3D Utility Survey and Modeling

Resolving the Utility Conundrum

3D Design and Modeling for Highway Structures
Iowa State Center Scheman Bldg, Ames, Iowa
April 14 – 15, 2015
Utility Mapping Services, Inc.
Philip J. Meis, M.S., P.E. - Principal Engineer
Utility Mapping Services, Inc.

Highly specialized, small business specifically focused on Subsurface Utility Engineering (SUE).

Established in 2002 and staffed by engineers, geophysicists, surveyors, and geospatial data experts who are advancing state of the art SUE practices, UMS is recognized as a leader with unparalleled expertise at minimizing issues with existing infrastructure.

Approaches SUE as a rigorous, innovative, strategic, and technologically advanced professional engineering service.

Active in ASCE, AASHTO, TRB, SHRP2 R01A, R15B
Committee Lead for CI/ASCE Standard for the “Collection, Administration, and Exchange of Utility Infrastructure Data”
Recent Research Participation

The Second Strategic Highway Research Program

Identification of Utility Conflicts and Solutions

Cesar Quiroga and Edgar Kraus
Texas A&M Transportation Institute, Texas A&M University System

Paul Scott
Cardno TBE

Tom Swafford and Philip Meis
Utility Mapping Services

Gary Monday
Ash Engineering
Leading New Standard Development

Consensus Activity for the Collection, Administration, and Exchange of Utility Infrastructure Data

American Society of Civil Engineers

Construction Institute
Recent UMS Research Efforts

Report No. UT-11.07

RECOMMENDED PROTOCOL AND STANDARDS FOR UTILITY DATA SUBMITTALS

Prepared For:
Utah Department of Transportation
Research Division

Submitted By:
Utility Mapping Services, Inc.

Authored By:
Philip J. Meis, P.E.

Final Report
February 2012

3-D Utility Survey Practices

August 13, 2014

PROJECT ID 0666-23-09

Wisconsin Department of Transportation
4802 Shabogam Ave., Room 451
Madison, WI 53707
p: 608.266.0310

Submitted to:
Utility Mapping Services, Inc.
3947 East Calvary Road, Suite 103
Duluth, MN 55810
p: 218.728.8007
www.umsi.us

Authored By:
Philip J. Meis, P.E., Rodney Kent, Thomas Spectfrey, Donald Haines, Nathan Grewe

Revised August 2014
WisDOT 3D Initiative

3-D Utility Initiative was started by WisDOT to:

1. Determine best practical mapping technologies for acquiring 3-D utility alignments; and
2. Incorporate associated standards and best practices.

The goal is to establish WisDOT guidelines for systematic and efficient acquisition of 3-D utility data for use with current and evolving virtual design and construction (VDC) and related digital project delivery technologies and utility engineering best practices that improve safety, mitigate risks and reduce costs.
WisDOT 3D Utility Survey Findings

- Evolving 2D Utility Survey Methods to 3D
- Geophysical Tools (sorry, no X-ray vision)
- Applicable Standards – Existing Infrastructure and New Infrastructure
  - CI/ASCE 38-02 – Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data
  - CI/ASCE XX – Standard for the Collection, Administration, and Exchange of Utility Infrastructure Data (aka “As-Builts”)  
- Data Management and Design Technologies (Utility Data is a Different Animal)
  - 3-D Model – Depicting an Interpretation and Risk (SHRP2 R01A)
  - Conflict Analytics, Resolutions, Agreements (SHRP2 R15B/C)
  - Digital Project Delivery / E-Delivery
  - As-Built / Life Cycle Data Management
- Professional Credentials for Utility Engineering
Utility Management Strategy
Digital Project Development and Delivery

Acquisition
CI/ASCE 38
2D QL B
Or Standardized
As-Built Data

WisDOT
3D Initiative

Prime Control Delivery

Utility Work Permitting

Data Management, Conflict Analytics

New Infrastructure

3D QL B (SPAR 300 and GPR), QL A

Relocations

Utility Work Permitting

Coordination, Conflict Resolution Engineering

3D Design (Bentley SUE, Civil 3D)

