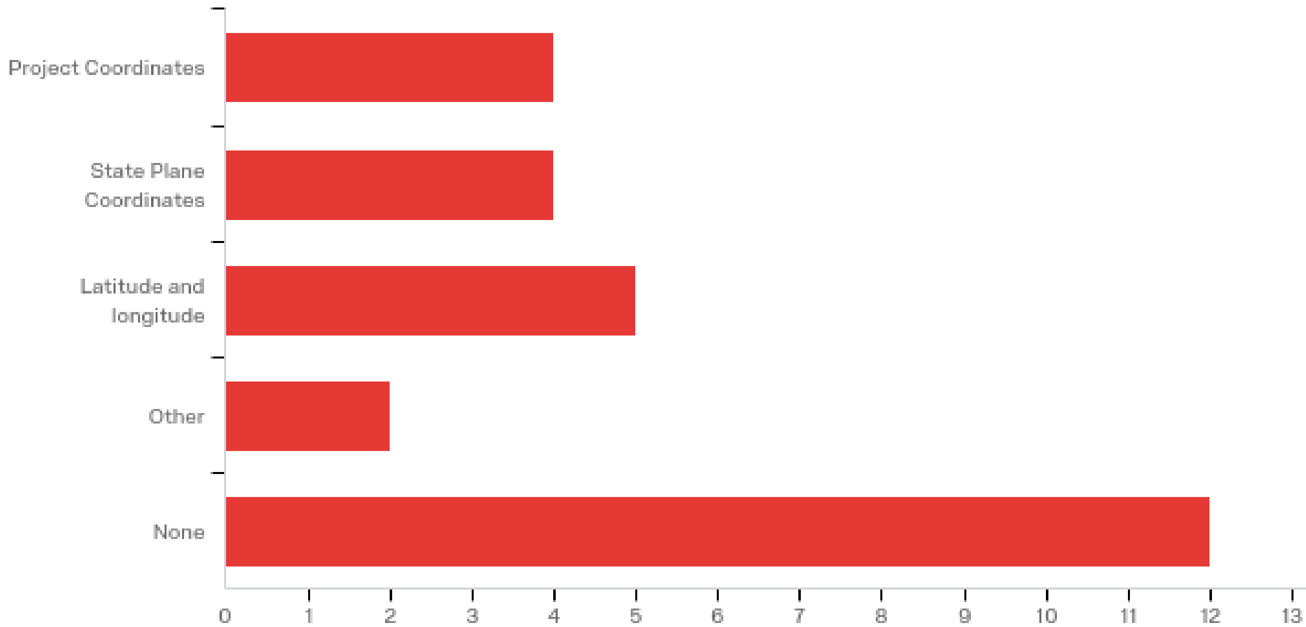
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Are utility installation (or relocation) as-built plans required according to geospatial locations or accuracy levels?	1.00	2.00	1.81	0.39	0.15	37

#	Answer	%	Count
1	Yes	18.92%	7
2	No	81.08%	30
	Total	100%	37

Q22 - If yes, could you provide a link or access to that documentation and/or provide comments below:

If yes, could you provide a link or access to that documentation and/or provide comments below:
See Table 105.10-1 per the following link: https://hidot.hawaii.gov/highways/files/2013/01/105E__Control-0f-Work__Print.pdf
Design Section is the custodian of As Built Plans
https://rules.utah.gov/publicat/code/r930/r930-007.htm
See Table 105.10-1 per the following link: https://hidot.hawaii.gov/highways/files/2013/01/105E__Control-0f-Work__Print.pdf
We are working on a Utility Information data repository that will capture this information in the future. We are currently testing new software so that will be ready to go when the revised Utility Accommodation Code rules go into effect around early 2020.
Still under development, but available during the summer of 2019
Horizontal locations are surveyed to the same accuracies and precision as is required for the topographic data - design-build only.

Q23 - If geospatial locations are required, what coordinate system is used?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	If geospatial locations are required, what coordinate system is used? - Selected Choice	1.00	5.00	3.52	1.52	2.32	27

#	Answer	%	Count
1	Project Coordinates	14.81%	4
2	State Plane Coordinates	14.81%	4
3	Latitude and longitude	18.52%	5
4	Other	7.41%	2
5	None	44.44%	12
	Total	100%	27

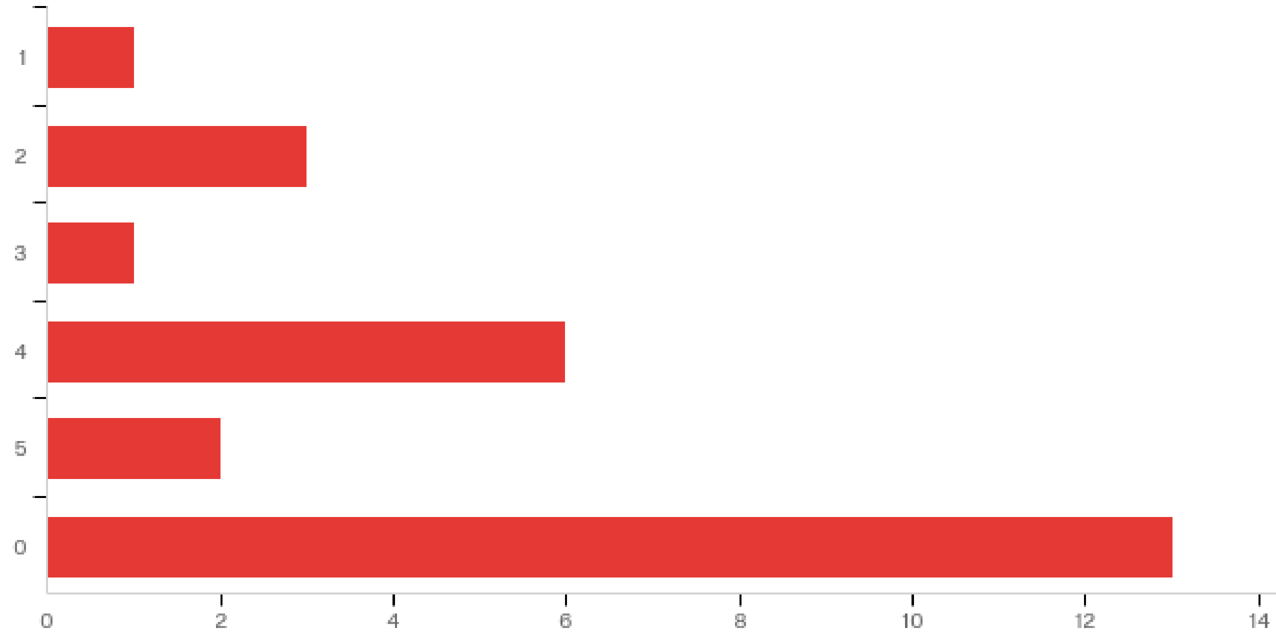
Q23_4_TEXT - Other

Other - Text
currently varies. Looking at using state plane and lat/longs
N/A

Q24 - Please describe the process by which utility as-built plan information is collected when horizontal directional drilling is used for utility installations.

Please describe the process by which utility as-built plan information is collected when horizontal directional drilling is used for utility installations.
Design section would monitor.
We do not have a final defined process for this at this time.
We do request as-built plan information for horizontal directional drilling on relocations for highway projects when available.
There is not a specific process for horizontal directional drilling as-builts.
This information will be collect using new software. The software will be free for contractors and inspectors to use. ProStar Geocorp has mobile Pointman software that can be used with survey equipment or smart phones and hand held devices.
Bore logs
none
CDOT's mobile application is utilized in the filed by HDD company capturing the bore log with a highly accurate horizontal position and approximate depth of installation.
This is greatly dependent upon the Utility Company. A few of the companies submit engineered drawings while other submit sketches. Currently, ITD doesn't directly collect as-built data.
The current process doesn't have a consistent format and method for collecting, but we expect to use the bore logs in the future and assign depths that can then be used to calculate elevation.
Receive bore log from contractor.
WisDOT is in the process of looking into the feasibility of collecting this type of information.
Spec for directional drilling, UAM
None currently
Utility submits as-bilt for location off right of way with depth being an exception if different that what our Utility Accommodation Policy states is the minimum.
If there is an inspector on site - they gather the information and document it. If no inspector is on site- the utility office typically will ask the utility/contractor to provide that.
At this time, Michigan DOT does not have defined process.
Hopefully utility permit inspectors are able to collect data points at each hole.
Bore logs are required on all bored in facilities on design-build projects.
None at this time.

Q25 - From the table below, what is the best representation of the location accuracy your DOT requires for utility company (or utility installation contractor) provided as-built plans (select all that apply)?
Positional Accuracy Level Positional Accuracy (English Units) 1 0.1 feet 2 0.2 feet 3 0.3 feet 4 1 foot 5 3 feet 0 Indeterminate

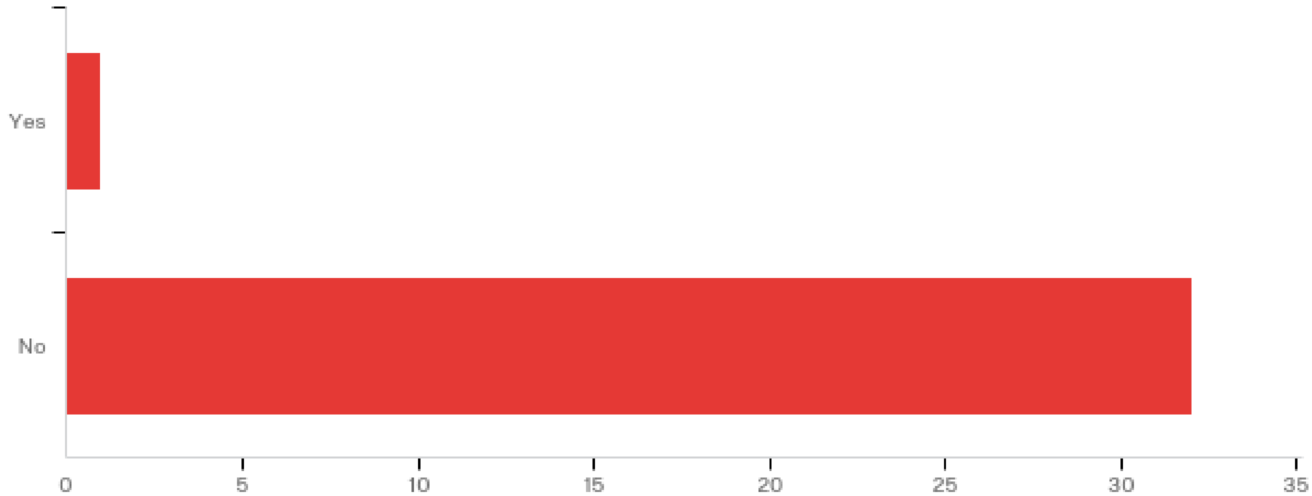


#	Answer	%	Count
4	1	3.85%	1
5	2	11.54%	3
6	3	3.85%	1
7	4	23.08%	6
8	5	7.69%	2
9	0	50.00%	13
	Total	100%	26

Q56 - Please provide any comments you have regarding the accuracy selection from the previous question.

Please provide any comments you have regarding the accuracy selection from the previous question.
See Chapter 15 (Accuracy Attributes) in the UDOT Survey & Geomatics manual https://docs.google.com/document/d/1dF_8qQHczpiN4J6_ZOGhLh74b2eM0uf0hEbi0l7yNik/edit
We do not currently incorporate an accuracy level into our as-built requirements.
The software will code in the level of accuracy so that it will be know what information and how it was collected.
The accuracy is dependent upon the project scope of work and not all utility companies have the means to obtain the accuracy levels identified above. CDOT will waive this requirement in certain instances and allow less accurate as-builts to be accepted.
Going forward, later this year we expect to use 3H and 4V
N/A
I am not personally aware of the current level of accuracy required
WisDOT has no set policy requirements.
Selected '0' as it depends on the type of utility
Utilities are given a five foot corridor to install the facilities from the edge of the right of way which they are expected to stay in along with other utilities that may be present.
At this time, Michigan DOT does not a required location accuracy requirement.
The accuracy standard requirement may be a function of the cost of gathering it.

Q26 - Have there been any legal cases in your state showing utility companies acted negligently in not providing, or providing inaccurate or insufficient existing utility as-built data resulting in project delays or damages?



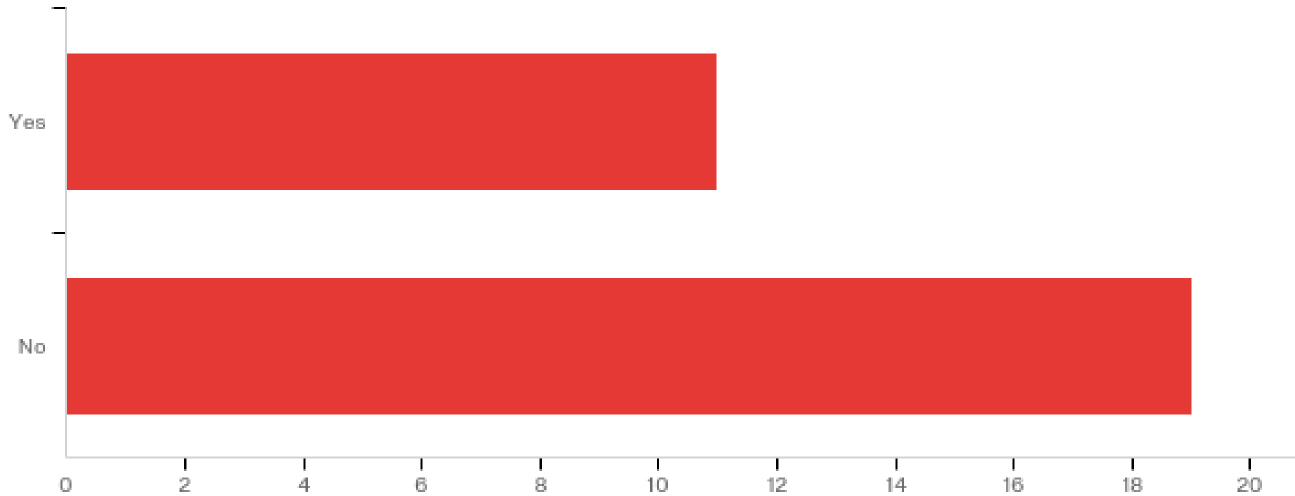
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have there been any legal cases in your state showing utility companies acted negligently in not providing, or providing inaccurate or insufficient existing utility as-built data resulting in project delays or damages?	1.00	2.00	1.97	0.17	0.03	33

#	Answer	%	Count
1	Yes	3.03%	1
2	No	96.97%	32
	Total	100%	33

Q27 - Please Explain:

Please Explain:

Q28 - Does your DOT have legal authority to require as-built plans to an accuracy level?



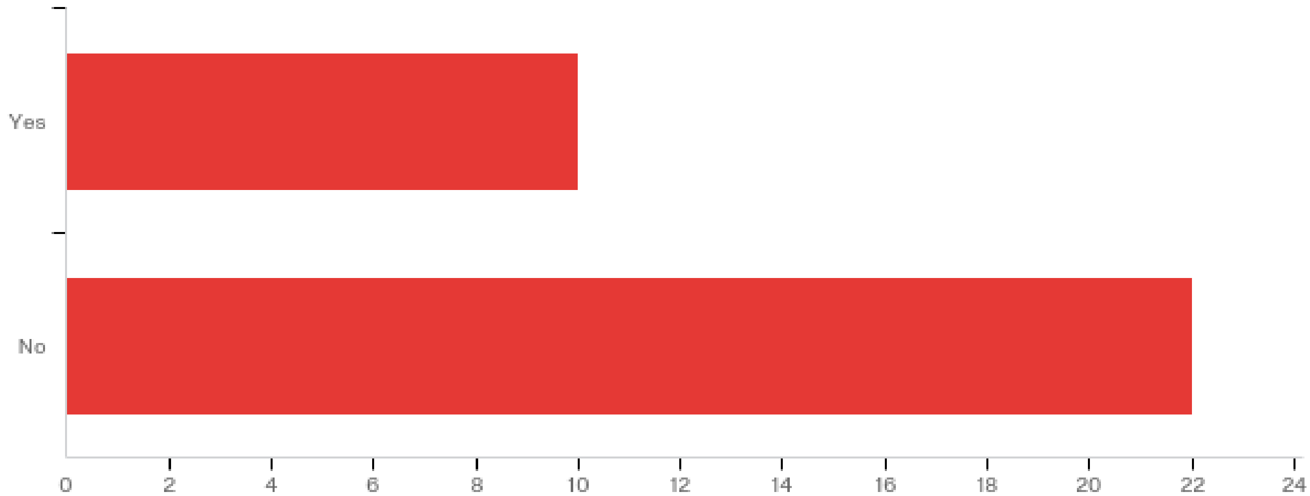
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT have legal authority to require as-built plans to an accuracy level?	1.00	2.00	1.63	0.48	0.23	30

#	Answer	%	Count
1	Yes	36.67%	11
2	No	63.33%	19
	Total	100%	30

Q29 - Comments:

Comments:
https://rules.utah.gov/publicat/code/r930/r930-007.htm Refer to Section R930-7(11)(6) GPS Requirements.
This is not required per our code of state regulations.
Yes, through the Utility Accommodation Code.
unknown: Our utility manual requires surveyed as-builts sealed by a licensed surveyor. However, this has not been enforced by the State. Utility companies are required to provide locates on the ground. From past communications and current practice regarding this topic the State of AK has accepted the design locates as a trade off to as-builts.
Not sure
See Div 1 of Specs
The level of accuracy can be defined/required in the special provision of the Permit.
For question "Have there been any legal cases in your state showing utility companies acted negligently in not providing, or providing inaccurate or insufficient existing utility as-built data resulting in project delays or damages?" I answered NO, however I need to clarify this with none that I'm aware of. For question "Does your DOT have legal authority to require as-built-plans to an accuracy level?" I answered yes, assuming Michigan DOT does, but this is currently not a requirements and if it were, and contested by utilities, then the outcome is unknown.
I think that we can require an accuracy standard, but we have not done so yet.
It is not something that is clearly outlined in our current regulation/law but that may change.

Q30 - Does your DOT require professional stamping (PLS or PE) for utility as-built plans?



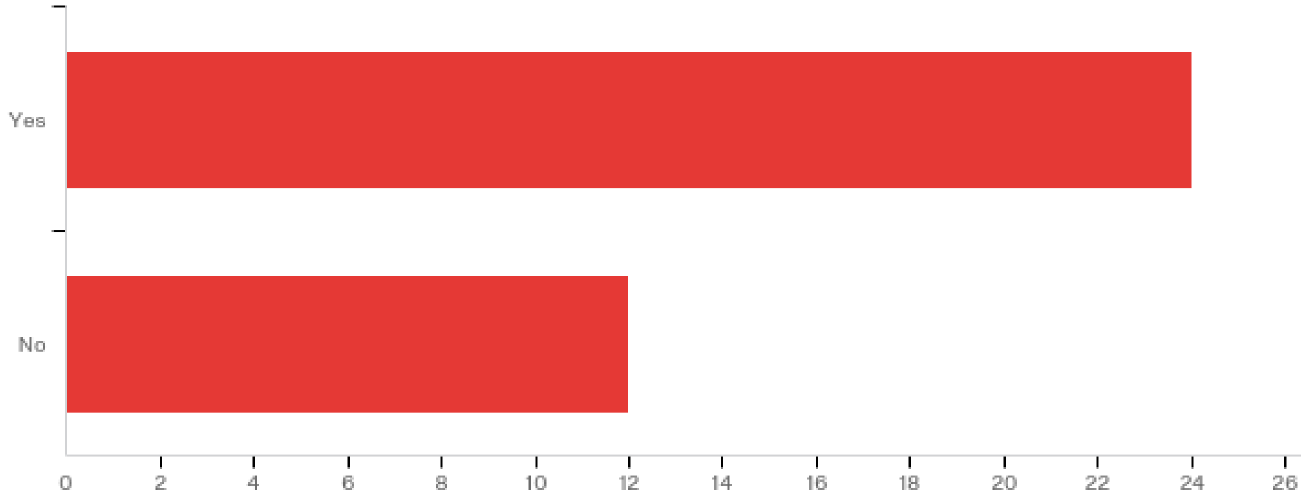
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT require professional stamping (PLS or PE) for utility as-built plans?	1.00	2.00	1.69	0.46	0.21	32

#	Answer	%	Count
1	Yes	31.25%	10
2	No	68.75%	22
	Total	100%	32

Q31 - Comments (If yes, please explain. Also, which entity provides the stamping):

Comments (If yes, please explain. Also, which entity provides the stamping):
Consultant
Yes, but we are only requiring professionally stamped as-built plans for professionally designed projects. Meaning, if a project is designed by a professional engineer, then stamped as-built plans will be required. If a project is not designed by a professional engineer, then stamped as-built plans will not be required.
This is a requirement, however, it is not actively enforced. It is required if regulated by others such as for water and sewer and oil/gas facilities. The stamping entity is provided by the utility company.
https://www.codot.gov/business/permits/utilitiesspecialuse/utility-accommodation-code Section 3.3.4.5
Not sure
About 5 years ago, ITD attempted to require survey grade as-builts from utility companies. Many of the smaller (Mom & Pop) utility companies pushed back, saying they didn't have adequate funds to provide this data, saying it would put them out of business if they were required to provide such. ITD dropped the requirement.
We are currently exploring requiring a PE or PLS to certify as-built data.
As built plans are not required, but PE standards require stamping/sealing all engineer drawings.
Not sure
typically only on Bridge plan submittals
Again, only underground as Utility owners employ Engineers for this service. Our DOT receives the records.
This is an item that may require further discussion as we set up a GIS.
The Design-Build Team's engineer.

