3D Utility Survey and Modeling

Resolving the Utility Conundrum

3 D 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

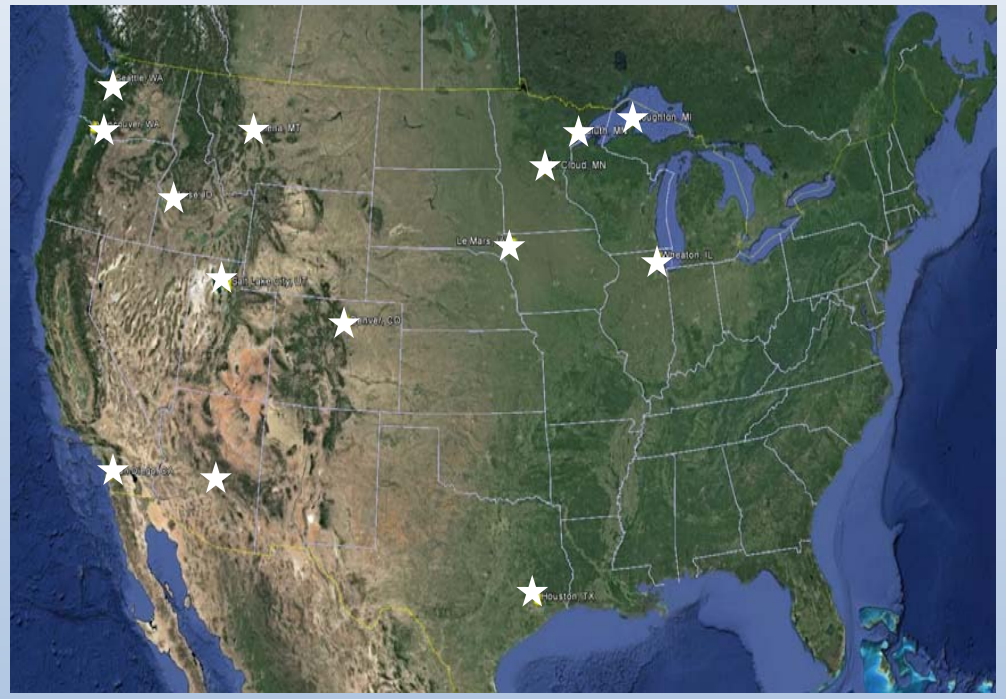
Company Background

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.