Agreements and Bid Doc Prep

WisDOT 3D Initiative
Strategic Utility Program for Project Development and Delivery

Rediscovery of Existing Utilities

• Standardize Utility Surveying (CI/ASCE 38-02)
• 3-D Utility Data Modeling for Design
• Utilize Cross Disciplined “Utility Engineers”
• Engage Utility Owners as Full Partners
• Design With and Around Utility Infrastructure
• Integrate Utility Work with Mainline Work
• Collect Standardized Utility “As-Built” Data

Digital Documenting of Newly Installed Utilities
Pain Points with Utility Management

• No data, poor data, or wrong data
• New infrastructure installations during development
• Rediscovery costs
• Nonresponsive and/or adversarial utilities
• Poor and latent coordination between all stakeholders
• Construction delays
• Service and Traffic Disruption
• Damage and Injury
• Lost Business
• Claims, Change Orders
• Litigation
• Contractor contingencies
Implications of Utilities on Bid

Contractor Contingencies for handling Utility issues can equal 10% of Contract Cost

Contingencies for **UNKNOWNNS / RISK** = Higher Bids
Handwork = Higher Bids
Coordination with Independent Contractors = Higher Bids

Loss of Control & Changed Conditions = Change Orders

With **Digital Project Delivery** the Project Schedule Critical Path is significantly shortened; however, archaic utility management practices wreak havoc on Digital Project Delivery time and cost saving strategies!
Call Before You Dig 811 is the Utility’s Last Line of Defense

Non-Standard Data Source
One call markings are made for contractor to avoid facilities, not to accurately map them.

True gas main location
CI/ASCE 38-02 QL A

811 Mark
Recommend Four Phase Approach

- **Phase I** – **2D** Mapping Effort, Conflict Identification & Matrix Development
- **Phase II** – **3D** Mapping Effort (Spar, GPR, & Test Holes), Conflict Resolution and Utility Workshops with Utilities & Designers
- **Phase III** – Utility Coordination & Conflict Resolution Engineering and Development of Master & Supplemental Agreements
- **Phase IV** – Construction Management & Oversight
Now an Industry Standard

CI/ASCE 38-02 (The Standard)

http://www.fhwa.dot.gov/programadmin/sueindex.cfm

SUE (The Engineering Process)

Adopted as a BEST PRACTICE
Utility Mapping Equipment Examples

- Electromagnetic (EM) Locate & GPS Survey
- SPAR 300
- Ground Penetrating Radar (GPR) Noggin Sensors & Software Smartcart
- Acoustic Detection
- Vacuum Excavation
Importance of a 2-D Base Map

American Society of Civil Engineers (ASCE) Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, CI/ASCE 38-02

Standardized Data = More Data Requires Better Data Management Methods
Recommend Four Phase Approach

• Phase I – **2D** Mapping Effort, Conflict Identification & Matrix Development

• **Phase II – 3D** Mapping Effort (Spar, GPR, & Test Holes), Conflict Resolution and Utility Workshops with Utilities & Designers

• Phase III – Utility Coordination & Conflict Resolution Engineering and Development of Master & Supplemental Agreements

• Phase IV – Construction Management & Oversight
GPR 3-D QL B (Ideal vs Reality)
2D QL B Map Required to Interpret GPR

- Need electrical property contrast
- Vulnerable to changes in soil and moisture
- Will not penetrate clay or highly conductive soil
- Need ground truth for depth interpretation (max depth <30ft)
- Need lots of recorded "geo-referenced" data
- Requires experienced operator
- Requires processing and experienced analyst

4/20/2015
Fundamental Electromagnetic (EM) Detection Principles
SPAR 300 – 3D QL B EM Tool

- Two 3-d magnetic loop antennas
- 20 Hz – 10 kHz frequency
- 3-axis digital compass
- 3-axis accelerometer
- RTK-GNSS (optional)
- Bluetooth or USB host interface
- Zigbee (wireless sensor networking)
- Model-based optimization processor
- Quick-change 8-hr Li-Ion battery
- 5 hour with internal RTK
SPAR 300 Data Monitoring and Management

