SHRP2 IMPLEMENTATION CLOSE-OUT REPORT

Utility Products Bundle

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REGARDING	Implementation Close Out of SHRP2 Utility Bundle Products: ***Identifying and Managing Utility Conflicts*** (R15B) ***3D Utility Location Data Repository*** (R01A) ***Utility Locating Technologies*** (R01B)

Executive Summary

Two critical factors contributing to utility inefficiencies in the delivery of transportation projects are: the lack of adequate information about the location and attributes of utility facilities that the project might affect; and the lack of an effective process to manage conflicts between those facilities and project features and phases. A significant challenge is how to manage information about utility facilities that occupy the rights of way in a manner that can facilitate data extraction and data analysis while contributing to an effective management of the rights of way.

As part of the SHRP2 Implementation Assistance Program (IAP) sponsored by the Federal Highway Administration (FHWA) and the Association of State Highway and Transportation Officials (AASHTO), three products designed to address these challenges related to utilities were offered to state departments of transportation (DOTs) in four rounds: *Identifying and Managing Utility Conflicts* (R15B*); 3D Utility Location Data Repository* (R01A); and *Utility Locating Technologies* (R01B).

Twenty state DOTs and the District of Columbia were selected to test and assess the products. The goals and scope of these implementation projects varied widely depending on the needs of the individual agency.

- Implementation of R15B ranged from using the standalone utility conflict list at a sample of pilot projects to the development and implementation of enterprise system modules to automate specific utility conflict management features.
- For R01A, implementation ranged from developing a 2D-standalone geographic database of existing utilities within the right of way to developing an enterprise system architecture to manage utility facilities in a 3D-environment.
- For R01B, implementation focused on the use of multi-channel ground penetrating radar (MCGPR) and time-domain electromagnetic induction (TDEMI) technologies to detect underground utility facilities.

Recognizing the synergies between and among the products, the products collectively became known as the Utility Bundle. A webpage containing all materials developed from their implementation are housed here for ease of use.

As part of the IAP technical assistance, training opportunities were offered to each DOT at the beginning of implementation. For R15B, training included one session of the one-day utility conflict management (UCM) business practice training course. For R01A, a brainstorming session was conducted with stakeholders at each state DOT to discuss topics such as implementation goals, challenges, leadership buy-in, information technology (IT) involvement, and ideas for implementation scope and schedule. For R01B, training involved conducting a field demonstration of MCGPR and TDEMI technologies and a discussion of potential projects and activities for the pilot implementation.

In addition to the initial training, regular peer exchanges were conducted to facilitate discussions among state DOTs. Some of the peer exchanges included presentations by state DOTs or invited experts to talk about specific topics of interest.

Lessons learned from the various implementations were documented in specific deliverables per product and in state-specific case studies. Contractors, utility owners, and other stakeholders were given the opportunity to contribute and learn. Cost and project delivery time savings were identified, particularly where states were able to make design changes to avoid unnecessary utility relocations and documented such results.

Brief Product Overviews

Individually, the three utility products were offered in two rounds and then were combined into a ***Utility Bundle*** in Round 7 in Spring 2016. Table 1 shows the agencies that received funds to implement the **R01A, R01B**, and **R15B** products. Appendix A provides a chart of all the states per product along with notes on their final implementation and future plans.

Identifying and Managing Utility Conflicts (R15B) included several tools that agencies can incorporate in existing business practices to identify and resolve utility conflicts. These tools include a standalone template for utility conflict lists (initially referred to as a Utility Conflict Matrix), a utility conflict data model and database, and a one-day UCM training course. Utility conflict management is a comprehensive multi-stage process that involves the systematic identification and resolution of utility conflicts during project delivery. Identifying utility conflicts as early as possible facilitates the implementation of optimum strategies to resolve those conflicts.

The **R15B** products suite provides a systematic approach for identifying, resolving, and managing utility conflicts throughout the design process. The products suite consists of a simplified, Excel-based Utility Conflict List, an MS Access scalable data model, and a one-day UCM training course**. R15B** was deployed under Rounds 3, 6, and 7 of the SHRP2 IAP. Round 3 awarded funds to seven state DOTs in March 2014. Six states received implementation awards in Round 6 in August 2015 and an additional five new states in Round 7 as part of the **Utility Bundle**.

3D Utility Location Data Repository (R01A) tested a procedure to manage utility data during project delivery. The **R01A** product supports the development of a 3D-data storage and retrieval model capable of accommodating large volumes of utility data, interfacing with existing design software, and providing a method for reliably organizing utility data for use throughout project design and construction, as well as on future projects. Stored data include horizontal and vertical utility locations, as well as descriptive attributes needed to effectively coordinate design and construction activities with utility owners.

R01A was first implemented under Round 5 as a "Proof of Concept" effort, with five state DOTs selected in March 2015; then six additional states in Round 7 were invited to conduct pilot utility data repository projects as part of the **Utility Bundle**.

Utility Locating Technologies (R01B) focused on combining two advanced geophysical technologies to compliment traditional Phase I Subsurface Utility Engineering (SUE) information, suit variable soil and groundwater conditions, right-of-way access issues, and other attributes of the target utilities for better generation of 3D subsurface utility models.

It promoted the application of two advanced utility detection technologies, identified in the original SHRP2

research initiative: Multi-Channel Ground Penetrating Radar (MCGPR) and Time Domain Electromagnetic Induction (TDEMI). MCGPR is defined as multi-antenna and/or multi-frequency ground-penetrating radar (GPR) instrumentation used to locate buried utilities, voids and trenches when the geologic conditions are not clay-rich soils. TDEMI is a highly sensitive metal detection instrument used to locate ferrous or non-ferrous metallic utilities, or utilities that are installed with a metal tracer wire, that is unaffected by the geologic materials surrounding the target utility.