Q32 - Do you believe DOTs should require professional stamping (PLS or PE) for utility as-built plans?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you believe DOTs should require professional stamping (PLS or PE) for utility as-built plans?	1.00	2.00	1.33	0.47	0.22	36

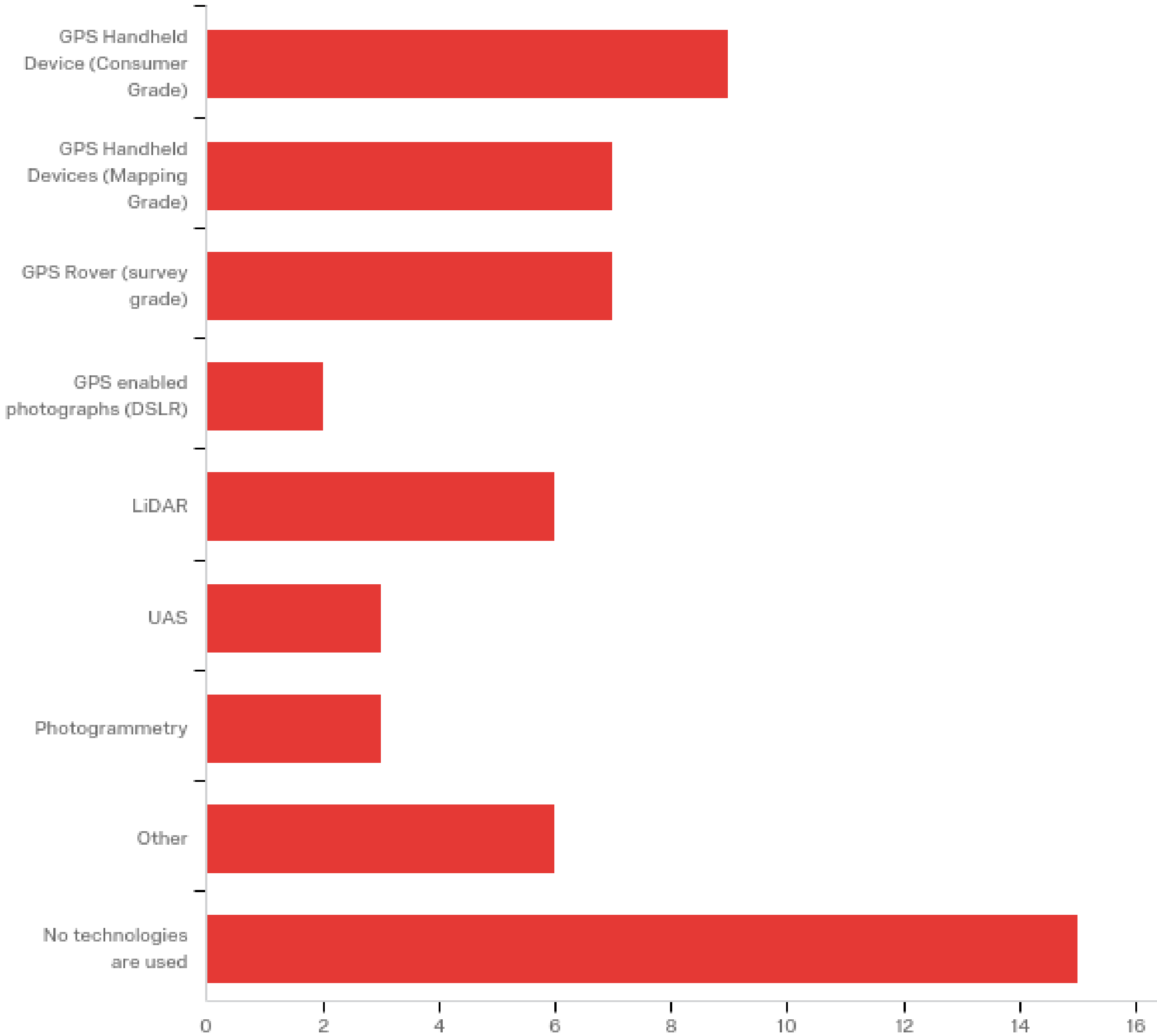
#	Answer	%	Count
1	Yes	66.67%	24
2	No	33.33%	12
	Total	100%	36

Q33 - Comments (If yes, please explain):

Comments (If yes, please explain):
This would be helpful. However there are several utility contractors they may not be able to provide professional stamping without changes in their operation.
It is my belief that the utility facilities located within the highway right-of-way become a physical feature of the highway facility and should therefore represent the same level of accuracy that we require for our highway plans. I am not sure the Iowa DOT would be successful in proposing the requirement of accuracy level certified as-built submission by utility companies. At this point in time we have no method or process to capture and utilize this information. It is my vision, however, to do so in the future.
Yes, but only projects or installations that requiring professionally stamped design plans. Meaning, if a project is designed by a professional engineer, then stamped as-built plans will be required. If a project is not designed by a professional engineer, then stamped as-built plans will not be required.
Utilities may not have that level of staff
This would be a very high cost to utility companies and also problematic for underground installations not installed via open trench. The state of AK is limited with specialty resources who are able to provide subsurface utility engineering.
Not all plan sets require a PE or PLS to be responsible in change. If a design requires the PE or PLS to be in responsible in charge, the answer is yes other wise no.
As builts should have professional survey to determine the best accuracy.
The demand for space within the rights-of-way is becoming increasingly significant. Accurately located and cataloged inventory is becoming more important as technology improves.
We are looking at making a PE/PLS an option to avoid MDT receiving bad information. Another option is certification from a manager within the utility
The current department position is as built plans are not maintained. Each new project requires new survey of facilities. Changes in data maintenance and storage has evolved, and personnally I consider any information available provides more knowledge. There remains the residual issue of revising those "as built" plans, and the resoruces that would be needed to maintain and up to date as built plans, and the value of such depository.
Not necessary
What should be, is not what's realistic for so many small companies who cannot afford the additional expense.
To provide a level of due diligence and ownership of the data provided.
I would like to see that.
If it is a utility relocation, most likely the utility would be reimbursable, so if we were paying to relocate, then we would pay for the As-Built Survey and would get what we want.
We also require a statement certifying that the record drawings reflect the true conditions in the field. Certification applies to new as-built information only.

This would help better ensure accurate info and to ensure requirements/tolerances were followed during collection.

Q34 - What technologies does your DOT use in collecting utility as-built information (select all that apply)?



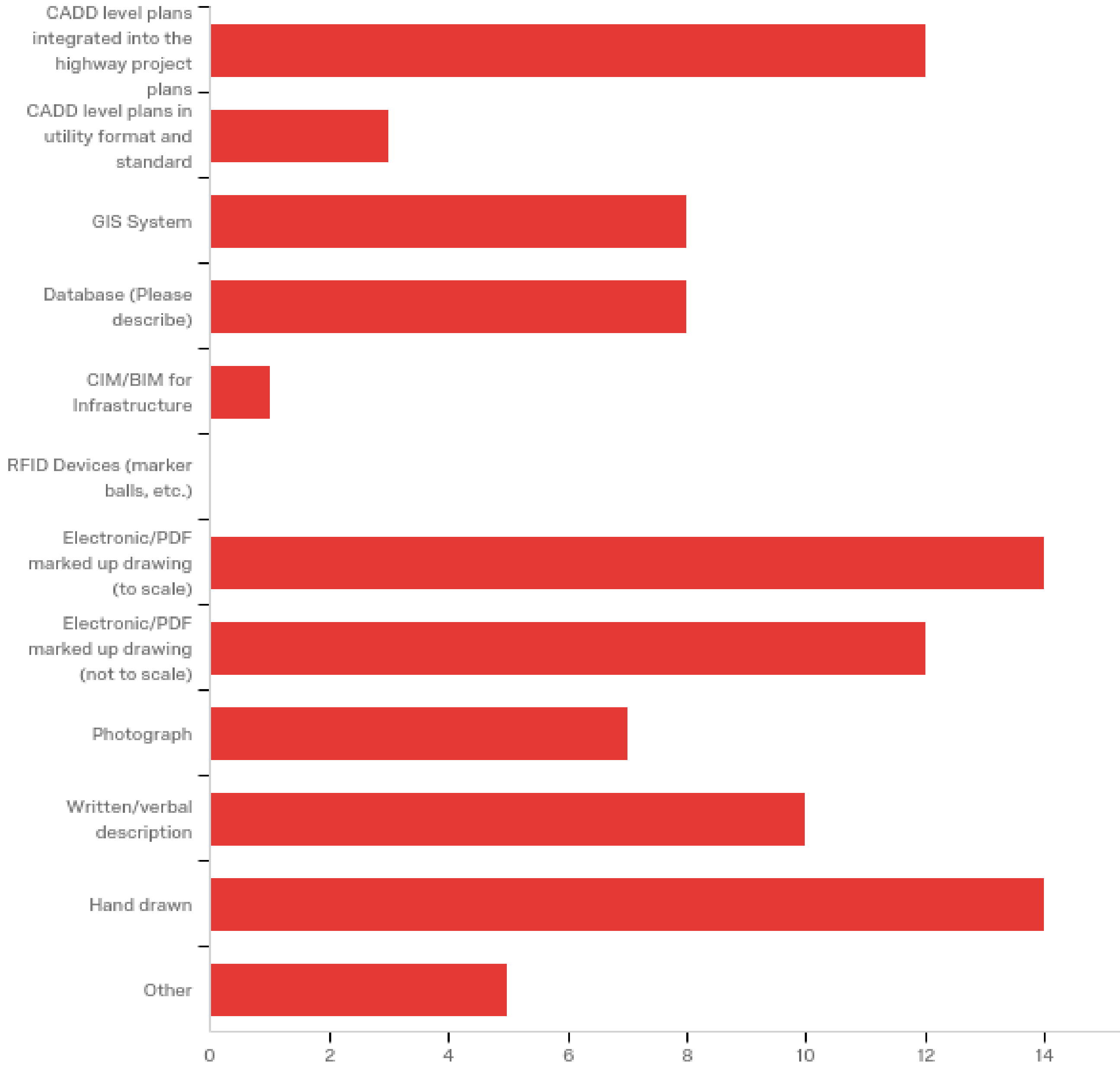
#	Answer	%	Count
15	GPS Handheld Device (Consumer Grade)	15.52%	9
1	GPS Handheld Devices (Mapping Grade)	12.07%	7
2	GPS Rover (survey grade)	12.07%	7
5	GPS enabled photographs (DSLR)	3.45%	2
10	LiDAR	10.34%	6
11	UAS	5.17%	3

12	Photogrammetry	5.17%	3
6	Other	10.34%	6
7	No technologies are used	25.86%	15
	Total	100%	58

Q34_6_TEXT - Other

Other - Text
Conventional Geodetic, Ground based scanning
Conventional Geodetic
Robotic and total station
Transit, tape, and level
Any technology to accurately track directional bore-head

Q36 - In what medium, does your DOT record utility as-built information (select all that apply)?



#	Answer	%	Count
1	CADD level plans integrated into the highway project plans	12.77%	12
2	CADD level plans in utility format and standard	3.19%	3
3	GIS System	8.51%	8
10	Database (Please describe)	8.51%	8
11	CIM/BIM for Infrastructure	1.06%	1

12	RFID Devices (marker balls, etc.)	0.00%	0
4	Electronic/PDF marked up drawing (to scale)	14.89%	14
5	Electronic/PDF marked up drawing (not to scale)	12.77%	12
6	Photograph	7.45%	7
7	Written/verbal description	10.64%	10
8	Hand drawn	14.89%	14
9	Other	5.32%	5
	Total	100%	94

Q36_10_TEXT - Database (Please describe)

Database (Please describe) - Text
ProStar Geocorp, Pointman
Shapefiles
Kepts and Kurt's have gespatial collection elements with low accuracy
Permitting Database
Utility and Permit database
iMap Maryland ArcGIS

Q36_9_TEXT - Other

Other - Text
not on a consistent basis
The Michigan DOT does no collect and/or record permitted utiltiy location information.
ProjectWise
Not requiring yet.
Mix right now when we collect

Q35 - Please provide the RFID protocol you use (location, attributes, etc. information on the device)

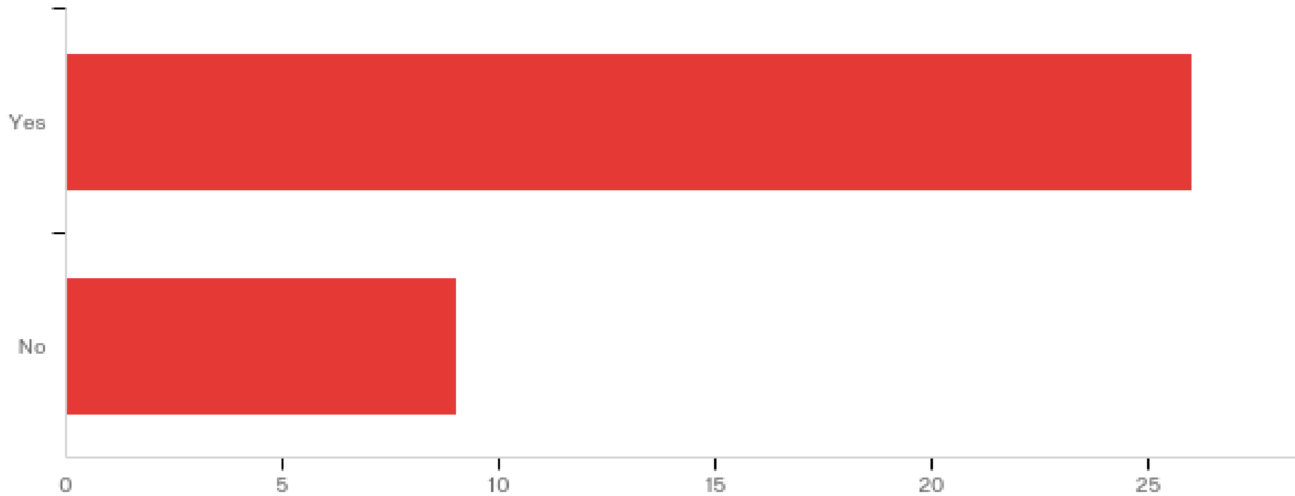
Please provide the RFID protocol you use (location, attributes, etc. information on the device)

Q37 - Please describe the process by which utility as-built plan information is collected (who, when, how).

Please describe the process by which utility as-built plan information is collected (who, when, how).
Before the closure of a project, all as-built data is required to be submitted to the DOT as a requirement of completion. The project PM will ensure the satisfaction of the as-built requirement and when the PM is satisfied that all requirements are met, the project will be officially closed.
When as-builts are provided for a relocation they are incorporated into the final as-builts for the project. If they are provided for a permit project they are included in the permit data base.
Upon completion of installation, the documentation, usually in the form of a pdf, is sent by email from the utility company to our Engineering Operations Technician that approved the installation permit and imported into our electronic records management system (document repository).
The utility as-build information will be collected by either the contractor or third party at the time of installation. If this information is collected during installation, x, y and z can be recorded for quality level B.
Voluntarily by the utility, occasionally by the inspector
Utility as built information is collected by the DOT&PF Utility section via a utility permit. The utility company is required to permit their facility and is required to obtain permit amendments for authorization to any changes. The initial permit requires a site map identifying the alignment of the facility. The location is based off an offset from the highway ROW. There are no resources available for inspection of facilities to verify accuracy of the permit.
Please refer to notes from 2019 AASHTO interview.
Construction Section Offices.
Permittee or utility performing relocation. Relocations may be field collected by kytc utility section staff spatially but those are a few single points with low accuracy.
Permit Coordinator in each of six district office collects (inconsistently) the as-built data. Some districts feed this information to the District GIS staff.
The Utility companies are responsible to provide the DOT with as-built information when requested. The Utility company complies and maintains its respective information.
As mentioned previously, we don't have a current process, but we envision a future process in which the utility collects as-builts following installation with their own gps equipment.
Currently do not maintain "As built" plans, only proposed relocation plans with construction revisions.
bu the utility coordinator at the time of installation
WisDOT collects this information on rare occasions so no set policy exists. In some instances, sewer and water installations installed by WisDOT contractor is collected by project field staff and documented via Bluebeam or Adobe and saved. That information is given to local utility responsible for the maintenance of the sewer and water installations.
See UAM. Collected at closing of permit.

Inconsistently applied. Contractor/sub-contractor to submit As-Built drawings to Resident Engineer
Most information is submitted by the utility upon completion of adjustments that are reimbursable on not to scale paper plans. Some do make available on a GIS format
During the design phase, the utilities are notified of the pending construction project and locations of the improvements. The utilities come with a plan to relocate their facilities to avoid any conflicts. These relocation plans are verified by the Utility Specialist prior to implementing the plan. The new locations, along with other known utility locations, are included into the construction plans. Verification of utility relocations is spot checked, at best.
As-built plans are received from the utility owners.
Data is collected by the Utility inspector for Accommodation projects. On WSDOT construction projects - it is a combination of the project inspector and at times a utility inspector.
If requested, it would be collected by the permit applicant and then submitted to the Michigan DOT.
Final invoices when State is accountable for a percentage of any relocations for roadway projects.
Not yet requiring.
The DB Team is responsible for managing, ensuring the accuracy of, and delivering all utility Record Drawings, which must be submitted for intermediate review and approval within 30 days after utility relocations, adjustments, abandonment and/or installations are completed.
Our construction inspectors will collect some utility information when they are present for work on highway projects. Any information collected would be done via marking up the highway construction plans by hand.

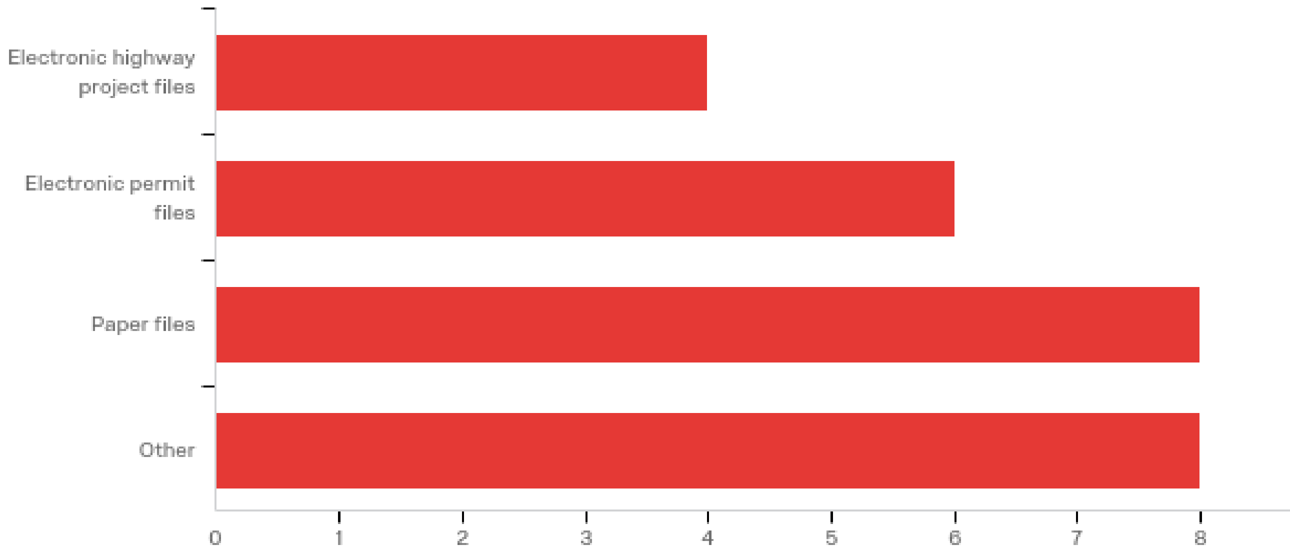
Q38 - Do you store the as-built information?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you store the as-built information?	1.00	2.00	1.26	0.44	0.19	35

#	Answer	%	Count
1	Yes	74.29%	26
2	No	25.71%	9
	Total	100%	35

Q39 - How does your DOT store/archive utility as-built information?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How does your DOT store/archive utility as-built information? - Selected Choice	1.00	7.00	4.62	2.43	5.93	26

#	Answer	%	Count
1	Electronic highway project files	15.38%	4
2	Electronic permit files	23.08%	6
6	Paper files	30.77%	8
7	Other	30.77%	8
	Total	100%	26

Q39_7_TEXT - Other

Other - Text
Electronic Records Management System (document repository)
ProStar Geocorp, Pointman Database

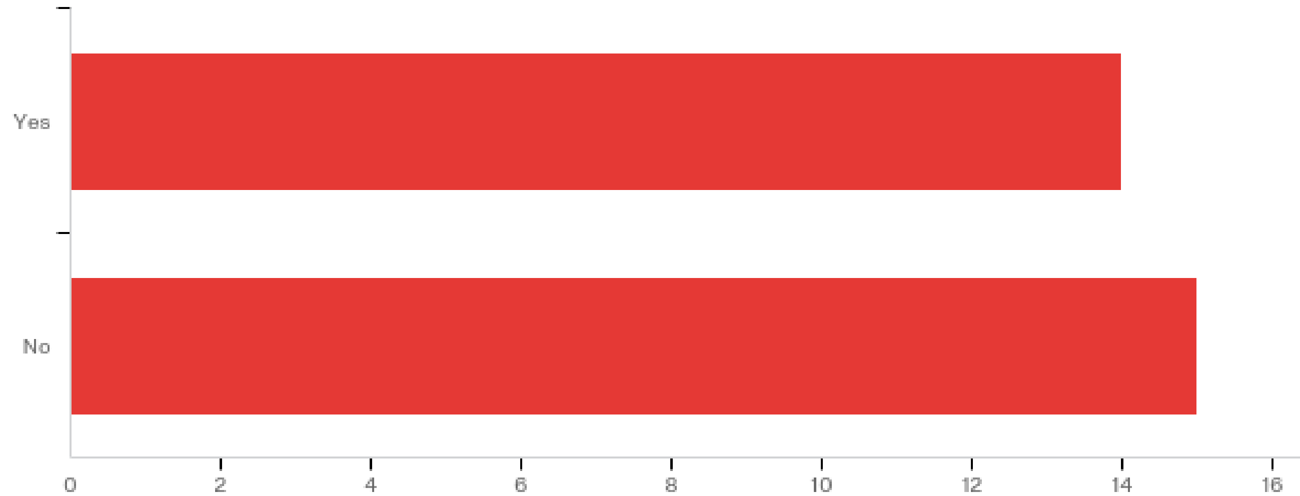
both paper and electronic permit files. The electronic files store utility attributes and a pdf copy of the design plan / as built (when received)
Both electronic and paper
All of the above.
Electronic highway project files, Electronic permit files, and some paper files
It is a combination of paper files and electronic files. It differes form region to region
And Paper

Q40 - How does your DOT access and use utility as-built information (in review of permits, new project alignments, etc.)?