Possible to determine when observations are good or suspect; record and quantify result accuracy.
SPAR 300 Data Management

Much Data to Manage and Interpret

Utility Engineering and Infrastructure Management
3D Cross Section Superior to Single Test Hole for Design
Full 3D Model Depiction for Design
Recommend Four Phase Approach

- Phase I – **2D** Mapping Effort, Conflict Identification & Matrix Development
- Phase II – **3D** Mapping Effort (Spar, GPR, & Test Holes), Conflict Resolution and Utility Workshops with Utilities & Designers
- Phase III – Utility Coordination & Conflict Resolution Engineering and Development of Master & Supplemental Agreements
- Phase IV – Construction Management & Oversight
Importance of Data Management for Utility Conflicts and Solutions

- Manage the complexity of utility infrastructure data (spatial, attribute, metadata) in a structured, secure, readily accessible offsite (cloud) repository
- Itemize, manage and coordinate clash detection and conflict analyses results with project design and utility teams for efficient design coordination and value engineering
- Facilitate utility coordination process and engagement of utility owners
- Integrate utility betterments, new installations, relocations, protect-in-place alternatives into mainline schedule
- Facilitate utility agreement development
- Facilitate digital project delivery (planning, bidding, and construction)
- Facilitate field acquisition and management of utility as-built data
Secure, robust web based utility infrastructure management (UIM) application is key to managing conflicts and resolutions within dynamic conditions (e.g., schedule, designs, segment limits) typically associated with large projects.
Ex. – Proposed Curb and Gutter and Existing Gas Pipe
## Conflict Resolution

### Conflict Analysis

The depth of the proposed cut at the McLoughlin under-crossing will require that this Gas Main be lowered/replaced (Ref. Transit 30% Plans, K159-K164). The Gas Valve at the Intersection of McLoughlin and G Street should also be relocated at that time to avoid a conflict with the proposed Storm Drainage along G Street. 3D QL-B data and Test Hole data has been obtained.

### Conflicts

<table>
<thead>
<tr>
<th>Conflict Number</th>
<th>Resolve By Date</th>
<th>Conflict Zone</th>
<th>Alignment</th>
<th>Features in Conflict</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>51339</td>
<td></td>
<td>CRC Project (Portland - Vancouver Bridge): Segment 5</td>
<td>G Street</td>
<td>GST</td>
<td>WSDOT (Washington Department of Transportation)</td>
</tr>
<tr>
<td>40915</td>
<td></td>
<td>CRC Project (Portland - Vancouver Bridge): Segment 4</td>
<td>McLoughlin Blvd</td>
<td>PSD562</td>
<td>WSDOT (Washington Department of Transportation)</td>
</tr>
<tr>
<td>40005</td>
<td></td>
<td>CRC Project (Portland - Vancouver Bridge): Segment 4</td>
<td>SB-LRT Light Rail Transit South Bound</td>
<td>DUCT BANK45</td>
<td>C-Tran</td>
</tr>
<tr>
<td>40907</td>
<td></td>
<td>CRC Project (Portland - Vancouver Bridge): Segment 4</td>
<td>McLoughlin Blvd</td>
<td>PSD562</td>
<td>WSDOT (Washington Department of Transportation)</td>
</tr>
<tr>
<td>40908</td>
<td></td>
<td>CRC Project (Portland - Vancouver Bridge): Segment 4</td>
<td>McLoughlin Blvd</td>
<td>PSD444</td>
<td>WSDOT (Washington Department of Transportation)</td>
</tr>
</tbody>
</table>
Utility Conflict Resolution Activities for Project Development and Delivery

1. Utility 2D and 3D Field Data Acquisition
2. Hard & Soft Clash Detection, Populate UIM, Analysis
3. Utility Betterment and Constraint Identification
4. Conflict Resolution(s) & Alternative Design
5. Value Engineer utility work, Integrate w/ mainline
6. Utility Coordination, Negotiations, Agreements
7. Utility Construction Management Support, Verification and As-buils
Terra Move™

Cost effective and time sensitive alternatives to utility relocation needs.
Terra Shield™