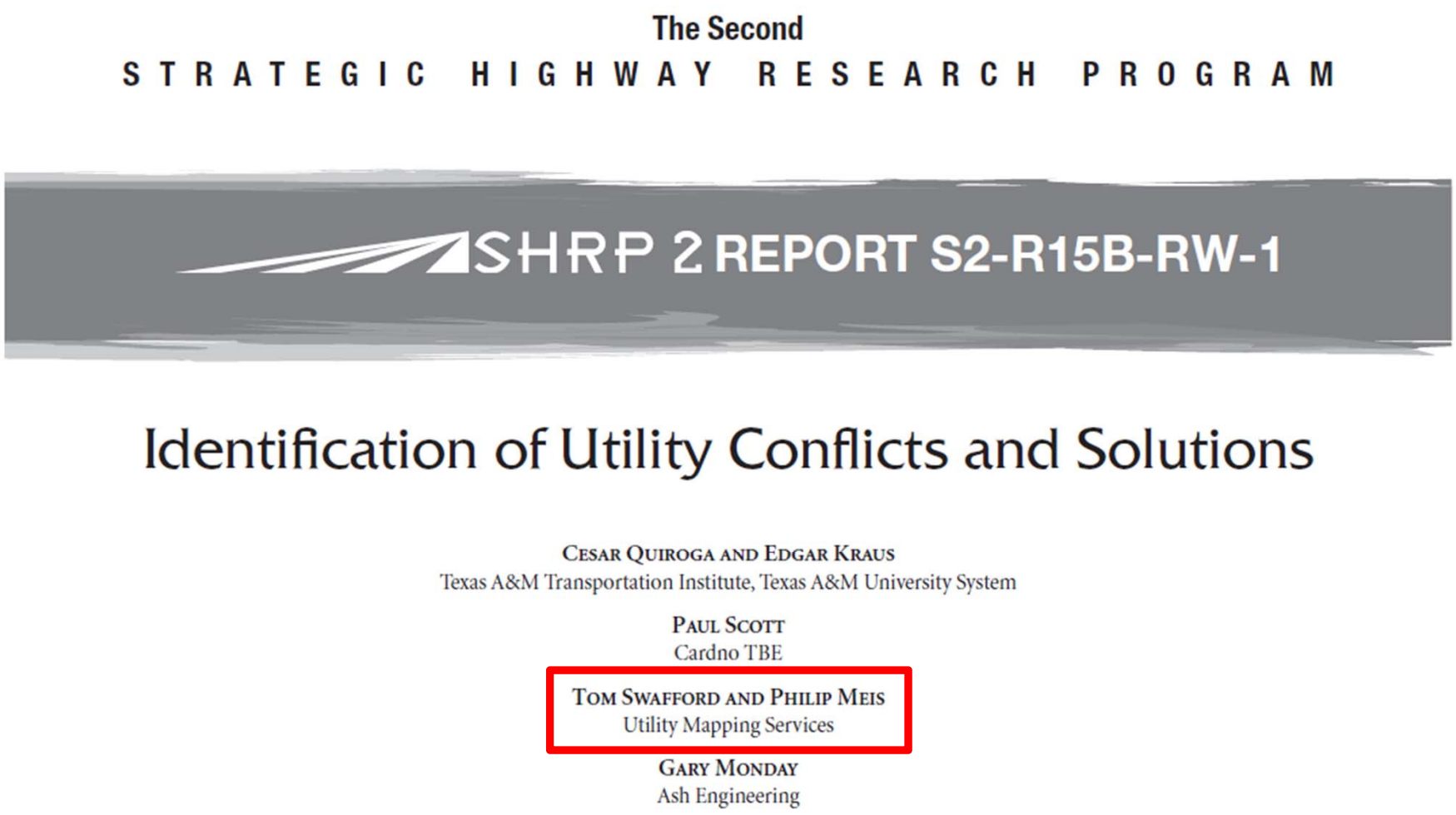


Active in ASCE, AASHTO, TRB, SHRP2 R01A, R15B

Committee Lead for CI/ASCE Standard for the "Collection, Administration, and Exchange of Utility Infrastructure Data"

GEO works

Recent Research Participation



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

RESEARCH

udot.utah.gov

Utah Department of Transportation . Research Division
4501 South 2700 West . P.O. Box 148410 . SLC,UT 84114-8410

Report No. UT-11.07

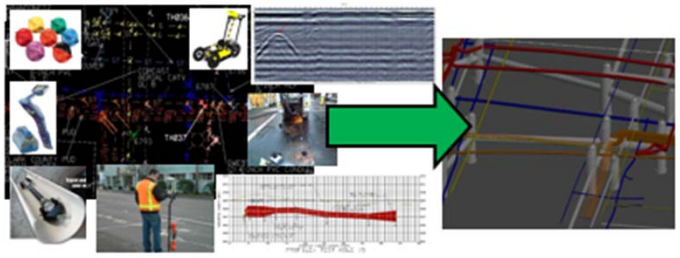
RECOMMENDED PROTOCOL AND STANDARDS FOR UTILITY DATA SUBMITTALS

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 0656-23-09

Submitted to:

Wisconsin Department of Transportation
4802 Sheboygan Ave., Room 451
Madison, WI 53707
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Authored By:
Philip J. Meis, P.E., Rodney Kent, Thomas Swafford, Donald Haines, Nathan Greer

Revised August 2014

WisDOT 3D Initiative

3-D Utility Initiative was started by WisDOT to:

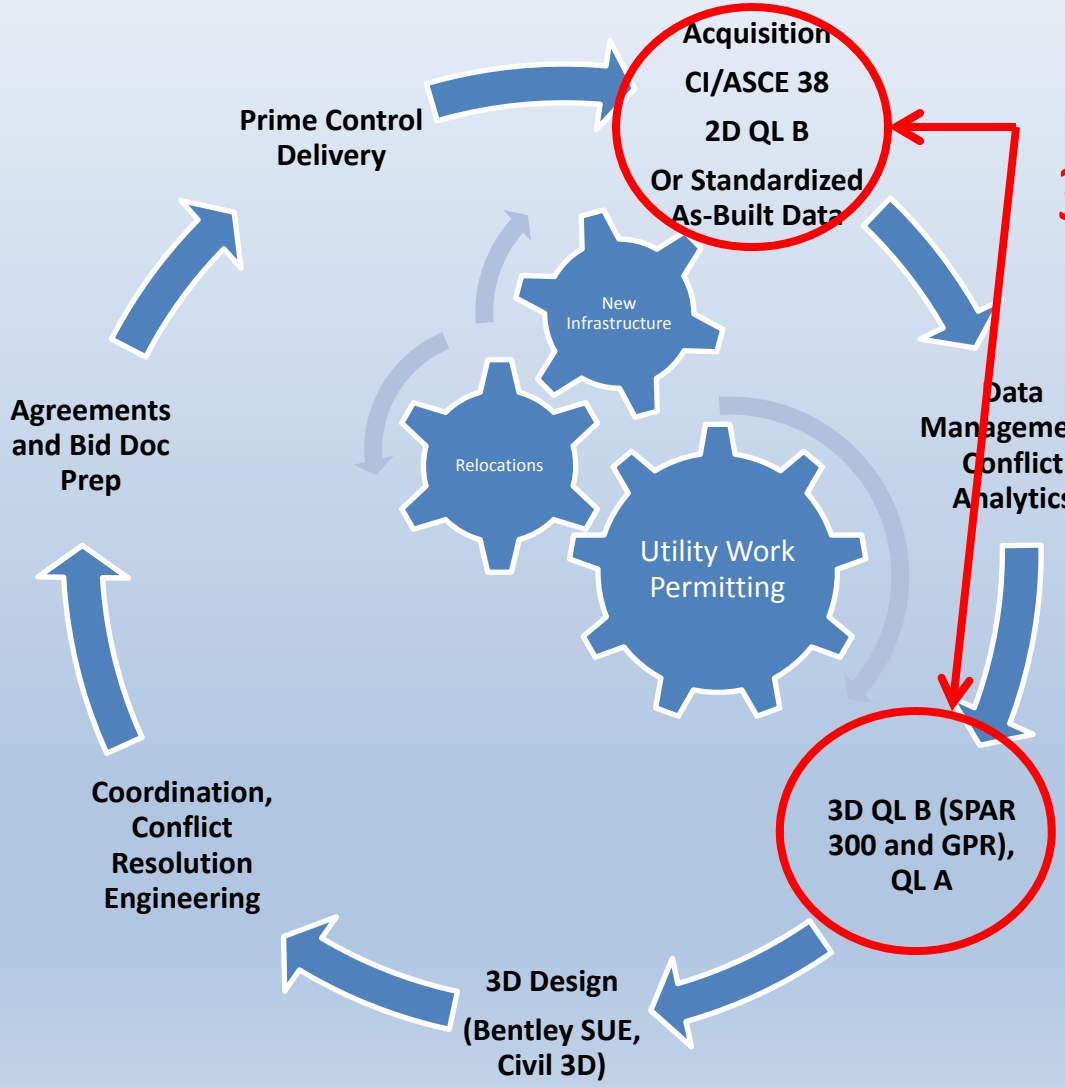
1. Determine best practical mapping technologies for acquiring 3-D utility alignments; and
2. Incorporate associated standards and best practices.

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



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

Implications of Utilities on Bid

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

Contingencies for UNKNOWNS / 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