How does your DOT access and use utility as-built information (in review of permits, new project alignments, etc.)?
As-built database along with a designated document storage area.
yes
they are obtain through our database or submitted by email.
As-builts and permits are retrieved from the Electronic Records Management System for use in reviewing future permits. We do not currently use the information for project planning or design.
By doing test hole and as built info provided by utility companies
As-built Database along with a designated document storage area.
ProStar Geocorp, Pointman Database
Electronic data base of historical permits
We only use it to verify relocation / property interest authority. We will call for design locates and will survey the located facilities into our project plans.
As-built data is utilized for planning, early cost estimates and preliminary scopes of work. The permit writers utilize as-built data to provide guidance to avoid certain utilities during permit planning and preliminary alignment determination.
Both electronic and paper
Inconsistently! Some districts use the data when issuing new permits. ITD relies heavily on the utility companies to provide existing facility locations thru the state's One-Call (Call 811) centers(Digline).
At the initiation of a state project, the Central Surveys Unit requests from all the utility companies (private and municipal) to provide any as-built information so that it may incorporated into the project design plan sheets.
Construction project design
Currently do not maintain "as built" plans
WisDOT has not used utility as-built information for permit reviews, but has used it on select highway projects for clash detection.
As-built plans to determine who is in the right of way and approximately where they are to determine whether a level A locate is needed or not.
As-built info is utilized for review of permits and during project development.
Unfortunately ODOT does not collect official as-built information
Mostly to document when a claim is made for reimbursement that the field data gather conflicts with the eligibility to seek.

It is spot checked by the construction office and the information is included in the construction plans.
Retrieve from electronic or paper files
For WSDOT projects the project office requests records from the region Utility office for project design. For new projects - WSDOT may not have records if the property is being acquired from another agency. For review of permits and franchises - with the exception of the Utility Accommodation Engineer's knowledge I can't say that as-builts are used for the reviews.
Yes, when available.
That actually hasn't come up yet, but it's the why behind this ua the tine to start.
I don't think that we are. At present, we likely just collect new survey data as needed.
Not currently, to my knowledge.
We do not rely on Level-C information which an as-built plan is. We rely on Level A or B locates to determine the location of utilities.
N/A

Q41 - Has your DOT experienced/incurred costs due to inaccurate geospatial utility as-built data?



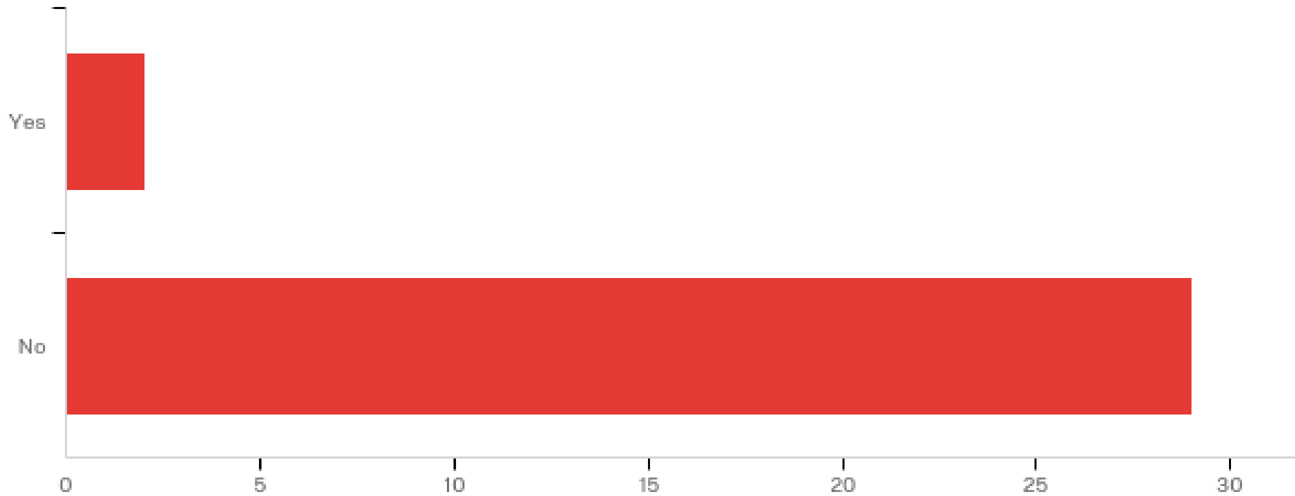
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Has your DOT experienced/incurred costs due to inaccurate geospatial utility as-built data?	1.00	2.00	1.52	0.50	0.25	29

#	Answer	%	Count
1	Yes	48.28%	14
2	No	51.72%	15
	Total	100%	29

Q42 - Please note if these costs are available.

Please note if these costs are available.
These costs have not been quantified.
This data is not collected / managed by a system and therefore is not available or known other than specific to a project by project basis.
Not available
Not defined but I expect we have
Not readily available
no
Not easily attainable or available.

Q43 - Does your DOT attempt to recover costs from utility companies due to inaccurate geospatial as-built data?



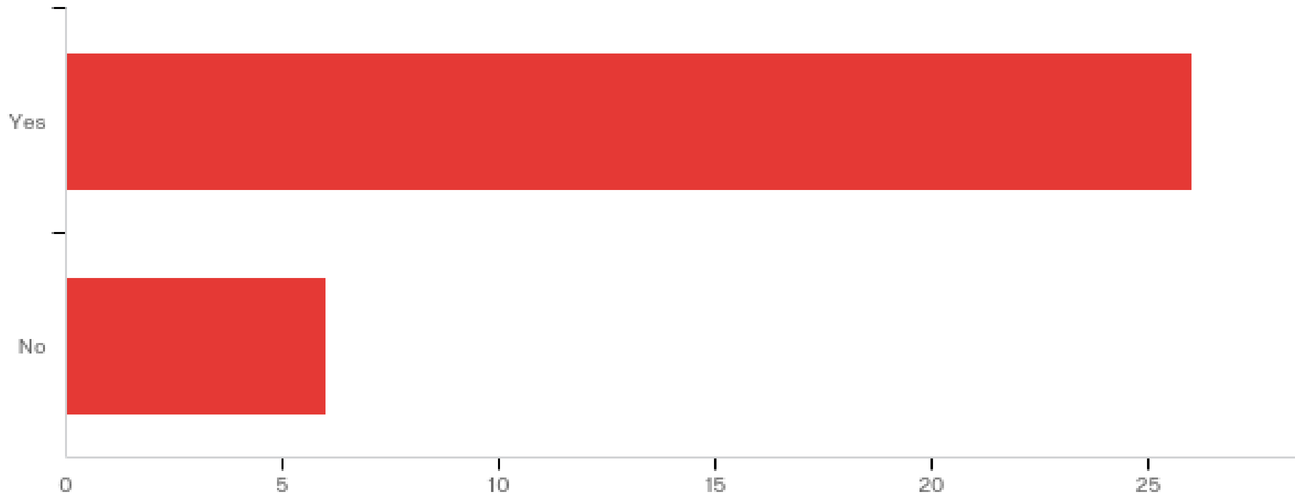
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Does your DOT attempt to recover costs from utility companies due to inaccurate geospatial as-built data?	1.00	2.00	1.94	0.25	0.06	31

#	Answer	%	Count
1	Yes	6.45%	2
2	No	93.55%	29
	Total	100%	31

Q44 - Explanation/Comments:

Explanation/Comments:
Our state has no standards or accuracy criteria in place which would allow for this.
In the future we will try and recover these costs.
Currenlty do not maintain "as built" plans
Not yet claiming, but it is being discussed for possible legislation.
We do not collect geospatial as-built data, but we have occasionally recovered cost from utilities due to not relocating their utilities correctly.
unknown
For question "Has your DOT experienced/incurred costs due to inaccurate geospatial utility as-built data?" I answered NO, due to the fact Michigan DOT does not currently have geospatial utility data (accurate and/or inaccurate) during project development and utility coordination. For question "Does your DOT attempt to recover costs from utility companies due to inaccurate geospatial as-built data?" I answered NO, due to the fact Michigan DOT does not have geospatial utility data (accurate and/or inaccurate) so a case involving costs recovery has not happen.
Patrick Allen may be better able to answer these last two questions.

Q45 - Has your DOT experienced barriers or difficultly in collecting utility as-built information?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Has your DOT experienced barriers or difficultly in collecting utility as-built information?	1.00	2.00	1.19	0.39	0.15	32

#	Answer	%	Count
1	Yes	81.25%	26
2	No	18.75%	6
	Total	100%	32

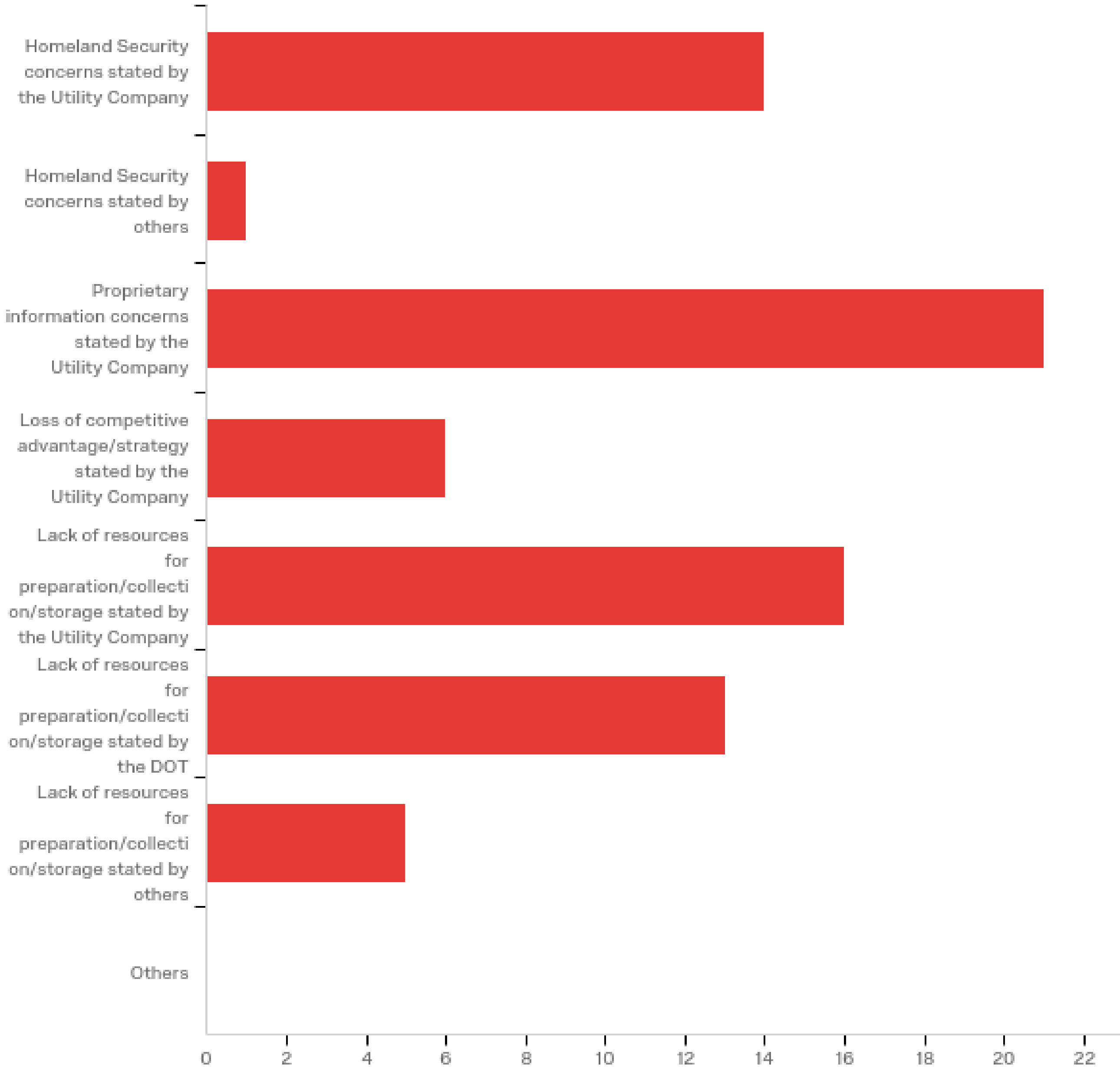
Q46 - Comments (If yes, please explain):

Comments (If yes, please explain):
Not all utility contractors are willing to provide the information.
The barriers are mostly internal. We do collect information from select utility companies during project development (not all of the utilities present on a project). We do not have a process for how to use the information nor an internal standard for accuracy level. Utility companies have also resisted in sharing as-built information (see below).
We are in the process of rolling out this new utility gathering of utility information. This is a new process that will not be required until early 2020.
unwilling utility companies due to liability and extra cost involved
Utility companies, particular telecommunications have no location data available. We are more successful obtaining location data during design and conflict mitigation efforts vs. during construction. As there are no consistent standards there is a risk of incorrectly evaluating the data.
Resources
Utility tends to cite Homeland security and open records
See my comments in response to a previous question.
utility companies have been difficult in times past.
Currenlty do not maintain "as built" plans
Utility companies do not like creating as-built plans due to an increase in staff time and cost.
Collecting as-built information is not a legal requirement.
As-built info is not always provided by utility company contractors.
Utility companies are hesitant to share this information. It is a challenge when there are not laws to inforce this.
It is sometimes difficult to prove.
Many companies are reluctanct for various reasons.
Not all utility companies are willing to provide the information.
Several different scenarios: their collection method can't be used - because data fields do not align.does not mesh, the utility says it is proprietary information. No one in the field collected the information
Michigan DOT can require a permit applicant to submit as-built information. However, at this time, there is no standard for submitting this data.
Certain companies utilize Miss Utility Law as a way around the requests and some simply do not have any records.

We only have minimal as-built information on design-build projects only. These are recorded as they as installed. We also may have SUE information for other existing utilities, but not as-built information, per se.

Most companies do not maintain good records whether asbuilts, GIS or anything else. Sometimes we are also given a hard time by companies when trying to collect the info on our own.

Q47 - If your DOT has experienced barriers or difficultly in collecting utility as-built information, please select those that apply:



#	Answer	%	Count
1	Homeland Security concerns stated by the Utility Company	18.42%	14
2	Homeland Security concerns stated by others	1.32%	1
3	Proprietary information concerns stated by the Utility Company	27.63%	21
4	Loss of competitive advantage/strategy stated by the Utility Company	7.89%	6

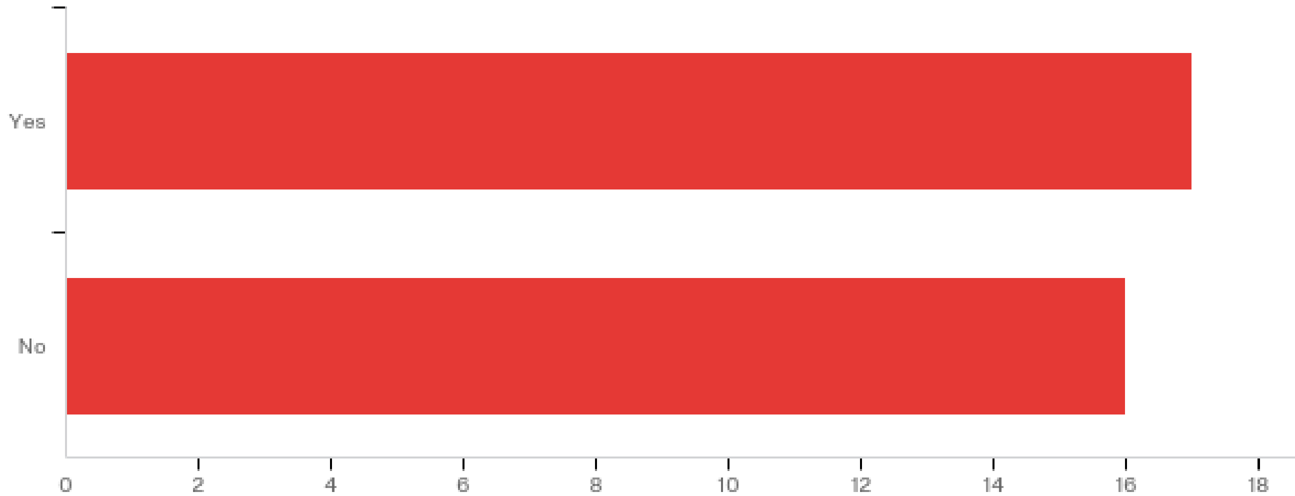
5	Lack of resources for preparation/collection/storage stated by the Utility Company	21.05%	16
6	Lack of resources for preparation/collection/storage stated by the DOT	17.11%	13
7	Lack of resources for preparation/collection/storage stated by others	6.58%	5
8	Others	0.00%	0
	Total	100%	76

Q47_2_TEXT - Homeland Security concerns stated by others
Homeland Security concerns stated by others - Text
Q47_7_TEXT - Lack of resources for preparation/collection/storage stated by others
Lack of resources for preparation/collection/storage stated by others - Text
Q47_8_TEXT - Others
Others - Text

Q48 - If your DOT has experienced barriers or difficultly in collecting utility as-built information stemming from Utility Company concerns, please provide contact information for a representative of the Utility Company(s).

If your DOT has experienced barriers or difficultly in collecting utility as-built information stemming from Utility Company concerns, please provide contact information for a representative of the Utility Company(s).
We are in the process of rolling out this new utility gathering of utility information. This is a new process that will not be required until early 2020.
Utility companies have concern with cost associated with delivering higher accuracy data requirements. For example very few utility companies have professional survey staff available to support higher accuracy level requirements imposed by the DOT.
Duke energy, contact me for more information
I can't recall the name of the attorney representing the Mom & Pop Utility companies that reached out to ITD on this matter.
We have not yet required as-built data, but hope to do so soon.
Currenlty do not maintain "as built" plans
At Headquarters I don't have that information. Those contacts would be region level.
Can provide many contacts...just reach out to me via email and I will prepare a list.

Q49 - Do you believe there are implications (risk, safety, liability) for DOTs requiring utility installation as-built plans to geospatial locations (or at defined accuracy)?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you believe there are implications (risk, safety, liability) for DOTs requiring utility installation as-built plans to geospatial locations (or at defined accuracy)?	1.00	2.00	1.48	0.50	0.25	33

#	Answer	%	Count
1	Yes	51.52%	17
2	No	48.48%	16
	Total	100%	33

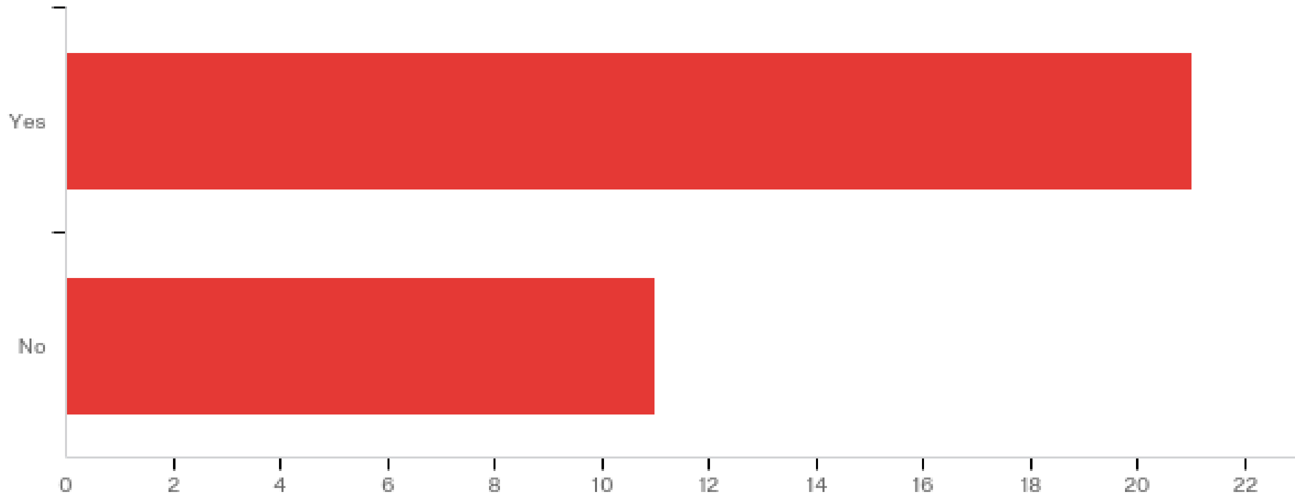
Q50 - Explanation/Comments:

Explanation/Comments:
Not certain.
There is always risk, but we are taking measures to minimize risk.
Conflicts with current 1 call legislation and would depend on how the DOT utilized that information
I have observed an increase in risk by projects by analyzing information provided by the utility companies independently. There is a risk of error by combining multiple as built sources. We have had a recent project where an error in analyzing information contributed to a gas line strike. I have also noticed that if we have more information to review (with little no control on the accuracy level) that less time is spent to verify actual conditions which triggers more changes in the field.
More accurate records leads to safer roads
Data needs to be managed and not available to the general public.
Utility proposed relocation detail plans are provided routinely to the Department, subject to FOI which conceptually contain the same information as AS BUILT plans. There have been no objections, concerns, etc expressed by the utilities. Of course the detail plans provided have been conditioned by Tn Chapter 86 reimbursement policy, so the utilities are receptive to Tn reimbursement conditional on providing the detailed plans necessary for the highway contractor to construct.
WisDOT has a hold harmless clause in all permits. In addition, adherence to the Diggers Hotline (One-Call (Call 811)) law would still be required.
It gives a false sense of security of having a reliable location. This a safety concern. It does not relieve us of having to pay for Level A locates to determine where utilities actually are. Spending money to collect data that does not relieve us of our liability is wasteful and a risk to our work program.
Accuracy is only as good as the data collected and with so many different groups collecting there is going to be variations. Other groups wanting to use that information may hold DOT responsible for its accuracy.
One implication is the risk that the utility geo-spatial information could be a liability for the DOT. In that, if shared, could be used against the utility and/or a community.
Only to the extent that all information collected by the WSDOT is subject to public disclosure. The utility requests to be in the WSDOT right of way and with that comes a certain element of risk. WSDOT permits require the utility to indemnify WSDOT.
4 items have been identified for Michigan DOT to proceed with GUIDE Resources (staff and money) legal Considerations Varying Standards Utility Resistance
The DOT should know what was permitted in their ROW and where it is located.
There may be some risk, if the As-Builts are incorporated into a GIS and the other information is not properly identified as to the level of accuracy.
There's risk in everything - it just needs to be minimized.