MCGPR has the distinct benefit to provide 3D-model results and provide depth to the utility, with calibration to ground truth information (e.g., positive location holes), allowing results to reach ASCE 38-02 QL-B rating. TDEMI provides robust 2D-plan maps of the detected utilities and other subsurface metallic objects. When used together, these two technologies have proven to enhance a state's SUE program; particularly as supplemental or complimentary 2D- and 3D-digital results integrated with traditional Phase I SUE information.

R01B was deployed under both Round 6 and Round 7 of the SHRP2 IAP. Round 6 (initial Proof of Concept) included five states (Virginia, Arkansas, California, Ohio, and Oregon) that received implementation awards in August 2016. In Round 7 as part of the **Utility Bundle**, two states (Montana and Indiana) were added to the IAP and received implementation funding in Spring 2016; California was also awarded Round 7 funding.

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

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

Output

The **Utility Bundle** work included all the deliverables listed in Appendix B. Two subject matter experts provided technical assistance to each state working on their respective products. Technical visits included training to state staff as well as coordination with consultants, technology vendors, and contractors.

Seven case studies on specific state DOT activities were developed along with a brochure outlining the three utility products. These materials were distributed at conferences, workshops, and meetings throughout the implementation. A "lessons learned" document was developed for each product. These materials as well as other tools such as webinars and videos can be found at the Utility Bundle webpage.

Identifying and Managing Utility Conflicts (R15B)

Round 3 Activities

All seven IAP states, plus CA, received the UCM training course: IA, KY, MI, NH, OK, SD, TX. Approximately 20 to 30 participants were present at each location. The one-day training courses were held between July 2014 and July 2015 as part of Round 3 implementation.

A peer exchange was held at the Annual Meeting of AASHTO's Right of Way, Utilities and Outdoor Advertising Control (ROWUOAC) Committee in 2016. This peer exchange was split into two sessions: state experiences and panel discussion.

During the peer exchange, four IAP state representatives (KY, IA, MI, and MD) shared their state experiences with implementing **R15B**. Key items discussed included an overview of their respective state utilities program, need for utilities conflict management, approach for implementing the **R15B** product, and implementation experience. During the panel discussion, all IAP states participated, focusing on implementation goals, challenges to implementation, and current implementation plans.

Rounds 6 and 7 Activities

Implementation of **R15B** is ongoing, and most states intend to adopt the tools into their state of practice once fully developed. Delaware has incorporated these tools into their utility manual and are using it in field. Based on work done in Round 6, Utah is developing an automated UCM as part of Round 7 implementation.

Training/brainstorming workshops were held with 10 IAP state DOTs: CA, DE, IN, OR, UT (Round 6); MT, PA, SC, VT, WA (Round 7). Between 15 and 20 people attended each event.

3D Utility Location Data Repository (R01A)

Training/brainstorming workshops were held with 10 IAP states: CA, DC, KY, TX, UT (Round 5); MI, MT, OR, PA, WA (Round 7). Between five and 10 participants attended each event.

Beginning in 2018, six quarterly peer exchange calls were held with all IAP states, with approximately 20 participants on each call. Calls included demonstrations by IAP states.

Initial meetings and training have been held with all IAP states. The subject matter expert is now following up and helping to develop and implement the 3D-repository. In addition, IAP states are developing business cases to get "buy-in" from management, which may lead toward changes in procedures and policies. Note that development of the data repository continues, and most states intend to adopt it into their state of practice once fully developed.

Utility Locating Technologies (R01B)

Classroom training and hands-on demonstration for the MCGPR and TDEMI technologies were held at seven IAP state facilities: CA, VA, OR, OH, AR, IN, and MT. The classroom training focused on the geophysical methodologies, whereas the field demonstrations allowed DOT staff to see the data acquisition computers and instrumentation in action. Processed results from each location demonstrated the utilities detected and highlighted visualization techniques in 2D and 3D, for TDEMI and MCGPR, respectively. Between 20 and 30 participants were present at each training session.

The implementation of the **R01B** product consisted of six phases: 1) planning; 2) training; 3) procurement (contractors or systems); 4) project selection; 5) execution; and, 6) reporting. Based on the training and their experience with SUE, five states chose to subcontract the deployment; however, because of California's strong SUE capabilities, **R01B** provided an opportunity to procure hardware and software in order to conduct the investigations in-house.

States then selected specialized contractors and a project that was at the appropriate design stage where a Phase I SUE investigation could be conducted followed by data collection using the two **R01B** technologies. The MCGPR and TDEMI results were integrated with the SUE data, as applicable, to generate 3D-models. No projects have progressed to construction, and only three (VA, OR and MT) have verified results with positive location borings.

Marketing

- A Utilities marketing brochure was produced and updated during the period of performance. It was distributed throughout implementation at meetings, conferences, and workshops.
- A utility conflict list template insert for utility manuals was produced for each of the three products in addition to a UCM training material package.
- Each product produced A short summary "lessons learned report" was developed for each product, and an additional "lessons learned report" was generated specifically for the Texas projects.
- Case studies were produced for the following implementation agencies: California (R01A), Montana and Oregon (R01B), Kentucky, Michigan, Delaware, and Texas (R15B).

Peer Exchange Calls

Quarterly conference call peer exchanges were begun in 2018 per product. On these calls, states were asked to report out on their progress, challenges, lessons learned and questions. Several of these calls led to presentations from states requested by their peers regarding topics such as database decisions or particular case studies.

Outcomes

The three SHRP2 utility products have had a significant impact on the national dialogue between state DOTs, utility owners, consultants, and contractors regarding the need to effectively manage utilities within the right of way. More specifically, the vision has been cast regarding the benefits of using robust utility investigation techniques and UCM practices to reduce the level of risk during all phases of the project delivery process.