GEO works

Recommend Four Phase Approach

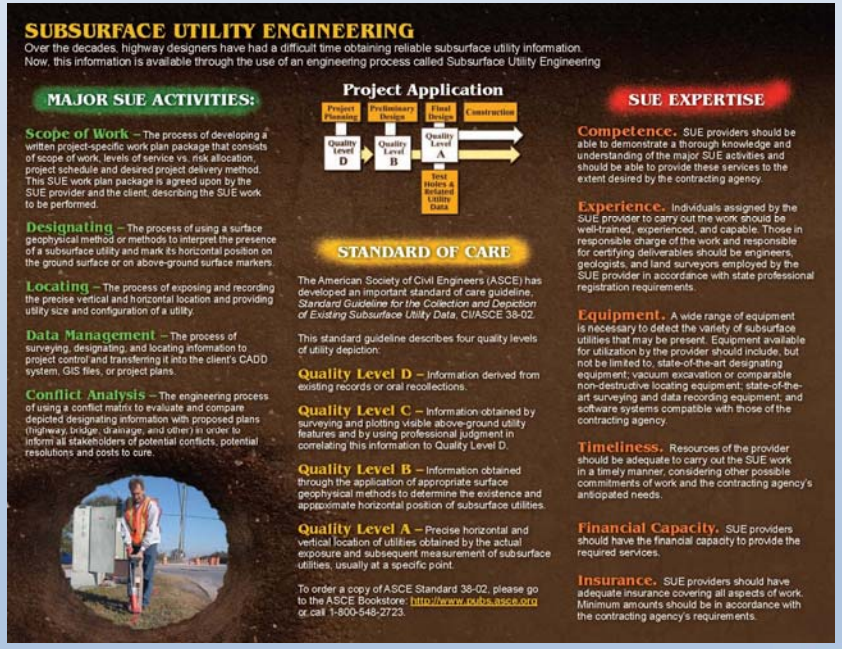
- Phase I – **2D** Mapping Effort, Conflict Identification & Matrix Development
- Phase II – **3D** Mapping Effort (Spar, GPR, &Test Holes), Conflict Resolution and Utility Workshops with Utilities & Designers
- Phase III – Utility Coordination & Conflict Resolution Engineering and Development of Master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

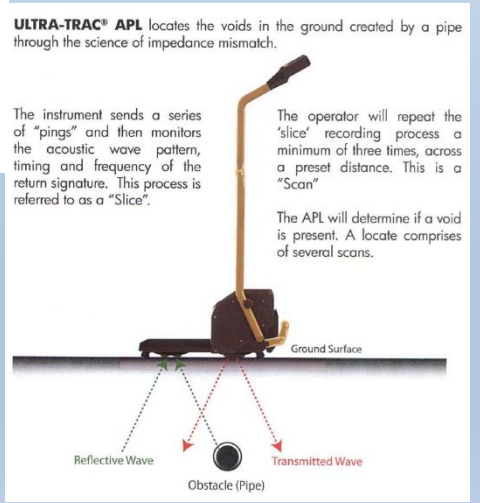
SUE (The Engineering Process)