I don't care how accurate the

Generally, I think having good, accurate utility information is crucial. However, if the DOT starts collecting and utilizing the info, companies might be able to hold the DOT liable for bad information that was provided. Not sure that really changes much since the DOT is already holding the burden for inaccurate info by way of delays, claims, added costs, etc. but it is worth noting and thinking through.

Q51 - Do you believe there are implications (risk, safety, liability) for Utility Companies providing utility installation as-built plans to geospatial locations (or at defined accuracy)?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you believe there are implications (risk, safety, liability) for Utility Companies providing utility installation as-built plans to geospatial locations (or at defined accuracy)?	1.00	2.00	1.34	0.47	0.23	32

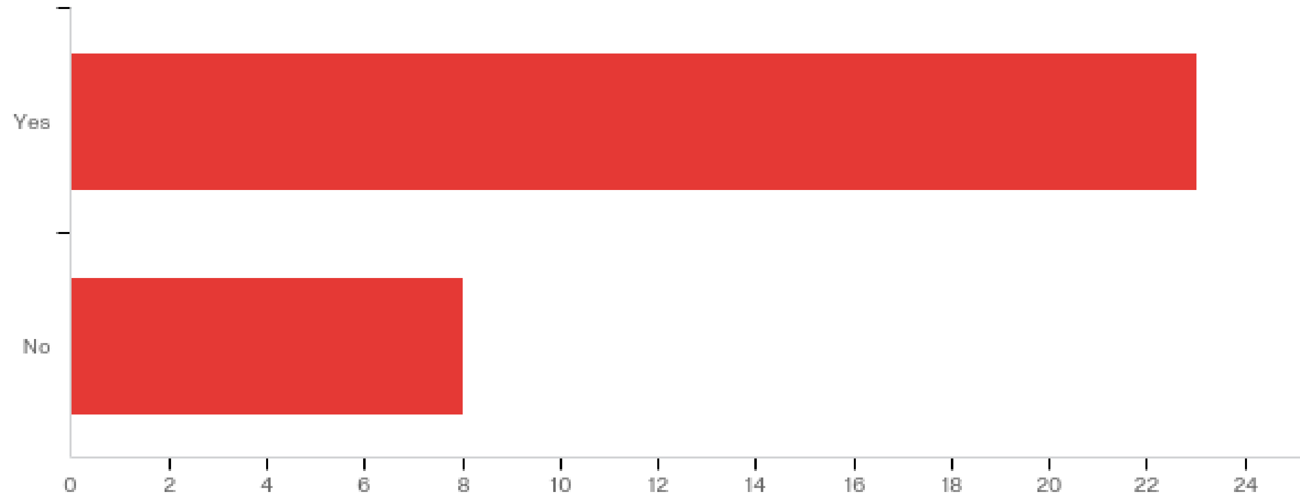
#	Answer	%	Count
1	Yes	65.63%	21
2	No	34.38%	11
	Total	100%	32

Q52 - Explanation/Comments:

Explanation/Comments:
However, the non-electronic as-build information from the utility companies has been suspect at best. We are hoping to improve our data with the changes we are making.
If a utility company certifies accuracy of their installations then there will expectations regarding shared liability during conflict. I would anticipate utility companies providing data, however, I would also expect utility companies would add a liability statement to the provided data.
If geospatial data is not accurate likely there is risk and liability to the Utility Companies.
The Utility Company may be financially responsible for any errors or omissions regarding data it provides to the DOT.
Any plans maintained by the Department are only provided to the public by a FOI action. Any nefarious use of that information would be documented by that FOI request. That such action, the Department would be aware of an increase, or unusual/out of character request for that information. To my knowledge, any FOI for utility detail plans would be unusual and out of character, not recalling any such request after the utility ionstallation is complete. Requiring FOI for utility detail plans would easily address any security concern the utilities may have. That being said, Department "map sales" providing historical plans are routinely provided to the public, and there has been no effort to differentiate highway plans from utility detail plans, and require the FOI for the utility plans. As well the contractors that bid on highway projects containing utility relocations are routinely distributed those plans for bidding purposes.
Adherence to the Diggers Hotline (One-Call (Call 811)) law would still be required.
Same as above.
If done correctly no.
Providing exact location of utilities could give enough information for someone to harm or cripple a utility.
Same as above- the utility takes on a risk being installed in a public right of way and choose to install in public right of way for financial reasons. They have chosen any risk that may exist by knowing their records are subject to public disclosure.
See comments to previous question.
Utility Owners should be required to record geospatially the accurate location of their facilities.
If there is inaccuracy, utilities could be damaged by construction. The question then is, who is at fault, the contractor or the utility?
See previous comments.
The most common argument I hear from companies is that they cannot provide information due to homeland security or proprietary reasons. Utility companies need to understand that any information shown in a DOT's construction plan sets are public documents and are subject to FOIA. Also, if there are certain aspects of their systems that need to remain

private, we might be able to filter those out but have accurate info on the remainder. Ultimately, accurate, geospacially referenced asbuilts are needed to help avoid conflicts and delays during construction. It is in the Utility and DOT's best interest to have this info.

Q53 - Would you be willing to participate in an interview to provide further details regarding the questions above?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Would you be willing to participate in an interview to provide further details regarding the questions above?	1.00	2.00	1.26	0.44	0.19	31

#	Answer	%	Count
1	Yes	74.19%	23
2	No	25.81%	8
	Total	100%	31

Appendix B: Interview Questionnaire

NCHRP 20-07/Task 418 STA Interview Questionnaire

The main objective of NCHRP 20-07/Task 418 is to improve the understanding of the impacts and value in requiring geospatial location within utility installation and relocation as-built plans. This objective will be accomplished through the following:

- Document effective Department of Transportation (DOT) approaches for requiring utility companies to install or relocate facilities to known geospatial locations,
- Identify the barriers to requiring utility companies to provide geospatially accurate as-built locations of their facilities,
- Investigate the implications (cost, security, resource constraints, etc.) of these requirements to the DOTs and the utility companies, and
- Recommend policy and legislation changes needed to implement these requirements.

In summary, the research team will use this interview of subject matter experts to capture details in regard to requirements for utility as-built plans and effective practices in collecting utility as-built information.

The main deliverable of this research will be a guidance document that DOTs will be able to use to inform their state approaches to utility company requirements for as-built plans in accommodation or relocation within public right-of-way.

Please provide your contact information.

Agency: ____

Address: ____

City: ____________________________________ State: __________ ZIP: ______________

Questionnaire Contact: ____

Position/Title: ____

In case of questions and for NCHRP to send you a link to the final report, please provide:

Tel: ____________________ Email: ____

1. Does your DOT dictate/propose specific geospatially locations for installation in their permits or even relocations?

2. Does your DOT dictate specific geospatially location for installation in their permits or even locations?

3. Discuss an overview of your DOT's approach to collecting utility as-built information? What are the geospatial components of that approach?

4. Who is responsible for ensuring the utility as-built information is collected and where is it stored? How is this information used?

5. Describe the accuracy requirements for the utility as-built plans. (Geospatial ranges, technologies used, impact of using HDD) How do you ensure that accuracy is achieved?

6. Have utility companies been receptive to providing this level of accuracy? Can you discuss any resistance or barriers to this information being provided as desired? Could you provide contact information to follow-up with utility companies you work with?

7. Who is liable in the even to of inaccuracies? Do you require utility as-built plans to be professionally stamped? What are the costs associated with inaccurate data and do you have details in regard to these costs?

NCHRP 20-07/Task 418 Utility Company Interview Questionnaire

The main objective of NCHRP 20-07/Task 418 is to improve the understanding of the impacts and value in requiring geospatial location within utility installation and relocation as-built plans. This objective will be accomplished through the following:

- Document effective Department of Transportation (DOT) approaches for requiring utility companies to install or relocate facilities to known geospatial locations,
- Identify the barriers to requiring utility companies to provide geospatially accurate as-built locations of their facilities,
- Investigate the implications (cost, security, resource constraints, etc.) of these requirements to the DOTs and the utility companies, and
- Recommend policy and legislation changes needed to implement these requirements.

In summary, the research team will use this interview of subject matter experts to capture details in regard to requirements for utility as-built plans and effective practices in collecting utility as-built information.

The main deliverable of this research will be a guidance document that DOTs will be able to use to inform their state approaches to utility company requirements for as-built plans in accommodation or relocation within public right-of-way.

Please provide your contact information.

Agency: ____

Address: ____

City: ____________________________________ State: __________ ZIP: ______________

Questionnaire Contact: ____

Position/Title: ____

In case of questions and for NCHRP to send you a link to the final report, please provide:

Tel: ____________________ Email: ____

1. Does your DOT dictate/propose specific geospatially locations for installation in their permits or even relocations?

2. Does your DOT dictate specific geospatially location for installation in their permits or even locations?

3. Discuss an overview of your DOT's approach to collecting utility as-built information? What are the geospatial components of that approach?

4. Who is responsible for ensuring the utility as-built information is collected and where is it stored? How is this information used?

5. Describe the accuracy requirements for the utility as-built plans. (Geospatial ranges, technologies used, impact of using HDD) How do you ensure that accuracy is achieved?

6. Have utility companies been receptive to providing this level of accuracy? Can you discuss any resistance or barriers to this information being provided as desired? Could you provide contact information to follow-up with utility companies you work with?

7. Who is liable in the even to of inaccuracies? Do you require utility as-built plans to be professionally stamped? What are the costs associated with inaccurate data and do you have details in regard to these costs?

Appendix C: Review of ASCE Utility As-built Standard

Standard Guideline for Recording and Exchanging Utility Infrastructure Data **(a.k.a. "Utility As-Built Standard") – Sponsored by the ASCE Construction Institute and Utility Engineering and Surveying Institute**

In 2013 the American Society of Civil Engineers brought together experts [*representing civil engineers, surveyors, utility engineers, geographic information system (GIS) software developers, computer aided drafting and design (CADD) software developers, construction, directional drilling, STA right-of-way managers, U.S. Department of Defense, Federal Highway Administration, Federal Aviation Administration, transportation technical institutes, standard developers, and pipeline, natural gas, power, public works, and telecom industries*] to form a committee focused on developing a practical, implementable, yet robust standard for documenting newly installed or exposed utility infrastructure data. Entitled the "*Standard Guideline for Recording and Exchanging Utility Infrastructure Data*", this standard (also known as the ASCE "Utility As-Built" standard) provides a framework and domain criteria for the collection of spatial and feature attribute data in which discrete observations of lineal and point features are organized in a basic spreadsheet format with sufficient information to enable utility features to be modeled and rendered into spatially and geometrically accurate 3D virtual reality format. The standard includes sufficient metadata to document accuracy and source information so subsequent users can utilize the "as-built" data appropriately for civil engineering planning and design, damage prevention, civil defense, resiliency analyses for emergency response planning, etc. The standard stems from long established survey data collection, organization, and documentation practices including: 1) the National Oceanic and Atmospheric Administration (NOAA), 2) the Federal Geographic Data Committee (FGDC), and U.S. Corps of Engineers. It also compliments a previous standard developed by ASCE entitled "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data" (ASCE 38-02). The utility "as-built" standard has passed the ASCE committee ballot in November 2019 and is currently scheduled to be published in the first half of 2020.

ASCE has published a White Paper describing the proposed standard. The research team has included a copy of the White Paper in its entirety as Appendix C-1 to assist in understanding the proposed standard.

APPENDIX C-1: White Paper on ASCE "Standard Guideline for Recording and Exchanging Utility Infrastructure Data"

Standard Guideline for Recording and Exchanging Utility Infrastructure Data

White Paper

Introduction

Poor utility records increase risk and costs for civil projects, private developments, and utility infrastructure installations. These risks and costs can be reduced by capturing and recording standardized utility data at the time of installation, and systematically recording standardized data on existing utilities exposed during ongoing construction. The Standard Guideline for Recording and Exchanging Utility Infrastructure Data (also referred to as the utility as-built standard) is being developed under the auspices of ASCE's Construction Institute (CI) and Utility Engineering and Surveying Institute (UESI). Committee members developing this standard guideline represent a wide range of backgrounds and experience, including, but not limited to, utility engineering, surveying, computer-aided design (CAD); geophysics; geodetics;

geographic information systems (GIS); civil infrastructure design and construction; right-of-way management; and geotechnical engineering.

Purpose

The purpose of this paper is to:

1) Introduce summarized content of a pre-ballot draft of the Standard Guideline for Recording and Exchanging Utility Infrastructure Data under development by the American Society of Civil Engineers (ASCE).
2) Promote testing of concepts included in the document by agencies who are developing systems to gather "as-built" utility data.
3) Accelerate use of the principles proposed to be embodied in the new ASCE standard guideline prior to formal adoption.

The draft standard guideline is currently under development and additional data items are being considered. ASCE welcomes feedback from early users of these draft concepts and principles to test and improve them, and for sharing lessons learned. Please submit your comments to CI Director Katerina Lachinova (at klachinova@asce.org). If you have suggested edits please use the Track Changes function in Word.

The new standard guideline is intended to provide non-binding guidance to assist right-of-way and utility owners in establishing their own standards. Some agencies have already used earlier versions of this draft standard guideline in development of their as-built processes and data repositories.

The intent of the standard guideline is to present a common definition for communicating the positional accuracy of utility assets and define a minimum set of data attributes necessary to communicate the position along with the type, function, ownership, materials, status and other information related to the asset. Furthermore, the standard guideline is intended to encourage the adoption of standard practices, contract requirements and jurisdictional requirements resulting in permanent records of location determined by direct measurement methods, and collection of data attributes on all new utility infrastructure.

The standard guideline specifies essential elements for the documenting the location and attributes of underground and aboveground utility infrastructure. This includes a particular focus on the documentation of newly installed or exposed infrastructure. It complements ASCE 38 (current version), *Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data*.

Administration

The standard guideline will describe the necessary functions to promote long-term reliable, functional, and secure data. The purpose is to facilitate data collection, data management, and data exchange among stakeholders. The standard guideline will recommend best practices with respect to administration of data, data exchange, and data governance.

Utility Infrastructure Data Content and Accuracy

The standard guideline will specify the level of reliability and accuracy of data collected and used to depict utility infrastructure locations, and provide a framework for data exchange that relies on utility location data and relevant attribute data.

The standard guideline specifies all relative positioning be transformed to absolute positions for mapping and data exchange purposes. Relative spatial positioning depends heavily on local conditions and is inappropriate for data exchange purposes.

Example: depth is a measurement to existing ground level and is subject to variations over time. These limitations make depth inadequate for recording vertical positions. To resolve this problem, all vertical measurements shall be recorded and exchanged as orthometric height elevations referenced to the vertical datum of the U.S. National Spatial Reference System (NSRS).

Example: it is common practice to define locations by measurements from other local features, such as locating a water valve by taped distances from face of curb and a nearby power pole. Since the reference objects themselves can be moved or lost over time, these measurements are unreliable for data usage. All relative measurements shall be transformed to a georeferenced system that represents X, Y, Z locations for recording and exchanging.

The standard guideline will specify that horizontal and vertical locations be shown by reference to the horizontal and vertical datums of the NSRS or some other commonly recognized horizontal and vertical coordinate system so data can be readily shared with others. If a recognized system cannot be used, e.g., a localized reference system, the necessary parameters for transforming the data from the local system to the NSRS horizontal and vertical datums are to be included with the infrastructure data. The horizontal and vertical datums shall be managed and exchanged at the record level (See Appendix A).

The standard guideline proposes requirements for levels of positional accuracy of utility infrastructure as shown in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized “utility as-built” data as facilities are installed. For this research effort the term “geospatially accurate” is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal

Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

Table 2-1.

Table 2. Positional Accuracy Requirements

Positional Accuracy Level	Positional Accuracy[1] (English Units)	Positional Accuracy[1,2] (SI Units)
1	0.1 feet	25 mm
2	0.2 feet	50 mm
3	0.3 feet	100 mm
4	1 foot	300 mm
5	3 feet	1000 mm
0	Indeterminate	Indeterminate

[1] At the 95% confidence level, in accordance with FGDC-STD-007.4-2002. Level 1 generally coincides with requirements for vertical Positional Accuracy in ASCE 38-02 quality level A (QLA).

[2] Positional Accuracy requirements in SI units should be used in jurisdictions that use SI units. There are minor variations between English-unit and SI-unit accuracy requirements for the same Positional Accuracy Level; this is to meet common conventions used in either unit of measure environment.

Note: The horizontal and vertical accuracy requirements help determine the type of data collection equipment and data collection methodology. Different Positional Accuracy Levels are possible when using global navigation satellite system (GNSS) equipment and real-time kinematic (RTK) methods, post-processed mapping GNSS equipment, and mapping GNSS equipment without post-processing. The combined effect of the characteristics of the positioning equipment, data collection procedures, and post processing support a specific statement of accuracy. For example, equipment and data collection and post processing procedures that are designed to achieve a 3-foot Positional Accuracy cannot be used to certify an accuracy smaller than 3 feet.

Framework for Data Exchange

The purpose of this standard guideline is not to dictate how utility data are collected or organized, but to standardize the spatial, attribute, and corresponding metadata components that are recorded and exchanged. The standard guideline provides sufficient information to recreate a 3D virtual reality rendering of the documented infrastructure. Utility infrastructure data can be modeled and visualized in a variety of manners, and stakeholders are free to develop various data schemas and management tools which are appropriate for their use. This section provides guidance on what data elements to collect and manage for recently constructed or exposed utility infrastructure to facilitate a variety of functions, including data exchange among stakeholders who have an interest in utility data. Appendix A contains a detailed list of the components and their data attributes.

Utility Infrastructure Data to Measure and Record

Documents

Documents such as inspection reports, specifications, photographs, and narrated audio and video files often provide additional information about utility infrastructure. These documents augment, but do not replace, authoritative georeferenced utility data. To be useful, these documents should be associated with the specific utility features they describe by using the feature's unique identifier (ID).

Trenchless Technology

Where part or all of the installation of a utility segment requires the use of trenchless technology, utility location data shall be obtained and recorded as follows:

- Use surveying protocols to measure the locations where the segment enters and leaves the borehole and at all required test pit verification points through which the boring passes.
- Use indirect means (e.g., bore logs with recorded inertial navigation data for the boring tip or 3D electromagnetic sonde observations recorded along the surface) between the entrance and exit of the borehole. These data shall be acquired and recorded in 3D to achieve Quality Level B designation as defined by ASCE 38-XX. Because these data are obtained by indirect methods, Positional Accuracy Levels are "Indeterminate".
- Where a utility segment cannot be exposed or designated (e.g., when it passes below a structure or body of water, or the feature is too deep to be detected using geophysical equipment), its location shall be measured where the utility feature was last observed entering or exiting the obscured area. The obscured portion of the utility feature shall be clearly indicated that it has not been measured or designated. For any portion of a trenchless feature not directly measured or designated, the Positional Accuracy shall be reported as Indeterminate (Accuracy Level 9, see Table 1).

> *Note: The project owner should collect boring logs from the constructor, recorded in accordance to owner specifications and containing distance and depth values at regular intervals, along with entry and exit points referenced to the project survey control.*
>
> *Collecting information about where a utility feature was last observed entering or exiting the obscured area is particularly important for deep borings that exceed practical limitations of*

electromagnetic detection and vacuum excavation methods as well as inaccessible borings, such as channel crossings or beneath structures.

Considerations When Exchanging Data

Metadata should be provided with all exchanged data. At a minimum, features that are exchanged include the metadata elements described in Table 3. In addition, include metadata that describes how and when the data was collected, the coordinate reference system and datum used, the individual(s) who certified the data, and any known limitations.

Several attributes defined in Table 3 are to be conveyed as real numbers. In these cases, the number of digits after the decimal point should correspond to the accuracy of the data. For example, a feature's width that is recorded to within a tenth of a foot should be specified as X.X feet (which in practice means X.X plus or minus 0.05 feet).

Utilities are an essential element of critical infrastructure. Utility data should be treated as sensitive information and handled accordingly. Utility data that support security operations may be considered sensitive security information (SSI) and must be labelled, distributed, and handled in accordance with 49 CFR 1520.

Each entity is responsible for the data it collects and disseminates; therefore, each entity must decide how to handle sensitive data. The following guidelines are recommended:

- Establish and document policies for exchanging utility data.
- Inform employees, consultants, and others with data access about the policies.
- Determine which data are defined as SSI by 49 CFR 1520. Label, disseminate, and handle the data accordingly.
- Classify data by level of sensitivity, label and handle in an appropriate manner.
- Clearly document in the metadata all data usage restrictions, including restrictions on access to the data.

Appendix A. Framework for Utility Data Exchange

The standard guideline will define a minimum set of data types and data attributes required for data exchange. Each feature is described using the following tables:

- Type as shown in Table 3.
- Geometry type as shown in Table 4.
- Attributes as shown in Table 5 and Table 6.

Table 3. Feature Types

Feature Type	Definition	Comment
Segment	A linear utility feature represented by a series of connected points.	Examples include water line, electric cable, and communication line.
Device	A discrete utility feature that is directly involved with the conveyance, control, or distribution of a particular utility service.	Examples include valve, splice, and transformer.
Access Point	An opening that provides access to utility devices, segments, and containing structures. This feature type is only a point or two-dimensional.	Examples include lid, cover, door, and grate.
Support Structure	A structure used to support utility lines and devices.	Examples include pole, tower, and thrust block.
Containing Structure	A structure or chamber that houses or provides access to utility devices and typically provides a junction area for multiple utility lines.	Examples include pull box, junction box, manhole, vault, and valve box.
Secured Utility Area	An area typically fenced off to restrict access to utility facilities.	
Encasement	A structure that encloses and protects utility facilities and surrounding infrastructure, environment, and the public.	Examples include concrete cap, steel pipe, and tunnel.
Marker	A visible or remotely detectable sign or device used to reference the location of a utility facility.	
Tracer	A wire or tape used to reference the location of a linear utility facility.	

Table 4. Geometry Types

Feature Type	Geometry Type (Minimum Required[1])	Geometry Type (Optional[2])
Segment	Line String	3D Object[3]
Device	Point	Polygon or 3D Object
Access Point	Point	Polygon
Support Structure	Point	Polygon or 3D Object
Containing Structure	Polygon	3D Object
Secured Utility Area	Polygon	
Encasement	Line String	3D Object
Marker	Point	
Tracer	Line String	

[1] Minimum required geometry type corresponds to the simplest geometric depiction of a feature type that conforms to this standard.
[2] Optional geometry type corresponds to alternative geometric depictions of a feature type that may be used under this standard.
[3] If using a 3D Object geometry type, the 3D Object shall include all the necessary transformation data to convert local coordinate data to real world coordinate data.