A few examples of specific outcomes follows.

Identifying and Managing Utility Conflicts (R15B)

- As part of the SHRP2 research phase conducted by the Transportation Research Board (TRB), the Kentucky Transportation Cabinet (KYTC) developed the Kentucky Utilities and Rail Tracking System or KURTS, an electronic database that allows utility and design subject matter experts to access project information remotely and securely with an Internet connection. The system provides a streamlined experience for approval of relocation plans, agreements, and invoices, as well as the ability to view utility relocation change orders and project status changes.

  Through the implementation of **R15B**, KYTC expanded KURTS (Release 2), to include the collection of alternative solutions for each conflict. These alternatives can include cost comparisons and schedule impacts, thereby giving KYTC decision makers a clearer perspective of the potential impacts to the road project as a whole. Release 2 has enabled the field collection of relocation inspection logs and the establishment of a database to collect historical unit prices.
- Both KYTC and Michigan DOT are using **R15B** tools in the field.
- Other states are updating utility manuals and their specifications to include the utility conflict list.
- States are updating their policies to use UCM on all projects. Iowa DOT and South Dakota DOT are close to having updated manuals available. A standard chapter on UCM has been developed that can be inserted into updated utility manuals.
- TxDOT will implement the UCM approach more widely throughout the state. This will involve continuing to provide the one-day UCM training course to districts that request it, implementing and monitoring the UCM approach at pilot projects at the remaining 20 districts, and documenting and sharing lessons learned.

- DelDOT prepared a UCM workbook, which is a customized version of the **R15B** standalone utility conflict list template. The workbook includes a user guide. DelDOT is implementing UCM concepts into internal design policy and process documents. In addition, DelDOT is evaluating the feasibility of using 3D utility data modeling techniques, including clash detection, as the agency begins the transition to a 3D-design and construction environment. DelDOT is also planning to implement strategies such as reviewing utility investigation deliverables for accuracy as well as inspecting fieldwork and documenting as-built conditions.
- Many IAP states are still developing and implementing the product, using UCM on many projects while receiving positive feedback from utilities divisions and contractors. This is helping identify conflicts and their resolution at an early stage.

3D Utility Location Data Repository (R01A)

- The Michigan DOT developed a program called the Geospatial Utility Infrastructure Data Exchange (GUIDE) that included the collection of utility location data by surveyors "while the trench was still open" to ensure the department obtained accurate utility as-built data.
- The California Department of Transportation (Caltrans) had previously developed a prototype GIS database with utility features residing in standalone CAD files. As part of the **R01A** pilot implementation, Caltrans developed an enterprise database architecture and wrote scripts to automate the extraction of utility features that resided in CAD files into records in the spatial database. These were CAD files that the surveying group had already prepared during the utility investigation phase. The Caltrans database environment supports 2D- and 3D-features. In the Caltrans implementation, all utility data resides in the spatial database, including information about the coordinate system used to generate each feature in the database.
- Utility data quality is an important requirement for most state DOT applications but is particularly critical in a 3D-design and construction workflow. State DOTs recognized the dilemma between having incomplete utility datasets (with varying levels of horizontal and vertical positional accuracy) and the need to reduce the level of risk when developing 3D-models of utility facilities. A strategy that state DOTs began to implement was to document the positional accuracy of utility datasets and make sure to include that documentation as part of the datasets, either as utility record attributes or in the metadata.
- State DOTs also began to implement libraries of 3D-objects to represent typical utility features in their 3D-CAD software platforms. As part of the process, state DOTs recognized that developing 3D-cell libraries of utility features could take a significant amount of time and effort. They also recognized that the shapes and outside dimensions of the 3D-cells would have to meet certain minimum standards to ensure the usability of the 3D-models beyond basic visualization applications, e.g., for clash detection. They also began discussions about the feasibility to develop 3D-cell repositories where multiple agencies share the responsibility to develop and have access to the 3D-cells available in the repository.

Utility Locating Technologies (R01B)

- States selected projects of varying size and difficulty. Across all the R01B projects, approximately 6.13**-line miles (32,366-line feet) of MCGPR and TDEMI data were acquired, processed, interpreted, and reported to the respective states. Even with four project data sets not finalized, approximately 730** hours** of data processing, reporting and interpretation were performed. Not all projects had favorable site conditions, but the majority did, and successful integration of the **R01B** 3D-technologies with the SUE proved useful.

  ***This number will be adjusted when Virginia DOT confirms its metrics, and MDT provides its final numbers.*

- Arkansas and California completed data acquisition at two separate project sites.
- In Montana, the **R01B** TDEMI results identified 352 anomalies not associated with the Phase 1 SUE utility data, but also correlated well with known metallic features such as the Yellowstone Gas Pipeline. The TDEMI data allowed them to map traffic signal detection loops and related subsurface communications and power cabling, paved over or covered manhole lids and valves, and metallic pipes. In addition, the MCGPR results identified 617 anomalies not associated with the Phase 1 SUE.

  MCGPR was effective for picking up certain apparent utility crossings that would otherwise have been missed; for instance, the MCGPR captured the dipping vertical alignment of a pipe or cable that had been bored under Custer Avenue. The MCGPR also identified pavement distress and cracks.
- The Oregon DOT SUE team has already selected the next project that will use a SUE consultant and the documents created during the **R01B** project are being used to expedite the review and procurement process. The scale of this new project should create a whole new round of lessons learned and potentially be the project that tips ODOT to evaluate the need for SUE on every project. They are also moving forward with creating an in-house capacity to conduct basic GPR investigations. They have had equipment demos, an advanced GPR trainings and rented equipment for some small pilot projects. The immediate goal is to create a core group of GPR users that can conduct basics GPR surveys, evaluate projects for GPR usage, review consultant GPR/SUE work, and advocate for SUE in general. They hope to purchase equipment and begin testing it statewide in the next three to four months.