The industry’s new standard for utility support and protect projects
Terra Cap™

High Performance Protection for New or Existing Underground Utilities
Resolution Report for Agreements

Report generated utilizing Task, Cost along with other governing information managed in UIM; reports are used to support and supplement Utility Agreements.
Recommend Four Phase Approach

- **Phase I** – 2D Mapping Effort, Conflict Identification & Matrix Development
- **Phase II** – 3D Mapping Effort (Spar, GPR, & Test Holes), Conflict Resolution and Utility Workshops with Utilities & Designers
- **Phase III** – Utility Coordination & Conflict Resolution Engineering and Development of Master & Supplemental Agreements
- **Phase IV** – Construction Management & Oversight
Construction Management

Utilize UIM to:

• Populate utility work within project scheduling software.
• Systematically evaluate technical approach and manage QA of utility work to ensure compliance with all identified governances and constraints.
• Automate creation of utility related agreements, submittals, permits, notifications etc.
• Monitor planned and approve completed work.
• Facilitate real-time as-built documentation of utilities in accordance with project requirements.
• Provide work verification information for payment.
Strategy Return on Investment (ROI)

• CI/ASCE 38-02(SUE) vs Non-Standard Method
  – 5 Independent Studies - $3.41-$22.21/$ invested
  – 10 States Utilize CI/ASCE 38-02 on all Projects (UT, MN, TX, VA, MT, PA, FL, SD, NC & GA) * More State Utilize on some Projects
  – FHWA Mandated for Reimbursement
  – NEPA Process
  – Mitigate Contractor’s Risk
  – Reduce Delay Impacts

• 3D QL B Geophysical Mapping vs Test Holes (Pot Holes)
  – 30%-60% Reduction in Test Holes
  – Complete Alignment for Design Purposes
  – Necessary for 3D Virtual Design and Construction Methods
Strategy ROI and Merits

• Transfers responsibilities to prime contractor, reduce utility related claims resulting from third party failures to perform
• Project schedule optimized
• Utility work is optimized - mainline effort, competitively bid
• Contractor can quickly work deals with utilities by offering betterment opportunities, joint construction work, etc. (Laws may prevent public agencies from making such deals.)
Strategy ROI and Merits

For an additional project development cost of roughly 1% of the project, the contract bid can be reduced by 10% by eliminating utility related contingency costs. This is a 9% cost savings to the project owners!
Long Term Strategies to Address Right of Way (ROW) Management

• Capture Standardized Documentation and Data on New Infrastructure Installations
• Robust Utility Infrastructure Data Repository
• WebGIS ROW Occupation Permit Application
• Coordinating / Monitoring External and Internal Construction Operations
Utility Life Cycle Management Strategy

• Current Status of Permitting – Paper, Slow, Painful, Inaccessible – Untapped Potential

• All changes within ROW can be controlled, managed, and documented through an effective permitting system.

Utility Life Cycle Management Strategy:

- 3-D Design
- Digital Project Development and Delivery
- ROW Occupation Permitting
- Virtual 3-D O&M
- Internal and External Work Coordination
- Utility Data Repository System Update
- Standardized As-Built Acquisition
- Standardized As-Built Acquisition
Utility Engineer Qualifications

• Must Understand BOTH Agency and Utility Needs
• Be Knowledgeable in BOTH Agency and Utility Company Policies, Procedures, & Requirements
• Have "Cross Discipline" Design and Construction Experience in BOTH Transportation & Utilities
• Experienced in Identifying, Prioritizing, & Mitigating Risks for BOTH Transportation & Utilities

Need To Bridge the Gap

Utility Technical Discipline void

TRB AFB70 Jan 2012
Utility Engineer Qualifications

- Ability to Establish Relationships, based on Mutual Understanding & Trust
- Ability to Recognize Time & Cost Innovative Utility Solutions
Some Meis’s Currently at ISU
Your Time is Appreciated

Philip J. Meis, P.E.
Vice President / Principal Engineer
c. 801.209.2032  d. 406.553.0883
pjmeis@umsi.us

www.umsi.us  &  www.geo.works