Table 5. Feature Attributes

Feature Attribute	Applies to Feature Type								
	Segment	Device	Access Point	Support Structure	Containing Structure	Secured Utility Area	Encasement	Marker	Tracer
ID	M	M	M	M	M	M	M	M	M
Owner	M	M	M	M	M	M	M	M	M
Operator	O	O	O	O	O	O	O	O	O
Utility Type	M	M	M	M	M	M	M	M	M
Utility Subtype	O	O	O	O	O	O	O	O	O
Feature Type	M	M	M	M	M	M	M	M	M
Component	M	M	M	M	M		M	O	O
Conveyance Category	M	M		M	M		M	O	O
Intended Permanence	O	O	O	O	O	O	O	O	O
Underground Status	O	O	O	O	O	O	O	O	O
Operational Status	M	M	M	M	M	M	M	M	M
Horizontal Spatial Reference	M	M	M	M	M	M	M	M	M
Vertical Spatial Reference	M	M	M	M	M	M	M	M	M
Horizonal Accuracy	M	M	M	M	M	M	M	M	M
Vertical Accuracy	M	M	M	M	M	M	M	M	M
Accuracy Units	C	C	C	C	C	C	C	C	C
XYZ	M	M	M	M	M	M	M	M	M
Azimuth		C	C	C	C	C			
XYZ Observed	O	O	O	O	O	O	O	O	O
XY Relative Position	C	C	C	C	C	C	C	C	C
Z Relative Position	C	C	C	C	C	C	C	C	C
XYZ Junction Point	O	O	O	O	O	O	O	O	O
Quality Level	O	O	O	O	O	O	O	O	O
Linked File	O	O	O	O	O	O	O	O	O
Date Data Collected	O	O	O	O	O	O	O	O	O
Data Sensitivity Level	O	O	O	O	O	O	O	O	O
Is Certified	O	O	O	O	O	O	O	O	O
Certification Summary	O	O	O	O	O	O	O	O	O
Material	O			O			O		O
Is Cathodic Protected	O			O			O		O
Is Encased	O								O
Is Filled	O				O		O		
Fill Material	O				O		O		
Conveyance Method	O	O							
Cross Section Configuration	O								
Number of Conduits	O								
Inside Height	O				O		O		
Inside Width	O				O		O		
Inside Length					O				
Outside Height	O	O		O	O		O		
Outside Width	O	O	O	O	O	O	O		
Outside Length		O	O	O	O	O			
Wall Thickness	O				O		O		
Measurement Units	C	C	C	C	C	C	C		

M = Minimum requirement
O = Optional
C = Conditional (becomes a minimum requirement if the geometry type used is a 3D object or if observed data are available)
Blank = Does not apply

Table 6. Feature Attribute Definitions

Attribute	Definition	Domain
ID	Alphanumeric utility feature identifier	
Owner	Name of the entity that owns the utility feature	
Operator	Name of the entity or entities that operate the utility feature	
Utility Type	Type of utility service that a utility feature carries (see definitions of various utility types in Table 7).	Communication Electric Non-Potable Water Petroleum and Gaseous Materials Potable Water Wastewater and Storm Water
Utility Subtype	Type of utility service at a finer level of disaggregation than utility type. The utility subtype domain may be edited as needed. Table 7 shows examples of associations between utility types and utility subtypes.	Alarm Alternating Current (AC) Cable Television Chemical Combined Sewer Compressed Air Cooling and Heating Crude Oil Direct Current (DC) Fiber optic Gasoline Hybrid Power Irrigation Natural Gas Other Petroleum Raw Water Reclaimed Water Recycled Water Salt Water Sanitary Sewer Slurry Steam Storm Sewer Street Lighting Telephone Traffic System Communication Traffic System Power
Feature Type	Category of utility feature based on feature function and configuration (see **Error! Reference source not found.**). Function refers to the main purpose of the utility feature. Configuration refers to geometric and structural characteristics of the utility feature. Depending on the implementation, feature differentiation may be at the feature class level (e.g., separate feature classes for devices, access points, support structures, and so on) or by attribute. Because of the small number of potential feature types, feature differentiation at the feature class level is common.	Segment Device Access Point Support Structure Containing Structure Secured Utility Area Encasement Marker Tracer

Attribute	Definition	Domain
Component	Utility feature subtype. A component is an element of a utility system, which corresponds to the lowest level of utility feature disaggregation for data exchange purposes. Depending on the implementation, component differentiation may be at the feature class level or by attribute. Because of the substantial number of different components in a utility system, differentiation by attribute is more common than at the feature class level. The component domain may be expanded as needed.	Air Eliminator Air Release Valve Amplifier Anchor Anode Antenna Armor Attenuator Capacitor Cable Camera Catch Basin Cathodic Test Station Clean Out Cap Chimney Circuit Breaker Compression Support Conduit Cover Culvert Culvert End Curb Inlet Detector Disconnect Door Downspout Drain Drain Separator Drop Inlet Duct Duct Bank Fill Point Filter Fire Connection Point Fire Wall Fuse Gathering Line Generator Glycol Recovery Pit Grate Grease Trap Grit Chamber Ground Ground Point Ground Rod Guy Anchor Guy Pole Guy Wire Hand Hole Head Bolt Outlet Headwall Hydrant Impedance Matching Point Inlet Intake

Attribute	Definition	Domain
		Inverted Siphon Junction Box Lid Lift Station Light Lighting Circuit Point Lighting Service Point Line Line Clean Out Load Capacitor Load Coil Manhole Marker Sign Marker Post Media Converter Meter Meter Box Motor Network Systems Site Neutralizer Oil Water Separator Outlet Paging Device Panel Pedestal Pig Launch Point Pipe End Pole Pre-Conditioned Air Unit Pressure Reducing Station Pressure Release Processor Pull Box Pump Pump Booster Station Pump Ejector Station Pump Station Pump Station Ejector Push Brace Radio Receptacle Rectifier Reducer Regulator Regulator Reducer Relay Repeater Reservoir RFID Marker Riser Sample Point Satellite Sensor Service Loop Service Point Shut Off

Attribute	Definition	Domain
		Signal Siltation Pond Solar Panel Speaker Splice Splice Box Splitter Sprinkler Stilling Basin Stormceptor Storm Filter Storm Gate Stub Out Switch Tank Tape Telephone Terminal Terminator Thrust Block Tower Tracer Transformer Treatment Unit Trench Tunnel Turnout Structure Undefined Utility Point Vault Valve Valve Box Vent Washer Wing wall Wire Other Unknown
Conveyance Category	Primary category or purpose of service of the utility feature. Included in each category is the supporting infrastructure, such as alarm and ventilation, needed to provide the corresponding utility service.	Distribution Gathering Service Transmission Other Unknown
Intended Permanence	Intended longevity of the utility feature. Depending on the implementation, most databases would probably only handle permanent features under the assumption that temporary features occupy the right-of-way for a limited period, after which the permit requires the removal of those features. However, if the temporary accommodation is via a lease (e.g., a temporary water line to support oil or gas shale developments), tracking the status of the temporary feature at any time may be important.	Permanent Temporary

Attribute	Definition	Domain
Underground Status	Indicator of whether the feature is partially or completely underground.	Aboveground Underground Submerged (i.e., laying on seafloor, lake bottom, or riverbed) Mixed (e.g., above and below ground)
Operational Status	Operational status of the utility feature (see definition of various operational status options in Table 8).	Proposed In Service Out of Service Abandoned in Place Backup Under Construction Removed Unknown
Horizontal Spatial Reference	Coordinate system, datum, and epoch date (if applicable) associated with the X and Y coordinates.	
Vertical Spatial Reference	Datum for the Z coordinate.	
Horizontal Accuracy	Circular error of a dataset's horizontal coordinates at the 95% confidence level, where 95% of positional accuracies are equal to or smaller than the reported accuracy value. It takes into account the combined effect of all X and Y errors.	
Vertical Accuracy Level	Linear error of a dataset's vertical coordinates at the 95% confidence level, where 95% of positional accuracies are equal to or smaller than the reported accuracy value. It takes into account the effect of all Z errors. Positional Accuracy is different from the root-mean-squared (RMS) error.	
Accuracy Units	Units used to express horizontal and vertical positional accuracies.	Feet Millimeters
XYZ	X-Y-Z coordinates representing the center of the utility feature for data exchange purposes. Depending on the implementation, the X-Y-Z coordinates may be stored as separate fields in a table or as part of an array that contains spatial data in a single field. For non-linear structures, XYZ represents an anchor point used for 3D representations, which may or not coincide with the feature's centroid. In many cases, XYZ coincides with the observed location in the field (e.g., center of manhole lid). For proper orientation in a 3D space, the Azimuth attribute is also necessary.	
Azimuth	Horizontal angle (measured clockwise) of the length dimension of a utility feature	

Attribute	Definition	Domain
	with respect to a north base line. The azimuth for circular objects is zero.	
XYZ Observed	X-Y-Z coordinates of the utility feature as measured in the field. Depending on the implementation, the X-Y-Z coordinates may be stored as separate fields in a table or as part of an array that contains spatial data in a single field.	
XY Relative Position	Relative position of XYZ Observed with respect to the horizontal alignment of the utility feature.	Left Edge Center Right Edge
Z Relative Position	Relative position of XYZ Observed with respect to the elevation of the utility feature.	Crown/Top Soffit Center Invert Bottom
XYZ Junction Point	X-Y-Z coordinates of the junction point where two features connect (e.g., the point where a pipe into a manhole or vault, or the point where a manhole chimney connects to a vault).	
Quality Level	Quality level in accordance with ASCE/CI 38-02.	A B C D
Linked File	Name of file or files that contain information about the utility feature. Examples of files include photographs, CAD files, sketches, video, permit files, agreement files, easement files, replacement cost estimates, and other supporting information. Depending on the implementation, the file names may be stored as separate field entries in a table or as part of an array that contains file names in a single field.	
Date Data Collected	Date when a utility feature was surveyed in the field.	
Data Sensitivity Level	Indicator of the sensitivity level of the data recorded for a utility feature. If the data are considered sensitive security information (SSI), the data must be labeled on any output produced and handled in accordance with 49 CFR 1520.	Unrestricted Restricted SSI
Is Certified	Indicator of whether the data have been certified	True False
Certification Summary	Name and credentials of the party that certified the data as meeting Positional Accuracy requirements as described in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with	

Attribute	Definition	Domain
	costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized “utility as-built” data as facilities are installed. For this research effort the term “geospatially accurate” is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies. **Table 2-1** and attribute data requirements as agreed for data exchange purposes.	

Attribute	Definition	Domain
Material	Predominant material of which the utility feature is constructed. For features that transmit a signal or electrical power, material refers to the conductor material.	Acrylonitrile Butadiene Styrene Aluminum Asbestos Cement Asphalt Brick Canvas Ceramic Clay Coaxial Cable Composite Concrete Corrugated Metal Corrugated Plastic Copper Ductile Iron Earthen Fiberglass Fiber Optic (or Optical Fiber) Galvanized Steel Geotextile Glass Gravel High Density Polyethylene (HDPE) Iron Multiple Nickel Other Pitch Fiber Plastic Polyethylene (PE) Polypropylene (PP) Polystyrene (PS) Polyvinyl Chloride (PVC) Reinforced Concrete Steel Stone Terracotta Tile Titanium Transite Twisted Pair Copper Wood Wrapped Steel
Is Cathodic Protected	Indicator of the presence of a cathodic protection.	True False
Is Encased	Indicator of the presence of encasement to insulate or protect the utility feature.	True False
Is Filled	Indicator of the presence of interstitial material inside the infrastructure encasement.	True False
Interstitial Material	Material used to fill the space between a utility feature and its encasement or an out-of-service feature.	Flowable Fill Foam Grout Sand Styrofoam

Attribute	Definition	Domain
		Nitrogen Gel Inert Gas
Conveyance Method	Method to move or convey matter through the utility feature.	Gravity Pressurized High Pressure Low Pressure Other Unknown Not Applicable
Cross Section Configuration	Configuration of the cross section of the utility feature.	Arch Box Cable Circular Pipe Duct Duct Bank Horizontal Ellipse Pear Rectangular Trench Other
Number of Conduits	Number of conduits within a pipe or duct bank.	
Inside Height	For circular shaped segments, not applicable. For non-circular shaped segments, maximum inside height of cross-sectional shape. For features other than segments, maximum inside height of feature.	
Inside Width	For circular shaped segments, inside diameter of the utility feature cross section. For non-circular shaped segments, maximum inside width of cross-sectional shape. For features other than segments, maximum inside width of feature.	
Inside Length	For segments, not applicable. For features other than segments, maximum inside length of feature (measured in the horizontal plane, perpendicular to the width).	
Outside Height	For circular shaped segments, not applicable. For non-circular shaped segments, maximum outside height of cross-sectional shape.	

Attribute	Definition	Domain
	For features other than segments, maximum outside height of feature.	
Outside Width	For circular shaped segments, outside diameter of the utility feature cross section. For non-circular shaped segments, maximum outside width of cross-sectional shape. For features other than segments, maximum outside width of feature.	
Outside Length	For segments, not applicable. For features other than segments, maximum outside length of feature (measured in the horizontal plane, perpendicular to the width).	
Wall Thickness	Maximum wall thickness.	
Measurement Units	Units used to express height, width, length, and wall thickness. For data exchange purposes, the units of measurement are the same for all dimensions.	Centimeters Feet Inches Millimeters

Table 7. Domain Definitions for Utility Type

Utility Type	Commodity or Service Carried	Examples of Utility Subtypes
Communication	Data, voice, and video signals.	Alarm Cable Television Fiber optic Telephone Traffic System Communication
Electric	Electric power.	Alternating Current (AC) Direct Current (DC) Hybrid Power Street Lighting Traffic System Power
Non-Potable Water	Water that is not safe for human consumption and is not wastewater or storm water.	Cooling and Heating Irrigation Raw Water Reclaimed Water Recycled Water Salt Water Slurry
Petroleum and Gaseous Materials	Petroleum products and gaseous materials.	Chemical Compressed Air Crude Oil Gasoline Natural Gas Other Petroleum Steam
Potable Water	Water that is safe for human consumption.	
Wastewater and Storm Water	Water that has been affected by human use and surface runoff from precipitation events.	Sanitary Sewer Combined Sewer Storm Sewer

Note: Utility subtypes may be associated with different utility types depending on the industry and specific application. For example, it is common to associate salt water and slurry with oil and gas industry processes.

Potable water may have several subtypes depending on factors such as water hardness and chemical composition that are specific to a geographic area. Potable water subtypes could also apply to physical factors such as pressure zone.

Table 8. Domain Definitions for Operational Status

Operational Status	Description
Proposed	Proposed utility feature that has not been built yet.
In Service	Active, in-service utility feature (including short-term service interruptions for maintenance activities).
Backup	Active, in-service utility feature that is kept as backup, reserve, or standby.
Out of Service	Temporary non-usage of a functioning utility feature in which property rights are maintained.
Abandoned in-Place	Permanent non-usage (i.e., the utility feature will not be used again) in which property rights are relinquished but liabilities are maintained (e.g., environmental liabilities).
Under Construction	Utility feature that is currently under construction.
Removed	Physically removed from the field.
Unknown	

d

Appendix B. Data Collection Intervals

During construction or when underground utility infrastructure is subsequently exposed, the horizontal and vertical position and corresponding accuracy levels shall be obtained at each distinct feature; at horizontal bends, vertical bends, and points of deflection; and at specific points or intervals as needed to ensure Positional Accuracy requirements (To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed _Standard Guideline for Recording and Exchanging Utility Infrastructure Data_ which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

Table 2-1).

Note: Data collection intervals along linear features depend on factors including physical characteristics of the features and accuracy level requirements. Data collection methods might also vary depending on the specific application, e.g., exposed trench direct survey versus remote sensing data collection. Although the principles described are generic and should be familiar to those in the engineering, utility investigation, and surveying fields, nothing described here replaces professional expertise and judgment. *Collecting data along linear features normally involves collecting data at specific locations. For traditional surveying methods, the spacing between points is relatively coarse. For remote sensing methods, the point density could be high, and the resulting dataset is a collection of data points that can be used to define a linear feature.*

The alignment of a linear feature and required Positional Accuracy Level determine the data collection interval. Guidance for data collection intervals is as follows:

- **Straight Alignments**. For straight alignments, survey point spacing shall be such that the positional error of the linear feature does not exceed the limits in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed <u>*Standard Guideline for Recording and Exchanging Utility Infrastructure Data*</u> which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

- **Table 2-1**.
- **Curved Alignments**. Figure 1 shows a curved linear feature, which could be horizontal, vertical, or a combination of horizontal and vertical. The offset error at point A is due to curvature for which a line string (dashed line), passing through the data collection points, varies from the true alignment of the curve (solid line). For a Positional Accuracy Level to apply to the linear feature, the positional error due to the chord offset (i.e., distance A in Figure 1) shall not exceed the limits in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the

term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

- **Table 2-1**.
- **Deflections**. In Figure 1, errors at points B and C are due to deflection. For a Positional Accuracy Level to apply to a linear feature with deflection points, additional points shall be collected at points B and C so that the offset errors do not exceed the limits in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

- **Table 2-1**.
- **Computed Splines or Curves**. It is increasingly common to use software functions to generate modeled splines or curves through a collection of points. Similar positional error requirements as those for chords could apply. However, data exchange could be problematic if the parameters of the computed curve are not identified and documented properly. For this reason, it is generally preferable and simpler to use chords when assessing Positional Accuracy requirements along linear features.

Note: Curves may be present concurrently in any combination with points of deflection (horizontally or vertically). Therefore, it is necessary to consider linear features in segments. For each segment, a point collection interval should produce a modeled feature whose position compared to the true position does not exceed the limits in Table 1 at any point along the segment.

Utility infrastructure, like other civil infrastructure, can shift over time. This effect can be particularly evident in the case of flexible materials. In some situations, it may not be possible to achieve the highest levels of Positional Accuracy described in To properly assess value and return on investment (ROI), costs incurred from not having geospatially accurate utility as-built data must be compared and contrasted with costs associated with collecting accurate data. Task 5 involved a cost-benefit analysis to specifically estimate cost implications for both STAs and utility owners to collect and manage reliable, standardized "utility as-built" data as facilities are installed. For this research effort the term "geospatially accurate" is based on established surveying practices required to reference positional coordinates to absolute reference datum managed by the United States Federal Government. In February 2018 the American Society of Civil Engineers (ASCE) released a white paper (5) describing the proposed *Standard Guideline for Recording and Exchanging Utility Infrastructure Data* which included the following positional accuracy levels in reference to the National Spatial Reference System (NSRS) as established and maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). NSRS is an absolute reference datum commonly used to establish geodetic coordinates [i.e., latitude, longitude, and ellipsoid and orthometric heights in the official U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88)] and projected coordinates, such as state plane coordinates, for STA projects using Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) survey technologies.

Table 2-1.

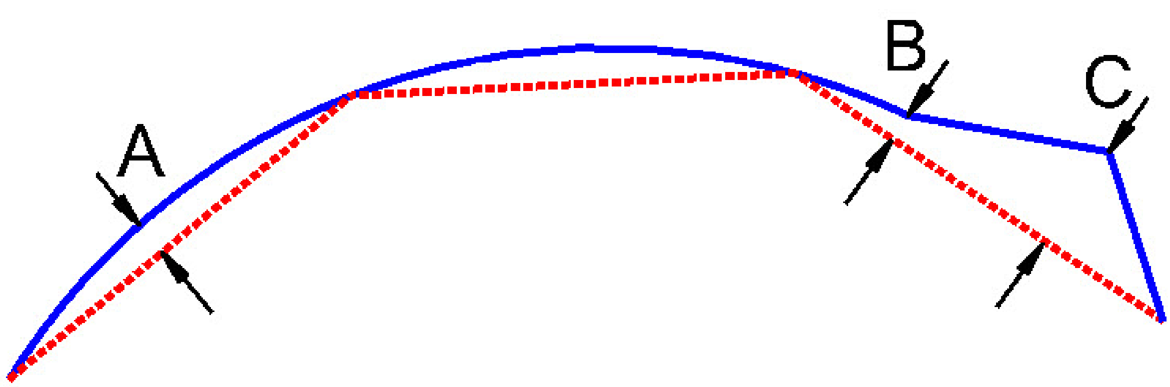


Figure 1. Offset Errors Due to Chorded Line String (Point A) and Deflection (Points B and C). The solid line represents the true alignment of the curve, while the dashed line connects the data collection points and approximates the true alignment of the curve.

Appendix D: Sample CDOT Language Illustrating Requirements for Georeferenced Utility As-built Data to be Collected

“As-Constructed” Supplemental Requirements

1. CDOT Utility as-constructed requirements, data content and accuracy

1.1. All utility installations, within CDOT Right of Way (ROW), shall be collected using CDOT’s mobile application (PointMan). If required please contact CDOT at cdotpointman@gmail.com in order to obtain new login and password information. Download PointMan mobile application through the Apple Store (iOS) or Google Play (Android). Finally, please watch the following quick start guide, the video can be found at the following link: https://youtu.be/X-tMvnK7vZw

1.2. High accuracy equipment

34

Supported GNSS Receivers
Trimble DA1 (Catalyst)
Trimble R2 (RTK)
Trimble R8 (current version is R8s)
Trimble R10
Trimble R12
Trimble SPS985 (current version is SPS986)

Supported Software
Android 7.1
iOS 12 & Up
HTML Web Browser

Blue Star RTK and emlid Reach RS2 RTK.	

One of the above GNSS receivers is acceptable to use at this time with CDOT's mobile application. Deviation from CDOT's list of accepted GNSS receivers must be requested and approved by the department in writing prior to submission of as-built data.

1.3. Projections and Coordinate Systems

Horizontal Datum: **The North American Datum of 1983, 2011 Adjustment** (NAD 83) and the Geodetic Reference System of 1980, (GRS80).

Vertical Datum: **The North American Vertical Datum of 1988**, (NAVD 88) RTK GPS is an acceptable method to derive NAVD 88 elevations and is the current Vertical Datum that is used for all projects performed for CDOT. Use the latest Geoid model from NGS to compute orthometric heights. The latest Geoid model that is acceptable is Geoid18.