Lessons Learned

The following is a brief summary of lessons learned from the three products.

Identifying and Managing Utility Conflicts (R15B)

Two critical factors that contribute to utility inefficiencies in the delivery of transportation projects are (a) the lack of adequate information about the location and attributes of utility facilities that might be affected by the project, and (b) the lack of an effective process to manage conflicts between those facilities and project features and phases.

Some key findings from the **R15B** implementation experience are as follows.

- It is critical to obtain and maintain buy-in from the administration.
- When in doubt, pursue a standalone UCM implementation.
- Follow standard information technology phases for developing an enterprise UCM system.
- The economic benefits of UCM are substantial.
- Upfront costs to implement UCM are real but should be looked at as an investment.
- Providing UCM training is critical.
- A one-day UCM training course appears to be sufficient; UCM training should target project managers and designers.
- The UCM training course brings increased awareness of the project delivery process.
- Sample project files revealed a need to improve utility data management practices.
- UCM standardization is critical. Specific recommendations for UCM standardization include the following:
  - Develop and disseminate a standard utility conflict list template;
  - Emphasize the use of the template for information exchange purposes, while emphasizing the need for complete documentation “behind the scenes” using the spreadsheet file or a database;
  - Use dedicated layers or levels to display utility conflict locations in the project design software environment; and,

- Conduct utility conflict analysis at important project delivery milestones, such as preliminary design; beginning of detailed design; 30 percent, 60 percent, 90 percent, and 100 percent design; and construction.

3D Utility Location Data Repository (R01A)

Transportation agencies are transitioning from 2D- to 3D-design and construction workflows. The challenges that agencies face with information managed in a 2D-environment are compounded when information is managed in a 3D-environment.

Lessons learned from implementing **R01A** include the following.

- It is critical to obtain and maintain buy-in from the administration.
- Understand short-term and long-term needs and objectives.
- Focus on the "low-hanging fruit" to begin a utility data repository.
- Follow standard information technology phases for developing an enterprise utility data repository.
- Address challenges for developing robust 3D-models.

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

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

Utility Locating Technologies (R01B)

- The SHRP2 implementation proved the industry readiness of MCGPR and TDEMI, and showed they represent advanced 3D-technologies that will supplement traditional 2D-SUE utility mapping, but not replace them.
- **R01B** IAP states learned that to successfully deploy advanced technologies, multiple DOT departments and their staff must be included, such as Utility, Right of Way, Surveying, Engineering, Safety, Design, and, because of FHWA and AASHTO interface – upper management as well.
- During procurement, including new and specialized technologies, contract language for solicitation and award of qualified and experienced service providers are crucial.
- Because of the many tasks within the execution phase, the time requirements and expectations must be understood and managed, since each task can become a lengthy process that requires coordination from the DOT staff and subcontractor.

- Coordination is the key. A project utilizing the technologies in **R01B** requires investment and participation from a variety of departments within the state as well as service providers, and the public. It is imperative to contract with qualified service providers willing and able to integrate standard SUE information.
- A unique challenge is to identify an upcoming state project at the right stage of development and scale to use the **R01B** product. For example, Montana was fortunate to find an urban project with enough survey information already acquired, and the design team was far enough along to allow this Utility Location Technologies project to get involved and started in a timely manner.
- The total process shows as much what not to do, as what to do when using **R01B** to implement advanced geophysical methods.
- It is most effective to include individuals covering operations, safety, right of way, surveying, design, and other departments to participate in the technical training and peer exchange calls with other states (i.e., their respective departments). For larger states, including these groups at the regional level is also helpful.
- Participating states need routine communication with their FHWA divisions to ensure a clear understanding of how the SHRP2 funding process works and to see a systematic use of allocated monies be spent, at a minimum, during each funding quarter of a multi-year project.
- The Peer Exchange format of information sharing between the participating states permitted everyone to gain from experiences, challenges, and questions encountered at each step of the process; it proved very helpful to further the process, create consistency, and efficiency.

Benefits

Identifying and Managing Utility Conflicts (R15B)

The economic benefits of UCM are substantial. As examples:

- At a pilot project in Vermont, officials identified 65 utility poles that were in conflict with the project. Most poles, however, did not affect the construction schedule, which brought the number of relocations from 65 to 25 poles, saving the agency substantial time and money.
- Texas Department of Transportation saw numerous benefits.
  - TxDOT reported nearly $10 million in monetary savings and 38 months in project delivery time savings after implementing UCM at five pilot projects. The savings were primarily the result of identifying changes in project design that avoided utility relocations.

Table 2. Economic and project delivery time savings at the five TxDOT pilot projects.

District	Estimated Economic Savings	Identified Time Savings
Austin	$0.09 million	n/a
Dallas	$0.50 million	15 months
Fort Worth	$1.80 million	38 months
Houston	$2.90 million	n/a
San Antonio	$4.60 million	24 months
Total	**$9.89 million**	**38**

  - Significant economic savings elsewhere in the state. TxDOT identified additional benefits totaling $13 million from projects elsewhere in the state that started using the UCM approach. In one instance, savings resulted from the redesign of a drainage pipe to avoid having to relocate major gas lines that crossed the highway and were in conflict with the proposed drainage pipe.