Adopted as a BEST PRACTICE

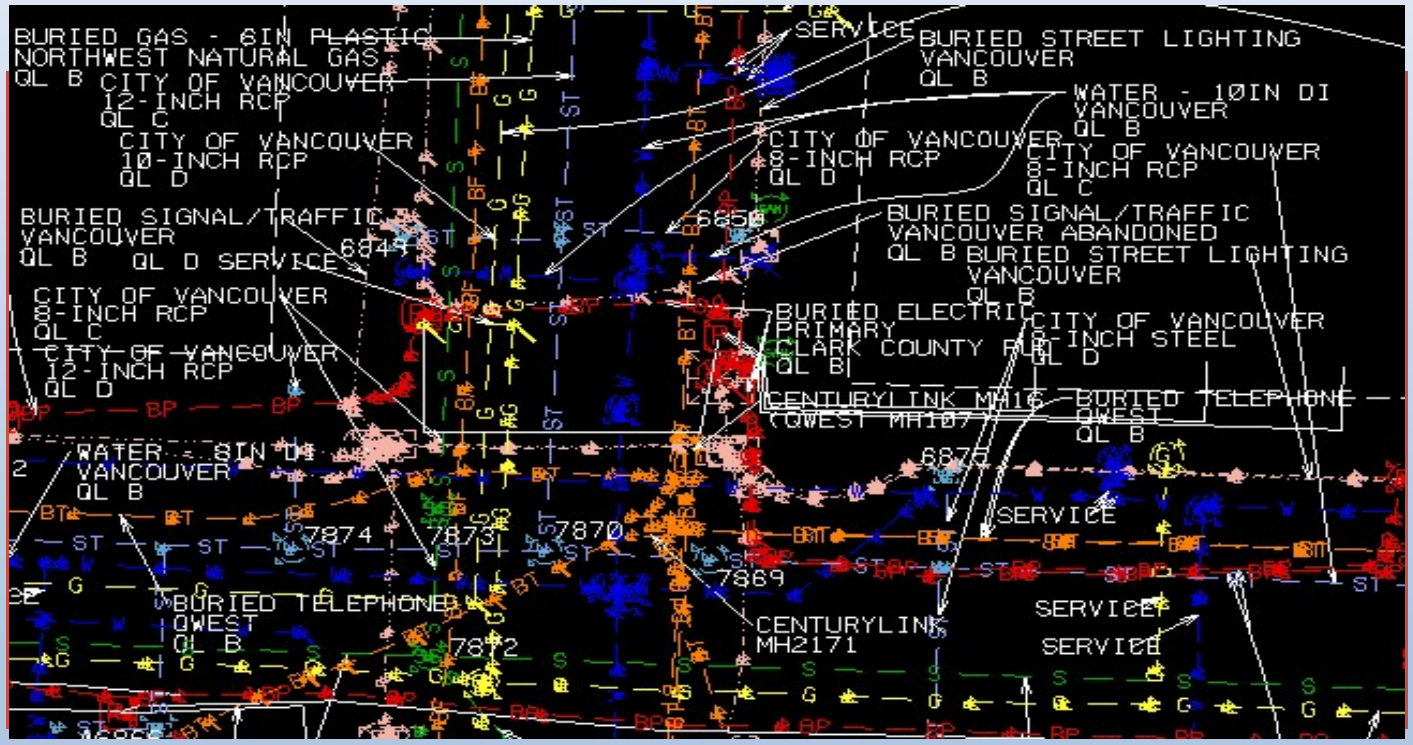
Utility Mapping Equipment Examples

- 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