1.4. Positional Accuracy Specification

CDOT requires positional accuracy 1 or 2 for all utilities installed within CDOT ROW. The designated Accuracy Level designation is shown in **Table1** below. Utilizing CDOT's mobile application pedigree (survey record) will assist in determining the accuracy levels that must be assigned to the specific permitted installation by the utility company representative responsible for collection of the as-built data.

Table 1. Positional Accuracy Requirements

Accuracy Level	Positional Accuracy[1]	Applies to	Comment
1	±25 mm (±0.1 feet) Vertical	Z data	Coincides with quality level A
	±50 mm (±0.2 feet) Horizontal	X and Y data	
2	±50 mm (±0.2 feet)	X, Y, and Z data	Coincides with quality level B
3	±150 mm (±0.5 feet)	X, Y, and Z data	
4	±300 mm (±1 foot)	X, Y, and Z data	
5	±1000 mm (±3+ feet)	X, Y, and Z data	
6	±1000 mm (±3+ feet)	X and Y data	Positional accuracy of the Z data is unreliable or not available
7	Indeterminate		Positional accuracy of the X, Y, and Z data is indeterminate.

[1] At the 95% confidence level, using the root-mean-square error (RMSE) in accordance with FGDC-STD-007.3- 1998. "Positional Accuracy" is in direct reference to the actual geodetic positional coordinates as referenced to the National Spatial Reference System (NSRS) maintained by the National Oceanic and Atmospheric Administration (NOAA) National Geodetic Survey (NGS). Geodetic positional coordinates (latitude, longitude, and orthometric heights) reference to the official

U.S. datums, currently, the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88).

Rigid aboveground features are subject to the same positional accuracy requirements as underground features. The positional accuracy of suspended aerial cables and wires is variable due to environmental factors and therefore shall be classified as Level 7, except at the points where they are anchored to support structures such as poles.

For linear features, the depicted position must meet the tolerances as specified in Table 1 at every position along the length of the feature in order to be designated at that accuracy level. Since survey collected data and resulting 3D models are usually chorded (line segments no arcs) then the point spacing must be close enough so that the true location and depicted location meet the tolerance along its entire length.

2.0 Utilities Collected – Table 2

Utility Type	Feature Code	Description of Utilities
Test hole	5950	Point - Test hole physically locating X,Y,Z underground facility location.
Proposed running line	6001 or 6075	Line segment code 6001 – Surface elevation of proposed HDD bore. Point - 6075 location bore log depth required for each observed point.
Communication	4210 4410 4211	Line segment - All communication facilities, including fiber optic (4211), copper (4210), coaxial (4410), including appurtenances within defined size parameter
Gas	4510 4511	Line segment – Low pressure (4510) High pressure (4511) Natural gas transmission, distribution, service lines, and appurtenances within defined size parameter.
Electric	4310	Line segment - Secondary electric or higher voltage
Pipe (Oil)	4610 or 4611	Line segment - Pipeline facilities, including crude oil, refined oil, or all other types of oil pipeline transmission, distribution, service lines, and appurtenances within defined size parameter.
Propane	4512	Line segment - Propane transmission, distribution and service lines, and appurtenances within defined size.
Sanitary Sewer	4811	Line segment - Sanitary sewer facilities including all mains, collection system, forcemains, services and leads, including appurtenances within defined size parameter. (Combined sewer is classified as sanitary sewer).
Surface Elevation	6075	Point – X,Y,Z single observation for surface elevation.

Storm Sewer	2712	Line segment - Storm sewer facilities including all mains and collection system, including appurtenances within defined size parameter. (Excludes underdrain)
Water	4710	Line segment - Water transmission, distribution, service lines, and appurtenances within defined size parameter. (Excludes irrigations
Unknown	6075 or 6001	Point and Line segment - This designation can be used for those facilities not covered by the above feature codes, including but not limited to industrial facilities of all types and discovered utilities where the type of utility is unknown.

During field data collection, it may be advantageous to locate positions using measurements relative to other identifiable features, such as measuring the depth from existing ground surface or measuring offsets from local landmarks. Directional boring installation methods are, by definition, indirectly measured. All such relative positioning measurements shall be reduced to actual absolute coordinate positions by utilizing CDOTs mobile application. All positions and elevations shall be stored in CDOT's As-Constructed database within 45 days of the permitted installation. Failure to submit As-Construction data will delay or suspend future utility permits.

2.1 - General Observations Standards

1. All transmission, distribution and collector system main lines
   a. Start and end points
   b. Minimum of every 100 feet with the following additional points
      i. Deviations in installation alignment (horizontal and vertical) including but not limited to the following:
         a. Intentional changes in geometry such as changing direction to avoid obstacles
         b. Fittings such as elbows (horizontal and vertical)
      ii. Changes in facility characteristics (eg. Change in size, material, number or pair, encasement size, material, etc...)
      iii. Start and end point for vaults
2. Appurtenances installed concurrently with new main installations, whereas appurtenances are defined as service leads and stubs.
   a. Tap-in at the main and at (near) the existing or new right of way line
3. New appurtenances from existing mains
   a. All size and material types shall be recorded for each utility type
   b. Tap-in at main and at (near) the right of way line
4. Transverse utility crossings installed via trenchless methods
   a. All qualified utilities crossing roads as described in Section 2.4
   b. 25 foot intervals across pavement sections when safely achievable

2.2 Direct Observations (Figure 2)

In a direct observation, a surveyor places the surveying instrument directly on the utility and records the XYZ position. This type of observation is commonly achievable if utilities are installed via open excavation methods, or at bore pits and tie in locations where trenchless technologies are used. Data collection of directly observed utilities yield the highest level of confidence but requires daily coordination with construction activities so the field surveyor can physically observe the utility at the required locations prior to backfilling.

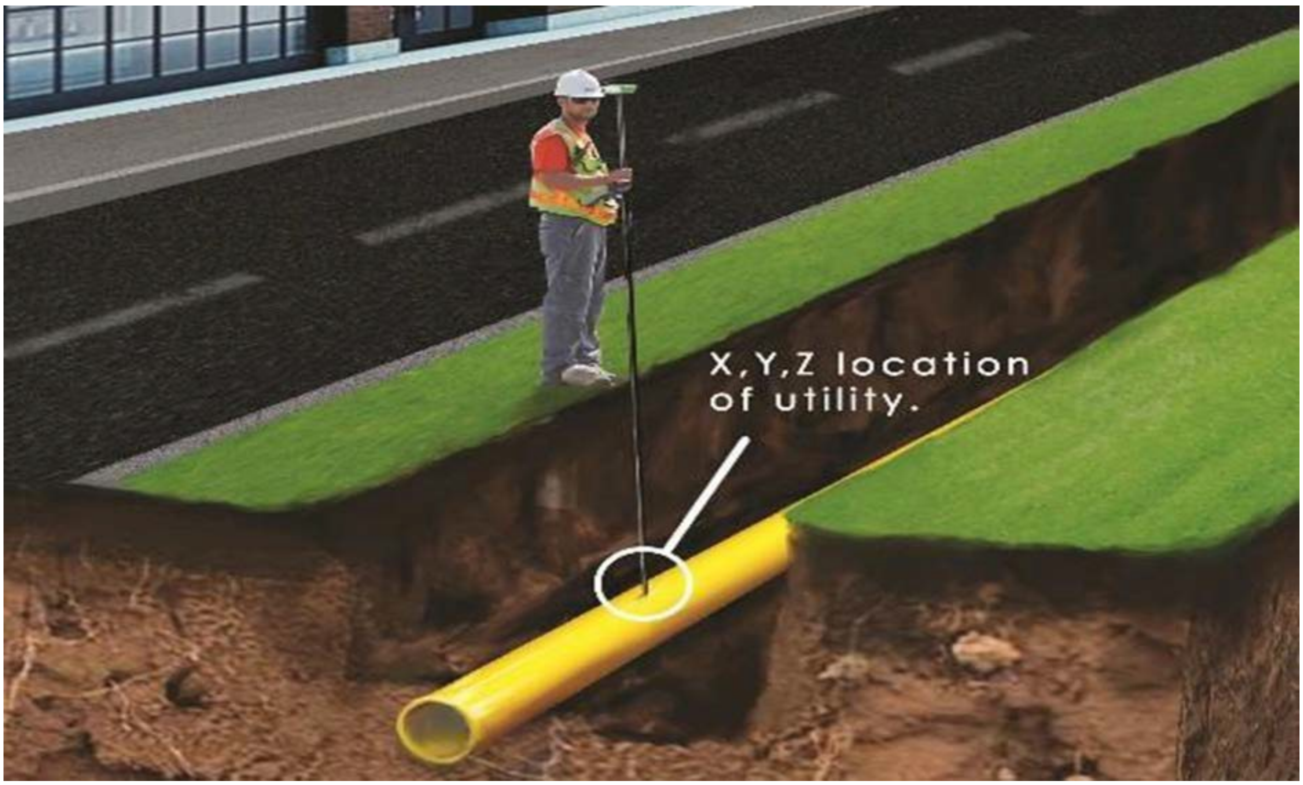


Figure 2

2.3 Indirect Observations (Figure 3)

Common installation methods include various trenchless technologies, which prevent the direct observation of installed utilities. The following are common methods of coordination of data collection aimed at producing high-level data collection results.

Field Witnessing: For trenchless installation methods, observe and survey all tie-in locations, bore pits, or any other areas where the utility is directly exposed. Construction crews must witness the location and depth of the installed utility during mainline trenchless operations. Field witnessing needs to consist of physical marks in the field so that a field surveyor can record a survey observation at the centerline of the utility on the ground, then compute the elevation of the utility by subtracting the field-witnessed depth from the ground elevation. **Figure 3** is an example of field witnessing a trenchless utility installation. A horizontal directional drilled (HDD) fiber optic line is documented with a mark on the centerline of the utility with the ground surface depth recorded within CDOT's mobile application. The reading from the bore head is also required to be documented within CDOT's mobile application (Use Table 2 for Proposed running line point code 6075 to record bore head depth). Utility companies must record a spatial position (X,Y,Z location) at the ground surface, and then compute the elevation of the top of the utility.

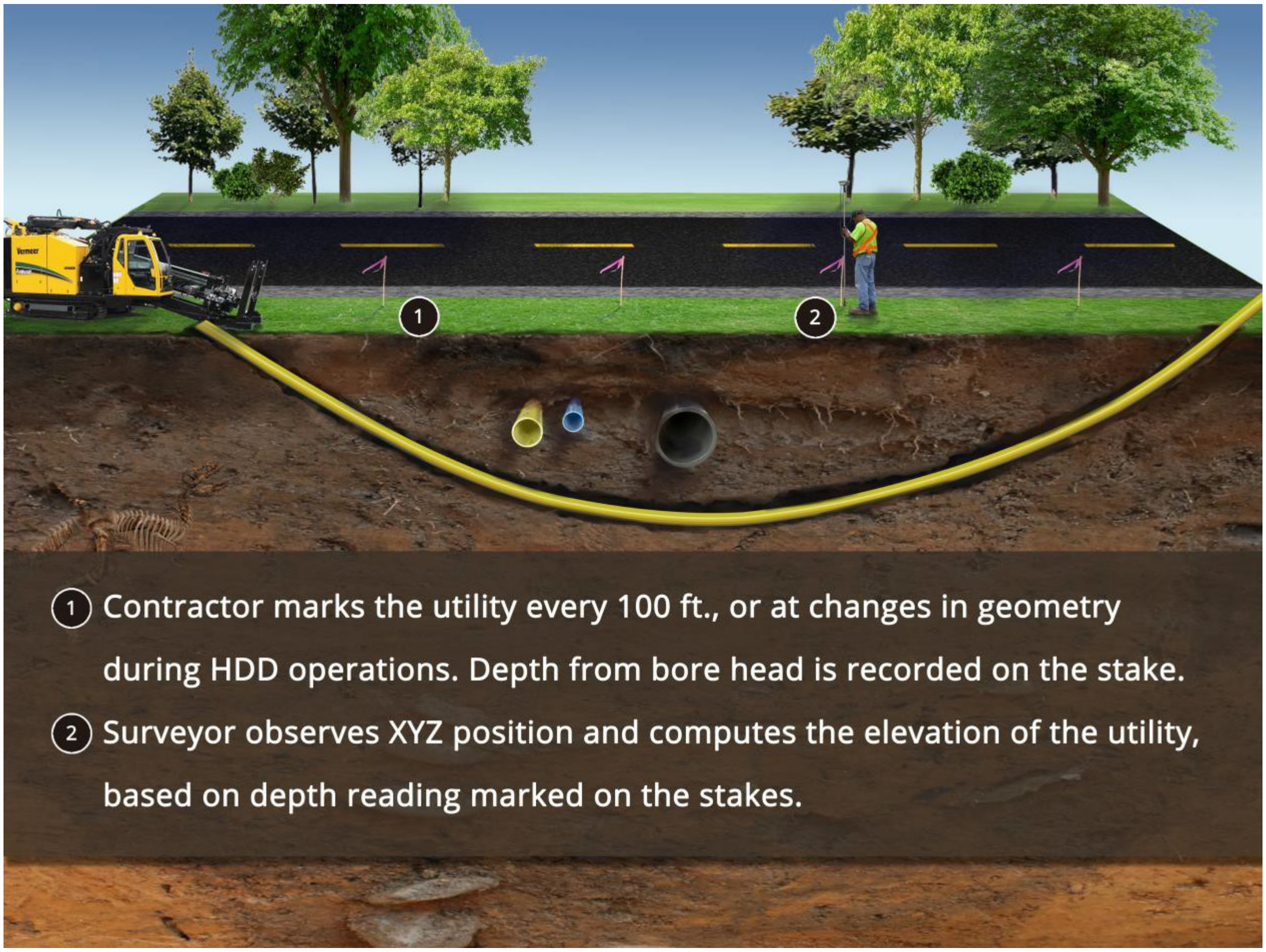


Figure 3

2.4 Unique Requirements for Trenchless Installations on Transverse Utility Crossings

Certain transverse utility crossings may require deviation from the standards in order to maintain a safe work environment. If there are no safe methods of field witnessing the boring location and depth within a pavement section, collect a survey observation at or near the edge of pavement before crossing the pavement section. Then continue by collecting a survey observation at or near the opposite edge of pavement and continue per the normal observation procedures previously described.

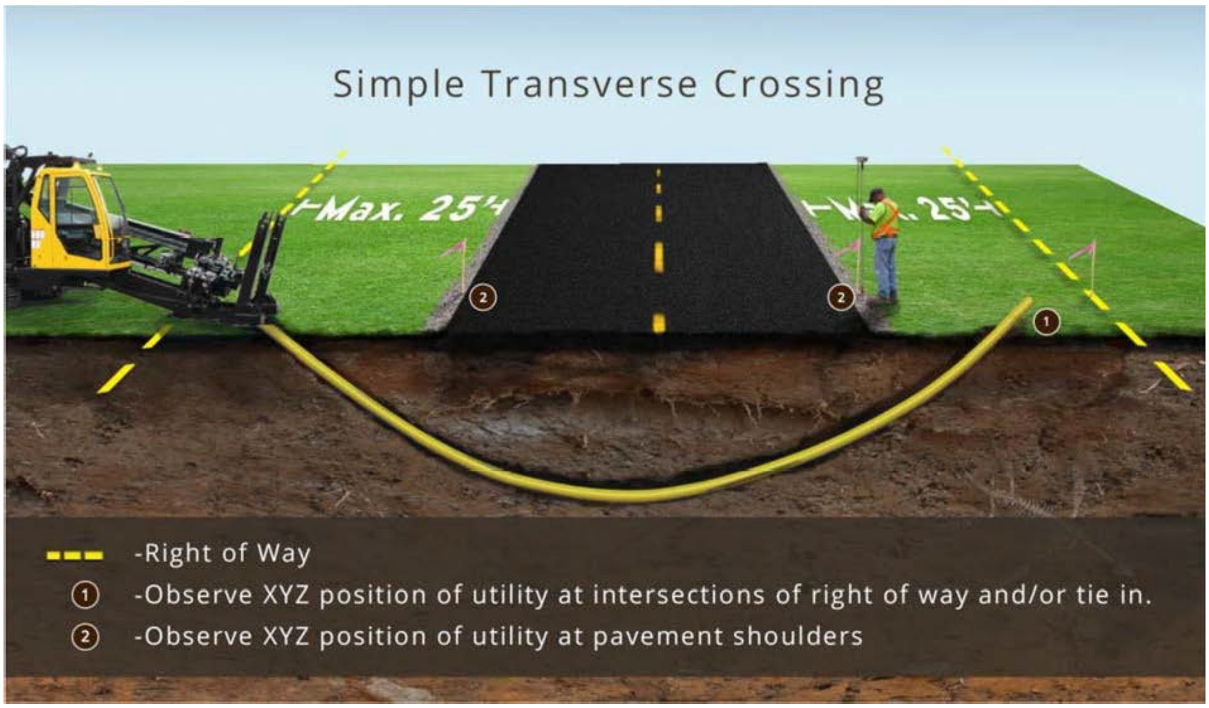


Figure 4

All other transverse utility crossings that are installed using methods conducive to a direct survey observation require survey observations to be collected at a minimum of 25-foot intervals when crossing a pavement section. Additionally, all utilities will be directly observed when installed using a method that support direct observation.

All utilities installed by trenchless technologies must be observed directly above the installed utility with the elevation computed from the best available depth readings (typically depths read from bore head during installation). The accuracy of the depth readings to the installed utility will vary depending on the type of equipment used during installation.

Direct survey observations are required where utilities are exposed, including tie-in locations, bore pits, hand holes, and manholes. Alignment and depth will be documented during boring operations at the required interval. Some form of field witnessing must be used to mark the horizontal location and depth of the utility based on readings from the equipment being used. Then, the utility company can survey each marked location and compute the elevation of the installed facility based on the recorded depth readings at each surveyed location. At a minimum, alignment and depths must be physically documented at an interval of not more than 100 feet and at all changes in horizontal and vertical alignment. The more survey observations collected along a utility line, the better the true three- dimensional alignment of the utility will be represented. For example, long and deep bores could create a parabolic curve shaped utility that will not be accurately represented with point spacing at 100 feet. Use professional judgement and collect additional points at a closer interval to generate a more representative geometry of the utility. **Figure 4** depicts a simple transverse crossing. **Figure 5** depicts two scenarios for complex transverse crossings.

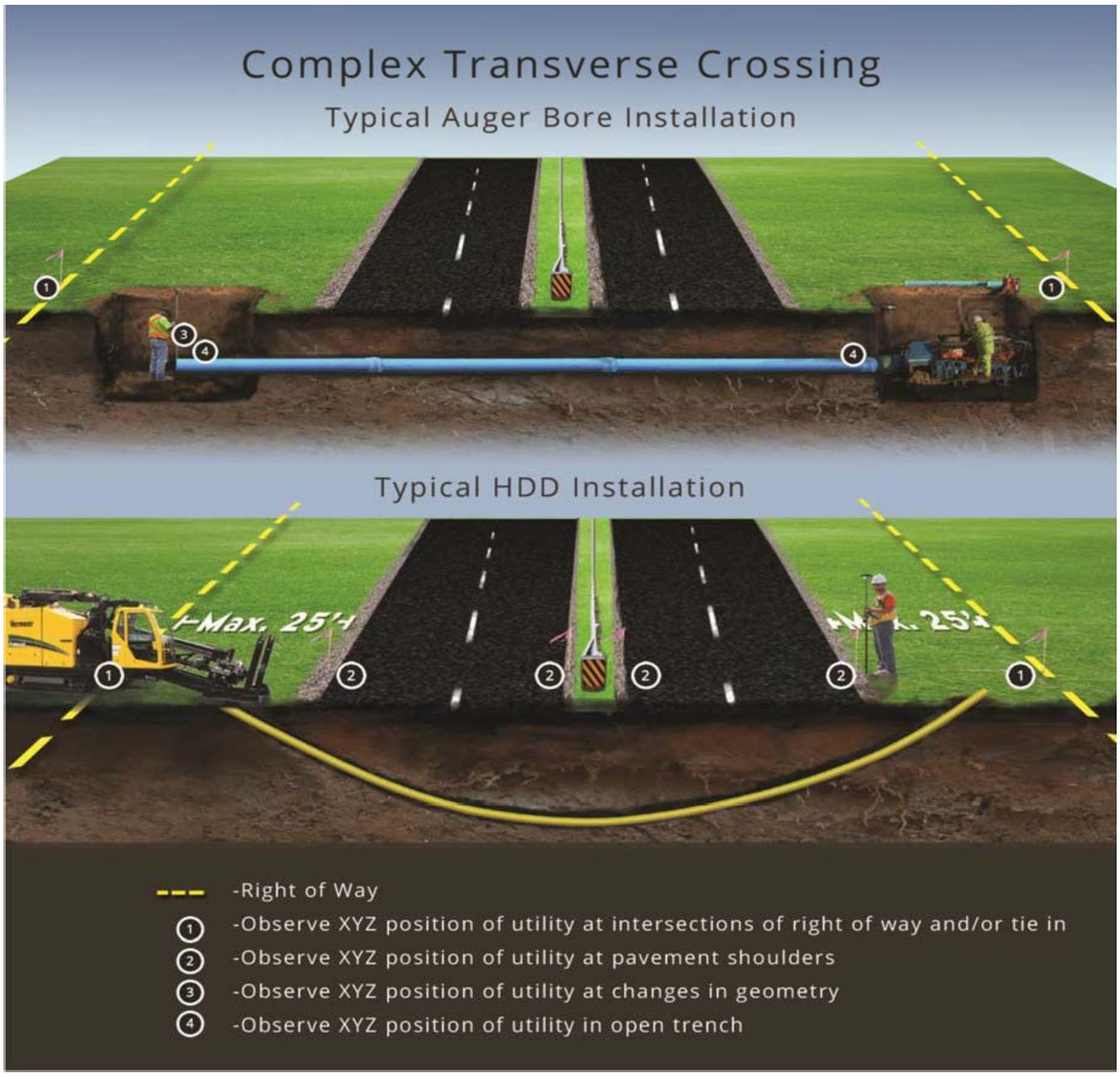


Figure 5

Appendix E Sample Documentation for MDT UPAS and ULDR Utility As-Built Data Upload