  - In another instance, savings resulted from the completion of a more comprehensive utility investigation and the identification of multiple locations where water and sanitary sewer lines conflicted with the project. The utility investigation revealed lines that were already abandoned, which enabled the district to have more meaningful discussions with the city.
  - As the positive results from the pilot UCM implementation began to emerge, the TxDOT administration increased its support for the adoption of robust UCM principles throughout the state. In turn, this support accelerated the adoption of the UCM approach at the districts, thanks in part to policy changes and corresponding memoranda intended to optimize the project delivery process at TxDOT.
  - In addition to the IAP award, TxDOT used internal resources to provide the one-day UCM training course throughout the state and implement a number of policy changes.
  - Utility industry officials, particularly at the project level, appreciated the implementation of a more proactive approach by TxDOT officials and its consultants for coordinating with the industry and for identifying and resolving utility conflicts.
- Delaware DOT identified several benefits resulting from the implementation of the UCM approach.
  - The UCM approach provides a standardized method and form for tracking utility conflicts and resolutions.
  - The utility conflict list enables the agency to create a record of utility conflict investigation and coordination efforts.
  - Using UCM systematically enables all stakeholders to be on the same page.
  - The UCM approach results in overall less work by avoiding last minute issues and construction conflicts.
- New Hampshire DOT reported that $500,000 was saved and 18 months of additional work on utility relocations was avoided on one project. Other states have noted similar savings.

3D Utility Location Data Repository (R01A)

Caltrans identified the following benefits resulting from the pilot utility data repository **(R01A)** implementation:

- Having a centralized, enterprise-level utility data repository offers significant advantages and potential compared to the standalone concept that existed prior to the **R01A** implementation.
- Although the database architecture and scripts involved a substantial amount of time and effort, the amount of work needed to extract features from MicroStation into Oracle Spatial users is anticipated to be relatively minor.
- 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.

Utility Locating Technologies (R01B)

Evaluating the ultimate engineering value for implementing these two **R01B** technologies has been difficult, since each state continues to complete data analysis and reporting for the project(s); verify their SUE, MCGPR and TDEMI results (e.g., final test hole investigation); complete design; and begin construction. It is in these two final stages of a transportation project, the return-on-investment will be calculated and presented from the integration

of traditional SUE with deployment of advanced utility locating technologies. This is when MCGPR and / or TDEMI technologies, as a routine part of a state SUE program, will prove their merit.

The SHRP2 implementations produced a number of benefits, ranging from an increased awareness of the importance of managing utility issues earlier during project delivery to tangible cost and project delivery time savings.

MDT plans to continue to explore the anomalies identified using the **R01B** technologies and will likely conduct Phase II SUE to positively identify what is producing them. MDT will also continue to develop the 3D-model so that as 3D-design advances, the data can continue to be used to make design decisions. One of the most relevant uses of the data is expected to occur during hydraulics design. If MDT can avoid relocating the Yellowstone Pipeline, a cost savings of up to $6 million is possible.

Photos or video links or website links

- DelDOT utility conflict list
- Oregon DOT utility conflict list and Oregon Subsurface Utility Engineering Resource Page
- Oregon photos and videos of **R01B** data acquisition on April 11, 2018

Appendix A – Participation

State	SHRP2 Implementation Goals and Activities
R15B (1)	
Iowa	Use standalone UCM on two sample projects. Develop web portal to handle utility conflicts as part of the department's Project Scheduling System (PSS) Update utility manual and related procedures. Conduct one-day UCM training course at six districts.
Kentucky	Enhance Kentucky Utilities and Rail Tracking System (KURTS) to accommodate utility data collected in the field, include a cost estimating engine, and provide support for an online version of the utility conflict list to manage utility conflicts. Integrate existing spatial utility information into system. Provide training to users.
Michigan	Enhance Utility Relocation Tracking System (URTS) to include support for UCM. Implement URTS UCM module in seven pilot projects. Prepare procedure for Utility Coordination Manual.
New Hampshire	Implement standalone UCM as a business practice throughout the department.
Oklahoma	Implement standalone UCM as a business practice throughout the department.
South Dakota	Implement standalone UCM at three sample projects. Update the Utility Manual.
Texas	Provide the one-day UCM training course at all 25 districts and headquarters. Monitor the implementation of the standalone UCM approach at pilot projects in the five metro areas. Update policy documents to support the use of the UCM approach. **Future Actions:** TxDOT will implement the UCM approach more widely throughout the state. This will involve continuing to provide the one-day UCM training course to districts that request it, implementing and monitoring the UCM approach at pilot projects at the remaining 20 districts, and documenting and sharing lessons learned.
California	Develop case studies to implement an automated UCM module within the Right of Way Management Information System (ROWMIS). Conduct one-day UCM training course at headquarters and at a district in Southern California. Update utility manuals to include support for UCM. Conduct strategy session with leadership to support further implementation of the UCM approach.

Delaware	Implement standalone UCM at three pilot projects. Implement standalone UCM throughout the state. Update utility manual to reflect the UCM approach. Conduct outreach with utility owners. Identify integration requirements with DelDOT systems, including scheduling software and the web-based Utility Permit Application (UPA) system. **Future Actions:** Implement UCM concepts into internal design policy and process documents. Use 3D utility data modeling techniques, including clash detection, to support 3D design and construction. Implement strategies such as reviewing utility investigation deliverables for accuracy as well as inspecting fieldwork and documenting as-built conditions.
Indiana	Implement standalone UCM at two sample projects. Update policy documents.
Maryland	Implement a tool to automate the detection of utility conflicts in a CAD environment.
Oregon	Implement standalone UCM at two sample projects. Update policy documents. Develop plan to integrate UCM into design software.
Utah (R6)	Develop SharePoint-based Utility Tracker Integrate system into existing business procedures. Conduct implementation at pilot project. Develop training video for designer and utility owners.
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.
Pennsylvania	Conduct one-day UCM training course at two locations for designers and utility coordinators around the state. Implement standalone UCM at 24 pilot projects. Identify lessons learned from the UCM implementation at seven pilot projects. Develop system requirements and develop IT system to include UCM in PennDOT's utility management system.
South Carolina	Develop customized UCM training module and procedures. Train district users. Implement UCM approach at three pilot projects.