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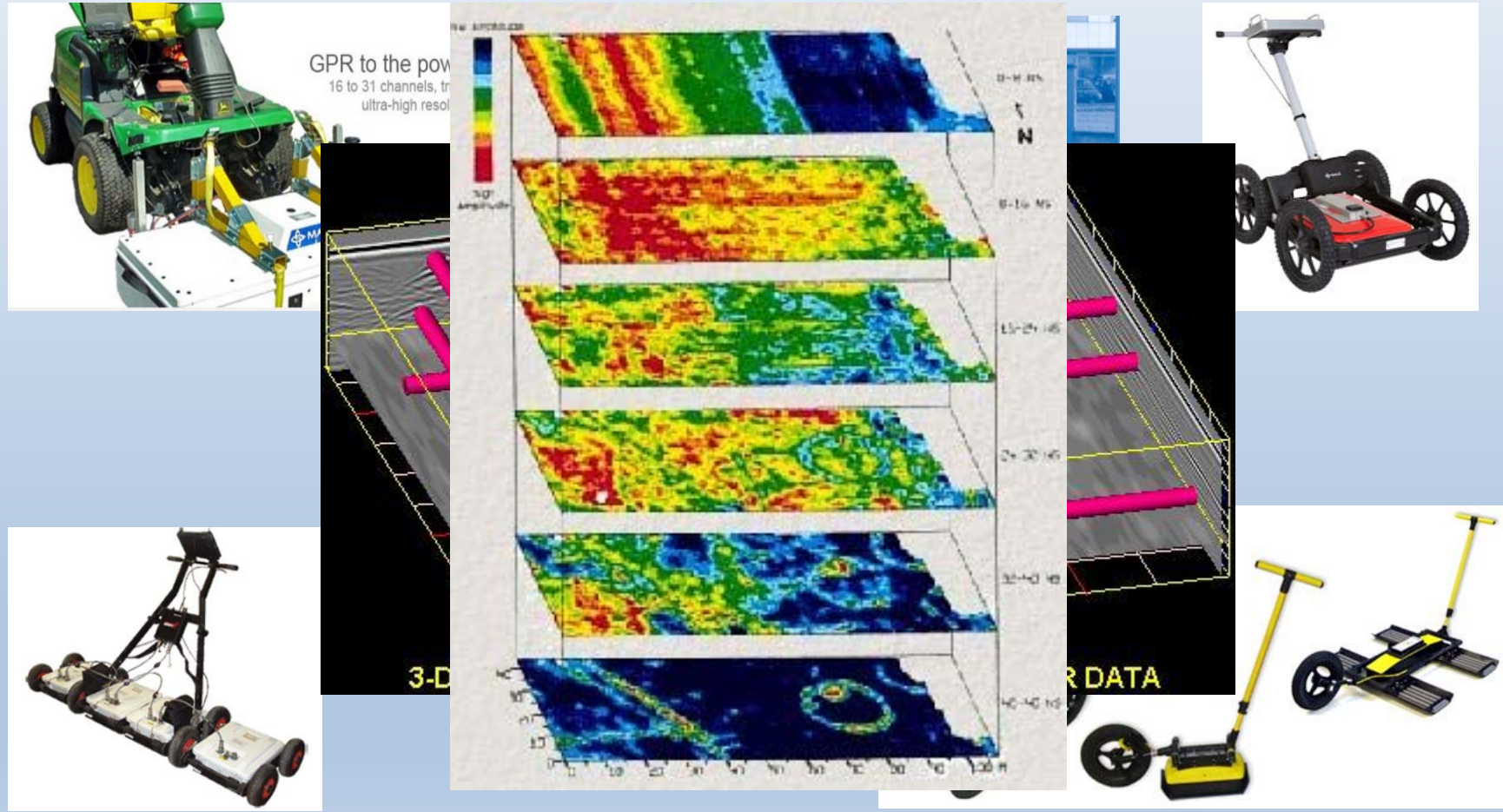
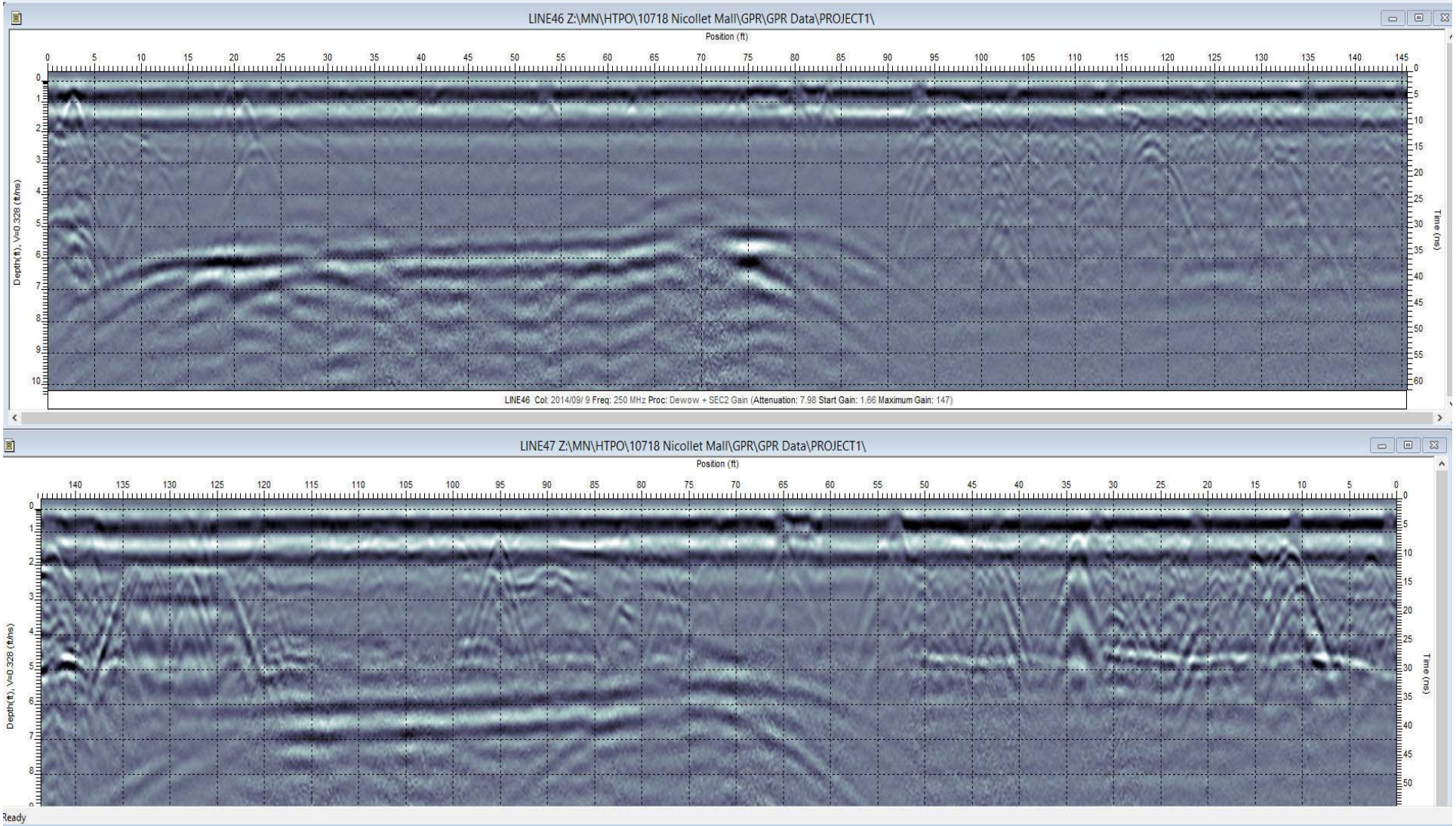
GPR 3-D QL B (Ideal vs Reality)