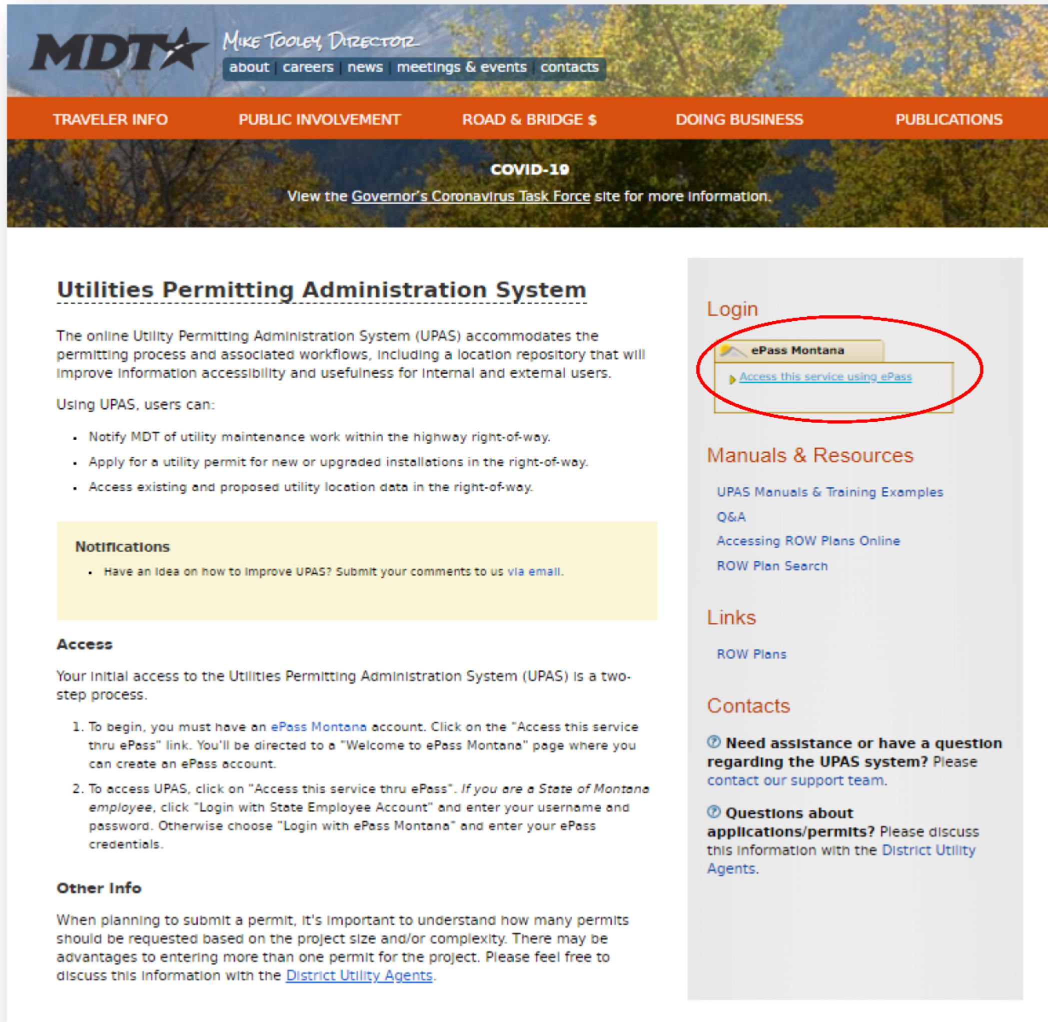
Surveyor

The role of the surveyor in the UPAS system is used to identify who is responsible for importing as-built data collected on utilities after installation. The surveyor is also responsible for indicating who collected the as-built data and **certifying** the associated accuracies of the data collected.

For the applicant to identify the surveyor's point of contact in the application workflow, the individual or company, if using a generic company account, must be in the UPAS system. The following provides an overview of logging into the system if you have an account or if not, how to establish an account using the ePASS system.

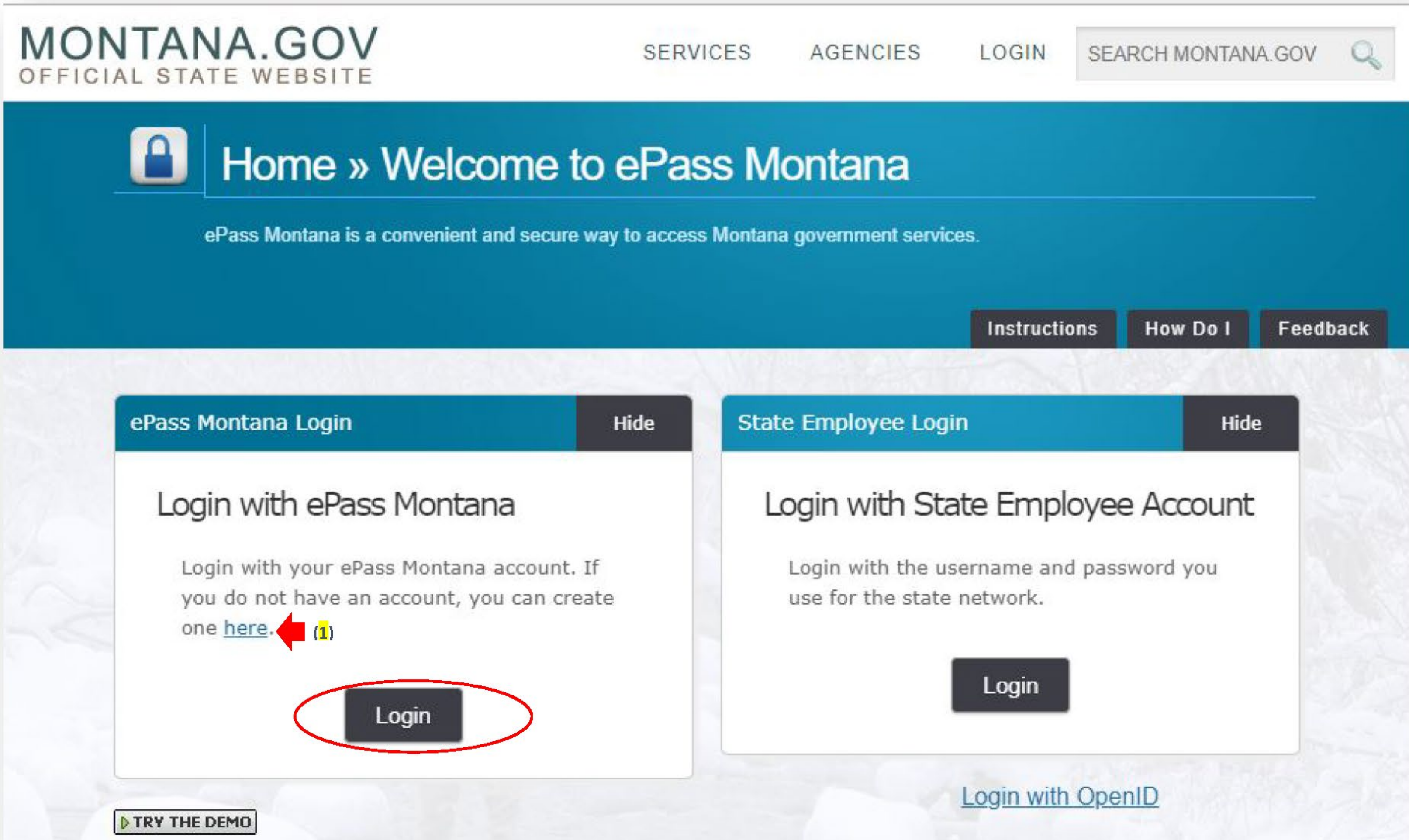
Enter ePASS Montana

Open your browser and type in the URL http://mdtupas.com. Click on the link **Access this service using ePass.**



Sign-in to MDT's Utility Permit Administration System (UPAS)

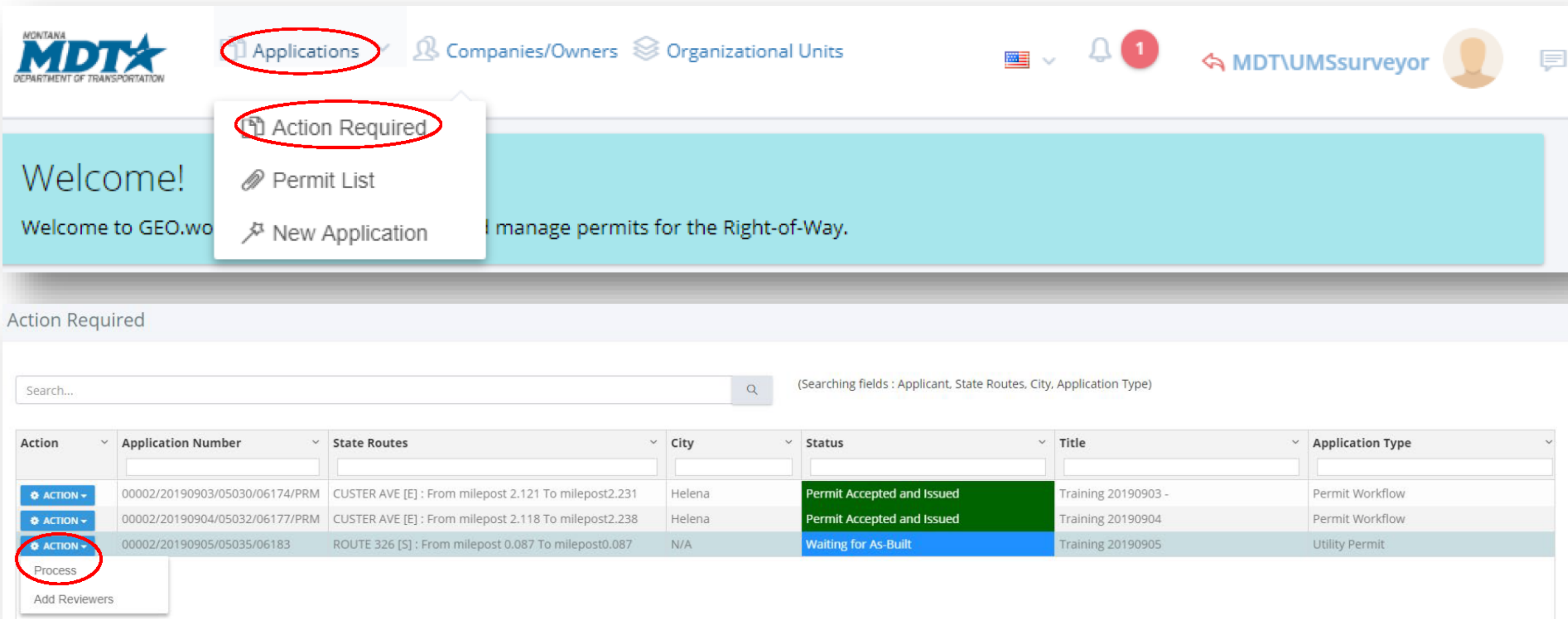
If you do not have an ePass Montana account, click on the link (1) and follow the prompts to create an account. Once you have created account return to the this page and click Login to access the system with your ePASS Montana account.



Loading As-Built Data

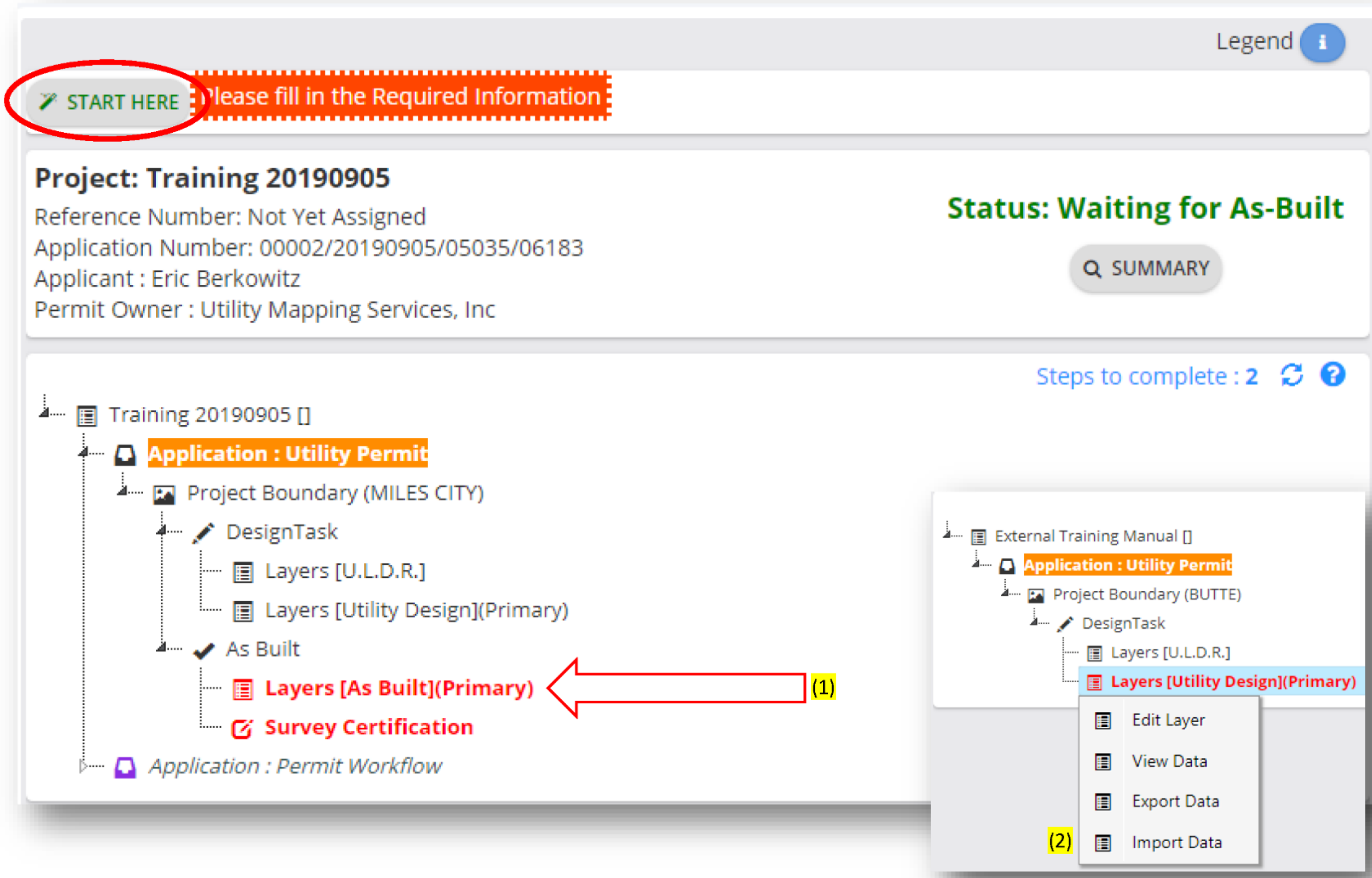
The Surveyor is responsible for uploading and certifying accuracy associated with the survey data. Surveyors are identified in the permit and receive automated notifications from UPAS when construction has started.

The automated email notification includes a link that directs the Surveyor to the permit application. Alternatively, the Surveyor can log into UPAS and see all permits assigned to them that are ready for uploading as-built data. After logging in, click the **Applications** dropdown menu and click **Action Required**.

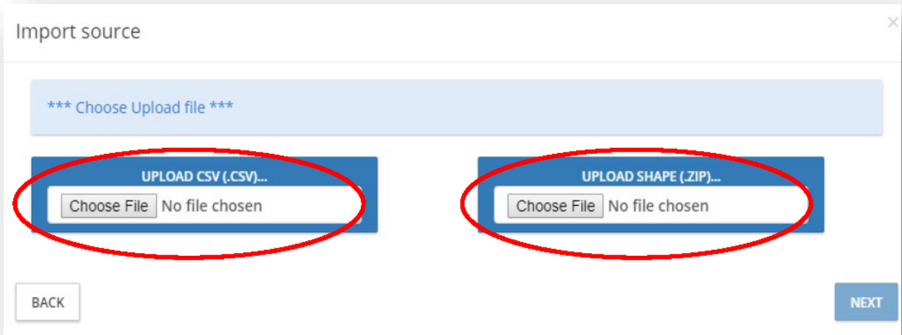


In the list of permits assigned to you, scroll to the line of the permit you want to work on (status is Waiting for As-Built), click the **ACTION** dropdown menu on the left-hand side and click **Process** to open the permit and begin uploading as-built data.

Click **START HERE** to begin uploading as-built data. Alternatively (recommended), right click on the **Layers** node (1) under the **As Built** branch and select **Import Data** (2) from the list of options.



Click **Choose File** for the file type (either CSV or SHP) you will be importing and click **NEXT**.



Setting Up Import Fields

Data can be imported via shapefile however it is only recommended for specific point type components. Importing a CSV file requires setting up the CSV file with the following data field headers. The list below indicates if the field is required, conditional or optional:

Code	Required/Conditional/Optional	Definition
Point ID	Required	The point ID is used to put any features that are chained together in the proper sequence (not needed in Shapefile import)
Easting	Required	The easting of the point(s) in Montana State Plane, NAD83 (2011) in feet (not needed in Shapefile import)
Northing	Required	The northing of the point(s) in Montana State Plane, NAD83 (2011) in feet (not needed in Shapefile import)
HAccurcay	Required	The horizontal accuracy of the survey point. Avialable options are (Enter the number only: 1, 2, 3, 4, 5, or 0): **1** - ± 0.1 feet **2** - ± 0.2 feet **3** - ± 0.3 feet **4** - ± 1 foot **5** - ± 3+ feet **0** - indeterminate

HQL	Required	Horizontal Quality Level. Available options are (enter the letter only): **A** – Obervation made on exposed feature **B** – Observation made via Geophysical Equipment (bore, pipe and cable locator, etc.) **C** – Observation made between two surface appurtenances with records (only for SUE – **never as-builts**) **D** – Observation from records or based on local knowledge (only for SUE – **never as-builts**)
Elevation	Required	The elevation of the points(s) in NAVD88 in feet
VAccuracy	Required	The vertical accuracy of the survey point. Available options (same as Haccuracy) are: **1** - ± 0.1 feet **2** - ± 0.2 feet **3** - ± 0.3 feet **4** - ± 1 foot **5** - ± 3+ feet **0** – indeterminate
VQL	Required	Vertical Quality Level. Available options are (enter the letter only): **A** – Obervation made on exposed feature **B** – Observation made via Geophysical Equipment (bore, pipe and cable locator, etc.) **C** – Observation made between two surface appurtenances with records (only for SUE – **never as-builts**) **D** – Observation from records or based on local knowledge (only for SUE – **never as-builts**)
VOffset	Required – **negative** for features below surface.	Numeric value in **feet** indicating the distance from the survey shot to the **Zlocation** of the component. This defaults to **zero** of no value is entered. The unit of measure is in feet. Used to enter the vertical distance from the observation to the Zlocation. Always **negative** for features below the surface.
LineFCode	Required – can be blank if not importing lineal components	The MDT survey code that defines connected points of linear features (see below).
PointFCode	Required – can be blank if not importing lineal components	The MDT survey code that defines points of non-linear features (see below).
ObsDate	Required	The date the data were collected
SurveyNotes	Optional	Notes that can be added and associated with each observation.

Survey Codes

The following tables list the MDT survey codes that can be used in survey controllers and for importing data. The survey codes, where applicable, have been mapped to codes within the ULDR so that some of the attributes are automatically populated during the import process. This can eliminate the need to import data using the Utility Type and Utility Subtype in data files. If the proper survey code is used the Utility Type and Utility Sub Type will be automatically set by the system and the user does not have to specify these fields during the import process. The tables included show all the possible Utility Types along with tables separated by Utility Type (Chemical, Communication, Electric, Petroleum & Gaseous Materials, Potable Water, Non-Potable Water, Sanitary Sewer, or Storm).

The survey codes provided are not required as the as-built data will be merged with the design data for utility attribution (Utility type, feature type, etc.). It is the Utility Companies responsibility to ensure the utility attributes are correct when submitted to MDT.

Note that there are generic codes for each Component listed (examples; ANC – anchor, BOX – Box). Using these codes during import will set the Utility Type to unknown unless the Utility Type field is filled out. If this field is which default to a Utility Type of Unknown. If the Utility type is known the Utility Type can be specified in the CSV or Shapefile fields during data import.

Table 1 – Example Survey Codes

Survey Code	Component/Feature Class	Utility Type	Utility Sub Type
ANC	Anchor	Unknown	
CANC	Anchor	Communication	
EANC	Anchor	Electric	
BOX	Box	Unknown	
CHCBOX	Box	Chemical	
CBOX	Box	Communication	
EBOX	Box	Electric	
PGCBOX	Box	Petroleum & Gaseous Materials	
PWCBOX	Box	Potable Water	
NPCBOX	Box	Non-Potable Water	
FIBERU	Cable	Communication	Fiber Optic
FIBERX	Cable	Communication	Fiber Optic

Appendix F: Review of Homeland Security Act of 2002 Public Law 107-296

Cursory Review of Homeland Security Act 2002 Public Law 107-296

Application to Utilities Occupying State Right of Way

June 2019

Richard Manser, P.E., M.S.

Submitted by
Utility Mapping Services Inc.

Introduction

This report is a cursory review of the Homeland Security Act 2002, Public Law 107-296 (HSA) as it applies to utilities occupying State highway rights-of-way. The vast majority of the HSA does not apply to utilities occupying State highway rights-of-way and is therefore excluded in this review.

Purpose of the Homeland Security Act

The purpose of the HSA was to establish a Cabinet-level Secretary for Homeland Security and a new Department of Homeland Security (DHS). The HSA combines responsibilities and organizations of several previously established federal entities. It defines how the DHS is to coordinate with various federal entities. The primary mission of the HSA (related to the scope of this report) is to:

- Prevent terrorist attacks
- Reduce vulnerability to terrorism
- Minimize damage and assist in recovery from terrorist attacks
- Ensure that overall economic security is not diminished by HSA activities

How the Homeland Security Act of 2002 May Apply to Utilities Occupying States' Rights-of-Way.

Summary

Some states report difficulty obtaining information from utilities occupying their state's right-of-way. Utility owners and operators sometimes make a blanket statement that they are not required to provide information based on the Homeland Security Act. Upon review of the HSA, it appears this argument is invalid in most cases. The HSA is written to direct the DHS's handling of defined "Critical Infrastructure Information". When DHS shares Critical Instructure Information directly with states the same HSA protections apply to states handling of the information. When states obtain information from sources other than the DHS, these protections do not apply.