Utah (R7)	Develop a GIS web-based platform to view and manage utility conflicts (initially in 2D, then potentially advancing to 3D). Develop training video for designers and utility owners.
Vermont	Implement UCM approach at five pilot projects. Update utility manual.
Washington	Evaluate the feasibility of using the department's Practical Solutions framework to start the identification of utility conflicts during the preliminary design phase.
R01A	
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 DDOT systems. Use utility data repository with the PLUG 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 UDOT. 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.

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.
R01B	
Arkansas	Classroom training and field demonstration completed July 15, 2016. Project selection included two sites (X and X), to test two geologic settings. Procurement and contracting concluded in February 2019. Field work was completed in March 2019. SUE and R01B Data integration is on-going. **Future Actions:** Integrate R01B results with one-call SUE information.
California	Classroom training and field demonstrations completed June 17 & 20, 2016, at south & north facilities, respectively. GeoSoft License acquired Spring 2018, and SME provided (1.5 day) software training July 18-19, 2018 for TDEMI data processing (for single EM61 unit with top and bottom coils owned by Caltrans). Purchased DXG 3D Radar instrument and controller unit, then fabricated tow system for data acquisition. Selected two field sites (Bishop and Calusa) for demonstration of new MCGPR unit and TDEMI system to verify SUE information and calibrate hardware. Because state owns both MCGPR and TDEMI systems, no contractors are involved for acquisition or processing. **Future Actions:** Process MCGPR and TDEMI results; integrate R01B results with Phase I & II information
Ohio	Classroom training and field demonstrations completed July 19, 2016 Project selected with SME, based on geologic setting, along Cleveland-Massillon Road (CR-17) Contract Awarded Cardno in January 2018 Data collection was carried out by Cardno in June 2018. Difficulties with data due to pavement overlay on reinforced concrete, therefore too much metal in the roadway to produce useful results for the majority of the project.

Oregon	Classroom training and field demonstrations completed June 22, 2016. Project selected in February 2017 – SW Canyon Road (SR8) Procurement and contractor award took almost 1 year Fieldwork carried out week of April 9, 2018 Report delivered January 2019 **Future Actions:** The ODOT SUE team has already selected the next project that will use a SUE consultant and the documents we created during the R01B project are being used to expedite the review and procurement process. The scale of this new project should create a whole new round of lessons learned and potentially be the project that tips ODOT to evaluate the need for SUE on every project. They are also moving forward with creating an in-house capacity to conduct basic GPR investigations. They have had equipment demos, an advanced GPR trainings and rented equipment for some small pilot projects. The immediate goal is to create a core group of GPR users that can conduct basics GPR surveys, evaluate projects for GPR usage, review consultant GPR/SUE work, and advocate for SUE in general. They hope to purchase equipment and begin testing it statewide in the next 3-4 months.
Virginia	Classroom training and field demonstrations completed July 22, 2016. Project selection VDOT on-call provider awarded project Contractor carried out data collection in October 17, 2017
California (R7)	State anticipated completion date to be confirmed. Implementation already underway from R6, so used training allocation for SME to travel to Caltrans and provide demonstration on use of software - GeoSoft. Caltrans purchased hardware for data collection. Caltrans got their DXG 3D Radar unit delivered 7/12. GeoSoft (TDEMI Processing) training provided 7/18. Caltrans expects 'radar van' set with DXG for fall field work 2019.
Indiana	Classroom training and field demonstrations completed May 9, 2018 Training and demo held 5/8&9. Working on developing plan and schedule. No longer implementing products. Will de-obligate funds.
Montana	Classroom training and field demonstrations completed July 20, 2017. Project selected is Custer Avenue, Helena, MT Vendor for data collection is UMS. MT GPR data capture held in August 2018 – they have set the bar for use of equipment & data collection (along with TDEMI). They collected 60-line miles over two nights and were very efficient – within 30 minutes of safety briefing were collecting data. Traffic control was good. Hoping for a quick turnaround on data – they have been doing this for 20+ years on UXO. TDEMI was for full lane width, GPR was not. **Future Actions:** MDT plans to continue to explore the anomalies identified using the R01B technologies and will likely conduct Phase II SUE to positively identify what is producing them. MDT will also continue to develop the 3D model so that as the Open Roads 3D design advances we can continue to use the data to make

	design decisions. One of the most relevant uses of the data is expected to occur during Hydraulics design. If we can avoid relocating the Yellowstone Pipeline, we may realize a cost savings of up to $6 Million. In summary, MDT learned that both technologies have their place in our toolbox for certain projects with the right types of soils, topography and scope; however even where all these variables are favorable, the R01B tools will need to be used in conjunction with other standard SUE methods and instruments.

Appendix B – Deliverables List

SHRP2 Utility Products: R01A, R01B & R15B: Utilities Bundle Implementation Work Plan Status

TASK 1 – PROGRAM MANAGEMENT, MARKETING AND SME OVERSIGHT

Subtask 1.1. Program Management

Deliverable	Scheduled Delivery	Status
General Program Management (R5&6, 7 & A2)	throughout IAP	Complete
Participation in introductory teleconference (R5&6)	October 2015	Complete
Participation in IAP state preliminary teleconferences (R5&6)	December 2015	Complete
Lead Round 7 IAP kick-off teleconferences (R7)	February 2017	Complete
Participation in kick-off meeting (R5&6)	January 2016	Complete
Participation in IAP state follow-up teleconferences (R5&6)	February 2016 – April 2019 quarterly	Complete
Six quarterly progress teleconferences (R5&6)	throughout IAP	Complete
Three program planning meetings (R5&6)	throughout IAP	Complete
Twelve ad-hoc planning meetings (R5&6)	throughout IAP	Complete
Six quarterly progress teleconferences (R7)	throughout IAP	Complete
Twenty (20), 1 hour-long quarterly progress teleconferences (A2)	Throughout IAP	Complete
Twelve (12), 1.5 hour-long Implementation Plan Development teleconferences (A2)	throughout IAP	Complete
Twenty (20), 1 hour-long Close out meetings (A2)	throughout IAP	Complete
Thirty-six (36), 1.0 hour-long ad-hoc coordination meetings (A2)	throughout IAP	Complete
Three program planning meetings (R7)	throughout IAP	Complete
Twelve ad-hoc planning meetings (R7)	throughout IAP	Complete
Administrative support & monthly/quarterly product reporting (R5&6)	throughout IAP	Complete
Implementation work plan (R5&6)	March 2016	Complete
Updated work plan (A2)	December 2017	Complete
Marketing & communications plan (R5&6)	March 2016	Complete

Subtask 1.2. Marketing, Outreach & Training

Deliverable	Scheduled Delivery	Status
Three (3) case history/product marketing articles for AASHTO/ASCE daily/weekly on-line publications, or similar web-based venues	December 2016	Complete
Two GOSHRP2 web content updates each year (R5&6)	throughout IAP	Complete
Coordination and review of SME presentations for Round 7 webinar (R5&6)	February 2016	Complete
Coordination and review of SME presentations for up to six (6) national conferences (R5&6)	throughout IAP	Complete

Review and produce SME-developed IAP training materials (R5&6)	May 2016 - complete	Complete
Review and -produce hard-copy classroom materials (R5&6)	throughout IAP	Complete
Coordinate travel	throughout IAP	Complete
Produce training presentation and handout materials for up to fifteen (15) IAP state training events (R7)	throughout IAP	Complete
Review and coordinate all travel and participation of the AASHTO management and SME team (R5&6)	throughout IAP	Complete
Attend up to three state meetings to monitor SME SHRP2 delivery (R5&6)	throughout IAP	Complete
Identify and collect existing SHRP2 technical products and develop content for a new SHRP2 web page (R5&6)	December 2016	Complete
Provide invitational travel to be set-aside for up to ten (10) state DOT and/or utilities industry participants (R5&6)	throughout IAP	Complete

Subtask 1.3. AASHTO & ASCE Committee Support

Deliverable	**Scheduled Delivery**	**Status**
Coordinate AASHTO/SME team participation in AASHTO Subcommittee Meeting & ASCE Meeting (R5&6)	throughout IAP	Complete
Coordination of SME support for six (6) total AASHTO and ASCE utilities committee meetings (R5&6)	throughout IAP TTI and Olson presented at ROWUAOC committee meetings in 2017 (IN) & 2018 (MD). Provided input for overview presentations at 2016 meeting peer exchange (FL). Held ASCE Standards call with presentation from TTI (March 2017). Presentations provided at TRB.	Complete
Utilities program lead will attend up to two meetings (R5&6)	throughout IAP	Complete
Sixteen (16) hours of general support to ASCE committee.	Throughout IAP	Complete

Subtask 1.4. Implementation Performance Metrics and Reporting

Deliverable	**Scheduled Delivery**	**Status**
Develop, track, and compile implementation delivery and performance metrics (R5&6)	June 2016	Complete
Compile a one to two page interim “lessons learned” summary for each of the three utilities products (R5&6)	December 2017	Complete
Track and compile additional Round 7 implementation performance metrics and prepare additional implementation reporting (R7)	March 2018	Complete

Final Implementation report for IAP implementation in 508 Compliant PDF	February 2019	Complete

TASK 2 – SME TECHNICAL ASSISTANCE

Subtask 2.1 – Development of Technical Content for Training and Marketing Materials

Deliverable	Scheduled Delivery	Status
Development of training material for **R01A** (R5&6)	May 2016	Complete
Development of training material for **R01B** (R5&6)	May 2016	Complete
Development of training material for **R15B** (R5&6)	May 2016	Complete
Update Rounds 3, 5 and 6 training presentation/handout materials technical content for Round 7 IAP state training events (R7)	May 2017	Complete
Development of presentation materials for 3 national conferences – **R01B** (R5&6)	June 2016	Complete
Development of presentation materials for 3 national conferences – **R01A & R15B** (R5&6)	June 2016	Complete
Development of presentation materials for 2 AASHTO and ASCE utilities committee meetings – **R01A** (R5&6)	June 2016	Complete
Development of presentation materials for 2 AASHTO and ASCE utilities committee meetings – **R01B** (R5&6)	June 2016	Complete
Development of presentation materials for 2AASHTO and ASCE utilities committee meetings – **R15B** (R5&6)	June 2016	Complete
Development of technical content for marketing brochure case study – **R01A** (R5&6)	December 2016	Complete
Development of technical content for marketing brochure case study – **R01B** (R5&6)	December 2016	Complete
Development of technical content for marketing brochure case study – **R15B** (R5&6)	December 2016	Complete
Development of technical content for 3 case history/product marketing articles for AASHTO/ASCE daily/weekly on-line publications (R5&6)	December 2016	Complete
Development of technical content for GOSHRP2 web content updates twice a year (R5&6)	throughout IAP – one done	Complete
Development of technical content for product presentations (all three) for a nationally advertised Round 7 webinar (R5&6)	February 2016	Complete
Support for identifying and delivering material to be added to a new SHRP2-related web page (R5&6)	throughout IAP	Complete
Generic insert chapters for **R01A** and R01B	April 2019	Complete