States may legally collect and use utility information, including all information in the public domain, provided the following criteria are met:

- States routinely and legally collect the information; and
- Utilities do not claim the information is proprietary or business sensitive; or states do not concur with a utility's claim that the information is proprietary or business sensitive; and
- States do not disclose whether or not DHS has designated the information 'Critical Infrastructure Information'.

Background

HSA defines "***Critical Infrastructure Information***" as information not customarily in the public domain and related to the security of critical infrastructure (as defined by Section 212) or protected systems, specifically:

A. Threats, attacks;
B. Vulnerabilities of critical infrastructure; and
C. Planned or known operational problems/solutions.

HSA defines "***Protected System***" as any service, physical or computer-based system, process, or procedure that directly or indirectly affects the viability of a facility of critical infrastructure.

The DHS has a directorate to:

1. Carry out comprehensive assessments of vulnerabilities of critical infrastructure, including risk assessments, probability of terrorist attacks, and potential countermeasures; and
2. Develop a comprehensive plan for securing critical infrastructure including power production, generation, and distribution systems, information technology and telecommunications systems, emergency preparedness communications systems, and physical and technological assets that support such systems.

The DHS directorate of performing vulnerability assessments and developing plans for securing critical infrastructure extends beyond the scope of what a state transportation agency typically needs to know when keeping records of utilities within its right-of-way.

Critical utility infrastructure information voluntarily shared from utility owners to DHS and subsequently shared from DHS to a State or local government is protected under the HSA with limitations:

1. DHS and subsequent State and local government recipients are restricted from publicly sharing information DHS collects and shall establish procedures protecting:
    a. The identity of the person or entity who submitted the information; and
    b. Information that is proprietary or business sensitive
2. Information in the public domain (not critical infrastructure information by definition) is not protected
3. Any State, local entity, agency or authority or any third party can legally obtain critical infrastructure information from other sources, excluding DHS, provided:
    a. They do so legally;
    b. The information is generally disclosed to them; or
    c. Is broadly available to the public.
4. Information obtained from other sources as described in #3 above is not protected by the HSA.

HSA excerpts from Sub-section 214 describing DHS requirements to protect voluntarily shared information:

a. Protection…information voluntarily submitted shall be exempt from disclosure under the Freedom of Information Act. Shall not, if provided to a State or local government
    i. Be made available pursuant to any State or local law requiring disclosure;
    ii. Be disclosed or distributed to any party by State or local government without the written consent of the person or entity submitting such information; or
    iii. Be used for any other purpose than protecting critical infrastructure.

b. Independently obtained information…Nothing in this section shall be construed to limit or otherwise affect the ability of a State, local entity, agency or authority or any third party, under applicable law, to obtain critical infrastructure information in a manner not covered by subsection (a), including any information lawfully and properly disclosed generally or broadly to the public and to use such information in any manner permitted by law.

e. Procedures …. shall establish procedures for protecting from public disclosure the identity of the submitting person or entity, or information that is proprietary, business sensitive, and is otherwise not appropriately in the public domain.

Federal Regulations Tied to the Homeland Security Act of 2002

The scope of this cursory review excludes federal regulations that may directly or indirectly relate to the HSA. The research team is aware of one regulation describing the classification of Sensitive Security Information (SSI), published in the Federal Register, May 18, 2004, FR 28082. Select excerpts of this regulation are included in Appendix B. The definition of SSI is found in § 1520.5 – Sensitive security information. An applicable part of this definition is:

> *(12) Critical aviation, maritime, or rail infrastructure asset information. Any list identifying systems or assets, whether physical or virtual, so vital to the aviation, maritime, or rail transportation system (including rail hazardous materials shippers and rail hazardous materials receivers) that the incapacity or destruction of such assets would have a debilitating impact on transportation security, if the list is -*
>
> > *(i) Prepared by DHS or DOT; or*
> > *(ii) Prepared by a State or local government agency and submitted by the agency to DHS or DOT.*

Similar to the HSA, this regulation focuses on information identifying specific facilities, which if incapacitated, would have a debilitating impact on the nation's transportation systems. States are prohibited from publicly identifying what facilities are on the Transportation Security Administration's critical infrastructure list and why they are on the list.

Potential Barriers that May Impact Agencies Abilities to Require Utilities to Install and Provide Accurate Geospatial As-Builts When Occupying States' Rights-of-Way

The HSA does not restrict states from requiring utilities to install at specific geospatial locations or provide accurate geospatial as-builts when occupying states' rights-of-way. Collecting as-built data requires several associated attributes, one of which is geospatial information. The handling of all attributes is of interest and potential concern to utility owners.

Utilities may have concerns about utility information being collected and shared with others, particularly if this information could be used to identify security vulnerabilities. Collecting information such as system capacity, daily operating pressures, number of fiber strands, customer service contracts, asset performance, etc. may be very sensitive to the utility and of limited value to the state.

Effective policies/practices that have enabled states to require accurate utility installations and collect accurate as-builts

Protect Proprietary or Business Sensitive Information

Most states have laws and rules addressing public access to government records. Utilities may not want proprietary or business sensitive information disclosed to the public.

Similar privacy concerns are at times addressed in permits, right-of-way agreements, or within contracts such as a contractor's alternative technical concepts. In each of these cases, confidentiality rules are used to protect the interests, intellectual property, or business practices of non-agency entities.

In these situations, the utility needs to convince the state that the utility's request meets the legal requirements for protection. When a state collects protected information, it needs to prevent its disclosure to the public, and obtain the utility's permission prior to disclosing the information to third parties when necessitated for state work.

Minimize Collection of Utility Attributes

States can minimize their information requirements and focus on basic high-value data such as the type of utility, size and occupied space (geospatial location) within the right-of-way.

Share Generic Information

Sharing a generic version of as-built data is a tool that may alleviate utility concerns. For example, the utility owner information that is important to states, is likely legally required, but may be withheld from the general public and 3rd parties who do not have a need-to-know. States who limit public access to utility data should do so in a consistent, transparent way supported by a legal framework of laws, rules and policy.

Manage Access to Utility As-Built Data

Access to as-built data can be restricted to specific geospatial areas of interest and specific individuals/groups on an as-needed basis. When states are performing their planning, environmental, design, construction and maintenance activities, access to as-built information is invaluable. Safety is significantly enhanced with geospatially accurate utility records. Avoiding, protecting-in-place, or minimizing utility impacts benefits utility owners, customers and state transportation agencies.

Within a state agency, individuals and groups have job responsibilities requiring access to utility as-built information. Managing access through user roles, passwords, confidentiality rules, etc. can help minimize utility concerns.

If 3rd parties need to know what utilities are in a specific location (e.g. working in the area), the state can share the geospatial locations and types of utilities without disclosing the owners. If 3rd parties need to coordinate with utility owners (e.g. designing and constructing a state project) utility information within the project limits can be shared with specific individuals who have a need to know. Non-disclosure agreements can be used.

Conclusions/Recommendations

The HSA does not restrict states from requiring utilities to install at specific geospatial locations or provide accurate geospatial as-builts when occupying states' rights-of-way. HSA applies to Critical Infrastructure Information, information not customarily in the public domain and related to the security of critical infrastructure or protected systems, specifically:

A. Threats, attacks;
B. Vulnerabilities of critical infrastructure; and
C. Planned or known operational problems/solutions.

States should be cautious about asking for or disclosing information which could be used to identify security vulnerabilities.

The HSA does not prevent states from collecting and using utility location as-built data. It is written to direct the DHS in handling defined "Critical Infrastructure Information". States may legally collect and use utility information, including all information in the public domain (e.g. the state's One-Call (Call 811) system, the Pipeline and Hazardous Materials Safety Administration, Public Service Commissions, or other agencies), provided the following criteria are met:

- States routinely and legally collect the information; and
- Utilities do not claim the information is proprietary or business sensitive; or states do not concur with a utility's claim that the information is proprietary or business sensitive; and
- States do not disclose whether DHS has designated the information 'Critical Infrastructure Information'.

Utilities may have legitimate concerns about sharing utility information, whether or not these are related to HSA, including:

- Protecting proprietary and business sensitive data
- Sharing information of low value to the state
- The breadth of information and details publicly accessible
- Limiting access on a need-to-know basis

Understanding the premises, purposes and content of the HSA should help states having difficulty obtaining information from utilities occupying public right-of-way. Armed with this comprehension, states will be in a more informed position to discuss reasons utility owners and operators may be reluctant to share information.

Appendix A-1 Detailed HSA Framework with Applicable Notes

(Organized by Title/Subtitle/Sub-section Number)

The notes (blue text) described below and referenced within the HSA framework, include combined summary narrative and applicable, partial excerpts from the law.

TITLE I—DEPARTMENT OF HOMELAND SECURITY

Sec. 101. Executive department; mission.

Establish a Department of Homeland Security

Primary Mission:

- Prevent terrorist attacks
- Reduce vulnerability to terrorism
- Minimize damage and assist in recovery from terrorist attacks
- Ensure that overall economic security is not diminished by HSA activities

Sec. 102. Secretary; functions.

Sec. 103. Other officers.

TITLE II—INFORMATION ANALYSIS AND INFRASTRUCTURE PROTECTION

Subtitle A—Directorate for Information Analysis and Infrastructure Protection; Access to Information

Sec. 201. Directorate for Information Analysis and Infrastructure Protection.

(d) (2) carry out comprehensive assessments of vulnerabilities of critical infrastructure, including risk assessments, probability of terrorist attacks, and potential countermeasures

(d) (5) develop a comprehensive plan for securing critical infrastructure including power production, generation, and distribution systems, information technology and telecommunications systems, emergency preparedness communications systems, and physical and technological assets that support such systems

Sec. 202. Access to information.

Subtitle B—Critical Infrastructure Information

Sec. 211. Short title.

Sec. 212. Definitions.

"Critical Infrastructure Information" means information not customarily in the public domain and related to the security of critical infrastructure or protected systems – (A) threats, attacks; (B) vulnerability of critical infrastructure; and (C) planned or known operational problem/solution

"Protected System" means any service, physical or computer-based system, process, or procedure that directly or indirectly affects the viability of a facility of critical infrastructure

Sec. 213. Designation of critical infrastructure protection program.

Sec. 214. Protection of voluntarily shared critical infrastructure information.

(a) Protection…information voluntarily submitted shall be exempt from disclosure under the Freedom of Information Act. Shall not, if provided to a State or local government – (i) be made available pursuant to any State or local law requiring disclosure; (ii) be disclosed or distributed to any party by State or local government without the written consent of the person or entity submitting such information; or (iii) be used for any other purpose than protecting critical infrastructure.

(b) Independently obtained information…Nothing in this section shall be construed to limit or otherwise affect the ability of a State, local entity, agency or authority or any third party, under applicable law, to obtain critical infrastructure information in a manner not covered by subsection (a), including any information lawfully and properly disclosed generally or broadly to the public and to use such information in any manner permitted by law.
(e) Procedures….shall establish procedures for protecting from public disclosure the identity of the submitting person or entity, or information that is proprietary, business sensitive, and is otherwise not appropriately in the public domain.

Sec. 215. No private right of action.

Subtitle C—Information Security

Sec. 221. Procedures for sharing information.
Sec. 222. Privacy Officer.
Sec. 223. Enhancement of non-Federal cybersecurity.
Sec. 224. Net guard.
Sec. 225. Cyber Security Enhancement Act of 2002.

Subtitle D—Office of Science and Technology

Sec. 231. Establishment of office; Director.
Sec. 232. Mission of office; duties.
Sec. 233. Definition of law enforcement technology.
Sec. 234. Abolishment of Office of Science and Technology of National Institute of Justice; transfer of functions.
Sec. 235. National Law Enforcement and Corrections Technology Centers.
Sec. 236. Coordination with other entities within Department of Justice.
Sec. 237. Amendments relating to National Institute of Justice.

TITLE III—SCIENCE AND TECHNOLOGY IN SUPPORT OF HOMELAND SECURITY

Sec. 301. Under Secretary for Science and Technology.
Sec. 302. Responsibilities and authorities of the Under Secretary for Science and Technology.
Sec. 303. Functions transferred.
Sec. 304. Conduct of certain public health-related activities.
Sec. 305. Federally funded research and development centers.
Sec. 306. Miscellaneous provisions.
Sec. 307. Homeland Security Advanced Research Projects Agency.
Sec. 308. Conduct of research, development, demonstration, testing and evaluation.
Sec. 309. Utilization of Department of Energy national laboratories and sites in support of homeland security activities.
Sec. 310. Transfer of Plum Island Animal Disease Center, Department of Agriculture.
Sec. 311. Homeland Security Science and Technology Advisory Committee.
Sec. 312. Homeland Security Institute.
Sec. 313. Technology clearinghouse to encourage and support innovative solutions to enhance homeland security

TITLE IV—DIRECTORATE OF BORDER AND TRANSPORTATION SECURITY

Subtitle A—Under Secretary for Border and Transportation Security

Sec. 401. Under Secretary for Border and Transportation Security.
Sec. 402. Responsibilities.
Sec. 403. Functions transferred.

Subtitle B – United States Customs Service
Sec. 411. Establishment; Commissioner of Customs.
Sec. 412. Retention of customs revenue functions by Secretary of the Treasury.
Sec. 413. Preservation of customs funds.
Sec. 414. Separate budget request for customs.
Sec. 415. Definition.
Sec. 416. GAO report to Congress.
Sec. 417. Allocation of resources by the Secretary.
Sec. 418. Reports to Congress.
Sec. 419. Customs user fees.

Subtitle C – Miscellaneous Provisions
Sec. 421. Transfer of certain agricultural inspection functions of the Department of Agriculture.
Sec. 422. Functions of Administrator of General Services.
Sec. 423. Functions of Transportation Security Administration.
Sec. 424. Preservation of Transportation Security Administration as a distinct entity.
Sec. 425. Explosive detection systems.
Sec. 426. Transportation security.
Sec. 427. Coordination of information and information technology.
Sec. 428. Visa issuance.
Sec. 429. Information on visa denials required to be entered into electronic data system.
Sec. 430. Office for Domestic Preparedness.

Subtitle D – Immigration Enforcement Functions
Sec. 441. Transfer of functions to Under Secretary for Border and Transportation Security.
Sec. 442. Establishment of Bureau of Border Security.
Sec. 443. Professional responsibility and quality review.
Sec. 444. Employee discipline.
Sec. 445. Report on improving enforcement functions.
Sec. 446. Sense of Congress regarding construction of fencing near San Diego, California

Subtitle E—Citizenship and Immigration Services
Sec. 451. Establishment of Bureau of Citizenship and Immigration Services.
Sec. 452. Citizenship and Immigration Services Ombudsman.
Sec. 453. Professional responsibility and quality review.
Sec. 454. Employee discipline.
Sec. 455. Effective date.
Sec. 456. Transition.
Sec. 457. Funding for citizenship and immigration services.
Sec. 458. Backlog elimination.
Sec. 459. Report on improving immigration services.
Sec. 460. Report on responding to fluctuating needs.
Sec. 461. Application of Internet-based technologies.
Sec. 462. Children's affairs.

Subtitle F—General Immigration Provisions
Sec. 471. Abolishment of INS.
Sec. 472. Voluntary separation incentive payments.
Sec. 473. Authority to conduct a demonstration project relating to disciplinary action.
Sec. 474. Sense of Congress.
Sec. 475. Director of Shared Services.
Sec. 476. Separation of funding.
Sec. 477. Reports and implementation plans.
Sec. 478. Immigration functions.

TITLE V—EMERGENCY PREPAREDNESS AND RESPONSE

Sec. 501. Under Secretary for Emergency Preparedness and Response.
Sec. 502. Responsibilities.
Sec. 503. Functions transferred.
Sec. 504. Nuclear incident response.
Sec. 505. Conduct of certain public health-related activities.
Sec. 506. Definition.
Sec. 507. Role of Federal Emergency Management Agency.
Sec. 508. Use of national private sector networks in emergency response.
Sec. 509. Use of commercially available technology, goods, and services.

TITLE VI—TREATMENT OF CHARITABLE TRUSTS FOR MEMBERS OF THE ARMED FORCES OF THE UNITED STATES AND OTHER GOVERNMENTAL ORGANIZATIONS

Sec. 601. Treatment of charitable trusts for members of the Armed Forces of the United States and other governmental organizations

TITLE VII—MANAGEMENT

Sec. 701. Under Secretary for Management.
Sec. 702. Chief Financial Officer.
Sec. 703. Chief Information Officer.
Sec. 704. Chief Human Capital Officer.
Sec. 705. Establishment of Officer for Civil Rights and Civil Liberties.
Sec. 706. Consolidation and co-location of offices.

TITLE VIII—COORDINATION WITH NON-FEDERAL ENTITIES; INSPECTOR GENERAL; UNITED STATES SECRET SERVICE; COAST GUARD; GENERAL PROVISIONS

Subtitle A – Coordination with Non-Federal Entities
Sec. 801. Office for State and Local Government Coordination.

Sec. 884. Federal Law Enforcement Training Center.
Sec. 885. Joint Interagency Task Force.
Sec. 886. Sense of Congress reaffirming the continued importance and applicability of the Posse Comitatus Act.
Sec. 887. Coordination with the Department of Health and Human Services under the Public Health Service Act.
Sec. 888. Preserving Coast Guard mission performance.
Sec. 889. Homeland security funding analysis in President's budget.
Sec. 890. Air Transportation Safety and System Stabilization Act.

Subtitle I – Information Sharing
Sec. 891. Short title; findings; and sense of Congress.
Sec. 892. Facilitating homeland security information sharing procedures.
Sec. 893. Report.
Sec. 894. Authorization of appropriations.
Sec. 895. Authority to share grand jury information.
Sec. 896. Authority to share electronic, wire, and oral interception information.
Sec. 897. Foreign intelligence information.
Sec. 898. Information acquired from an electronic surveillance.
Sec. 899. Information acquired from a physical search.

TITLE IX – NATIONAL HOMELAND SECURITY COUNCIL

Sec. 901. National Homeland Security Council.
Sec. 902. Function.
Sec. 903. Membership.
Sec. 904. Other functions and activities.
Sec. 905. Staff composition.
Sec. 906. Relation to the National Security Council.

TITLE X – INFORMATION SECURITY

Sec. 1001. Information security.

Sec. 1002. Management of information technology.
Sec. 1003. National Institute of Standards and Technology.
Sec. 1004. Information Security and Privacy Advisory Board.
Sec. 1005. Technical and conforming amendments.
Sec. 1006. Construction.

TITLE XI – DEPARTMENT OF JUSTICE DIVISIONS

Subtitle A – Executive Office for Immigration Review
Sec. 1101. Legal status of EOIR.
Sec. 1102. Authorities of the Attorney General.
Sec. 1103. Statutory construction.

Subtitle B – Transfer of the Bureau of Alcohol, Tobacco and Firearms to the Department of Justice

Sec. 1111. Bureau of Alcohol, Tobacco, Firearms, and Explosives.

TITLE XIV—ARMING PILOTS AGAINST TERRORISM

TITLE XV – TRANSITION

TITLE XVI – CORRECTIONS TO EXISTING LAW RELATING TO AIRLINE TRANSPORTATION SECURITY

TITLE XVII—CONFORMING AND TECHNICAL AMENDMENTS

Appendix B SSI Classification Under 49 CFR 1520

(Published May 18, 2004 FR 28082)

Title 49. Transportation
Subtitle B. Other Regulations Relating to Transportation
Chapter XII. Transportation Security Administration, Department of Homeland Security
Subchapter B. Security Rules for all Modes of Transportation
Part 1520. Protection of Sensitive Security information

1520.1 Scope.
(a)Applicability. This part governs the maintenance, safeguarding, and disclosure of records and information that TSA has determined to be Sensitive Security Information, as defined in § 1520.5. This part does not apply to the maintenance, safeguarding, or disclosure of classified national security information, as defined by Executive Order 12968, or to other sensitive unclassified information that is not SSI, but that nonetheless may be exempt from public disclosure under the Freedom of Information Act. In addition, in the case of information that has been designated as critical infrastructure information under section 214 of the Homeland Security Act, the receipt, maintenance, or disclosure of such information by a Federal agency or employee is governed by section 214 and any implementing regulations, not by this part.

1520.3 Terms used in this part.
Record includes any means by which information is preserved, irrespective of format, including a book, paper, drawing, map, recording, tape, film, photograph, machine-readable material, and any information stored in an electronic format. The term record also includes any draft, proposed, or recommended change to any record.
SSI means sensitive security information, as described in § 1520.5

1520.5 - Sensitive security information
(12) Critical aviation, maritime, or rail infrastructure asset information. Any list identifying systems or assets, whether physical or virtual, so vital to the aviation, maritime, or rail transportation system (including rail hazardous materials shippers and rail hazardous materials receivers) that the incapacity or destruction of such assets would have a debilitating impact on transportation security, if the list is -
(i) Prepared by DHS or DOT; or
(ii) Prepared by a State or local government agency and submitted by the agency to DHS or DOT.

1520.9 Restrictions on the disclosure of SSI.
(a) Duty to protect information. A covered person must -
> (1) Take reasonable steps to safeguard SSI in that person's possession or control from unauthorized disclosure. When a person is not in physical possession of SSI, the person must store it a secure container, such as a locked desk or file cabinet or in a locked room.
> (2) Disclose, or otherwise provide access to, SSI only to covered persons who have a need to know, unless otherwise authorized in writing by TSA, the Coast Guard, or the Secretary of DOT.
> (3) Refer requests by other persons for SSI to TSA or the applicable component or agency within DOT or DHS.
> (4) Mark SSI as specified in § 1520.13.
> (5) Dispose of SSI as specified in § 1520.19.

1520.15 SSI disclosed by TSA or the Coast Guard.
(a) In general. Except as otherwise provided in this section, and notwithstanding the Freedom of Information Act (5 U.S.C. 552), the Privacy Act (5 U.S.C. 552a), and other laws, records containing SSI are not available for public inspection or copying, nor does TSA or the Coast Guard release such records to persons without a need to know.
(h) Disclosure of Critical Infrastructure Information. Disclosure of information that is both SSI and has been designated as critical infrastructure information under section 214 of the Homeland Security Act is governed solely by the requirements of section 214 and any implementing regulations.