Subtask 2.2 – Support for the Implementation Assistance Program

Deliverable	Scheduled Delivery	Status
Participation in a 1-hour-long introductory FHWA-AASHTO-SME team teleconference (R5&6)	October 2015	Complete

Participation in up to 5, 1-hour-long preliminary AASHTO-SME team informational teleconferences – **R01A** (R5&6)	December 2015	Complete
Participation in up to 5, 1-hour-long preliminary AASHTO-SME team informational teleconferences – **R01B** (R5&6)	December 2015	Complete
Participation in up 6, 1-hour-long preliminary AASHTO-SME team informational teleconferences – **R15B** (R5&6)	December 2015	Complete
Participation in a one-day, face-to-face, FHWA-AASHTO-SME team kick-off meeting (R5&6)	January 2016	Complete
Participation in up to 5, 1-hour-long follow-up AASHTO-SME team planning teleconferences – R01A (R5&6)	February 2016	Complete
Participation in up to 5, 1-hour-long follow-up AASHTO-SME team planning teleconferences – **R01B** (R5&6)	February 2016	Complete
Participation in up to 6, 1-hour-long follow-up AASHTO-SME team planning teleconferences – **R15B** (R5&6)	February 2016	Complete
Participate in up to 6, 1-hour-long FHWA-AASHTO-SME team planning teleconferences with Round 7 IAP award states – **R01A** (R7)	February 2017	Complete
Participate in up to 3, 1-hour-long FHWA-AASHTO-SME team planning teleconferences with Round 7 IAP award states – **R01B** (R7)	February 2017	Complete
Participate in up to 6, 1-hour-long FHWA-AASHTO-SME team planning teleconferences with Round 7 IAP award states – **R15B** (R7)	February 2017	Complete
Participation in up to six (6), 2-hour-long quarterly progress teleconferences (R5&6)	throughout IAP	Complete
Participation in three (3), 4-hour-long SME IAP program planning meetings (R5&6)	throughout IAP	Complete
Participation in up to twenty-four (24), 2-hour-long ad hoc planning teleconferences (R5&6)	throughout IAP	Complete
Participation in up to six (6), 2-hour-long quarterly progress teleconferences (R7)	throughout IAP	Complete
Participation in three (3), 4-hour-long SME IAP program planning meetings (R7)	throughout IAP	Complete
Participation in up to twelve (12), 2-hour-long ad hoc planning teleconferences (R7)	throughout IAP	Complete
Twenty (20), 1 hour-long quarterly progress teleconferences (A2)	throughout IAP	Complete
Twelve (12), 1.5 hour-long Implementation Plan Development teleconferences (A2)	throughout IAP	Complete
Twenty (20), 1 hour-long Close out meetings (A2)	throughout IAP	Complete
Thirty-six (36), 1.0 hour-long ad-hoc coordination meetings (A2)	throughout IAP	Complete
Five (5) 1-day training/planning on-site kick-off meetings – **R01A** (R5&6)	throughout IAP	All complete –

	MI felt not necessary as their R01A implementation was a follow-up to their R15B implementation, focusing on data elements of the implementation of the GUIDE program. OR implementation began late and training was not requested. Queries and information were provided via conference calls.	except MI & OR.
Five (5) 1-day training/planning on-site kick-off meetings – **R01B** (R5&6)	throughout IAP	Complete
Six (6) 1.5-day training/planning on-site kick-off meetings – **R15B** (R5&6)	throughout IAP	Complete
Six (6) 1-day training/planning on-site kick-off meetings – **R01A** (R7)	throughout IAP	Complete
Three (3) 1-day training/planning on-site kick-off meetings – **R01B** (R7)	throughout IAP	Complete
Six (6) 1.5-day training/planning on-site kick-off meetings – **R15B** (R7)	throughout IAP	Complete
Ten (10) hours of tele/web conference technical assistance (R5&6)	throughout IAP	Complete
Ten (10) hours of tele/web conference technical assistance (R7)	throughout IAP	Ongoing
Five (5) 1.5-day on-site meetings for **R01B** field support (R5&6)	throughout IAP	4 Complete
Generalized MS Project delivery schedules for all three products. (R5&6, 7, A2)	June 2016	Complete
Hold quarterly progress update meetings with each IAP state – all three products (R5&6)	throughout IAP	Complete

Subtask 2.3 – Other Technical Support

Deliverable	**Scheduled Delivery**	**Status**
Presentations at 3 national conferences – **R01B**(R5&6)	throughout IAP	As needed
Presentations at 3 national conferences – **R01A & R15B** (R5&6)	throughout IAP	As needed
Presentations at 2 total AASHTO and ASCE utilities committee meetings – **R01A** (R5&6)	throughout IAP	Complete
Presentations at 2 total AASHTO and ASCE utilities committee meetings – **R01B** (R5&6)	throughout IAP	Complete
Presentations at 2 total AASHTO and ASCE utilities committee meetings – **R15B** (R5&6)	throughout IAP	Complete
R15B SME support to the FHWA utilities program lead for planning and specifying NHI training products (R5&6)	throughout IAP	Complete

R01A, R01B and **R15B** product presentations within one national webinar promoting Round 7 (R5&6)	February 2016	Complete
Ad hoc technical assistance to non-IAP transportation agencies (R5&6)	Throughout IAP	Complete
Ad hoc technical assistance to non-IAP transportation agencies (R7)	Throughout IAP	Complete
Support for collecting and developing Rounds 3, 5 and 6 IAP lessons learned for all three products, as well as reporting metrics for “output” and “outcome” AASHTO reporting (R5&6)	Throughout IAP	Complete
Track and compile additional Round 7 implementation performance metrics and prepare additional implementation reporting to be added to reporting covered under Work Order #10 (R7)	Throughout IAP	Complete
Technical support and assistance for the development of the final report	Throughout IAP	Complete