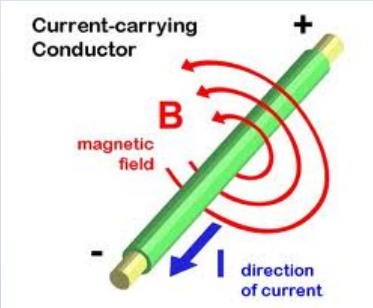


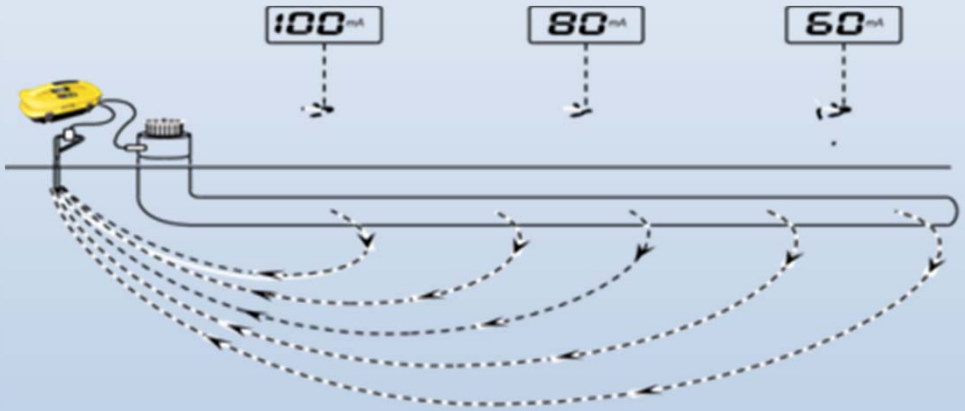
GEO works

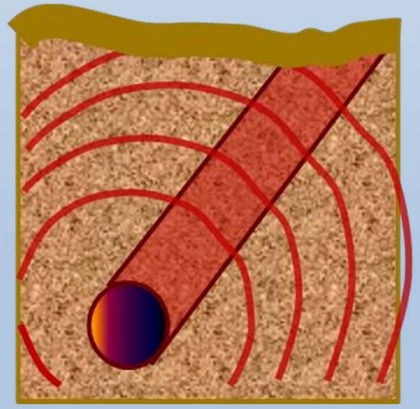
2D QL B Map Required to Interpret GPR

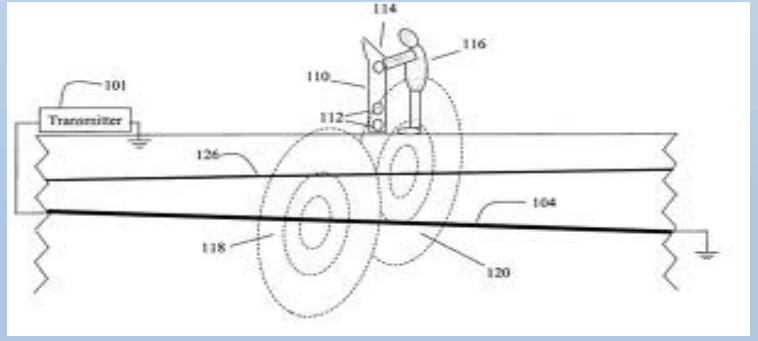


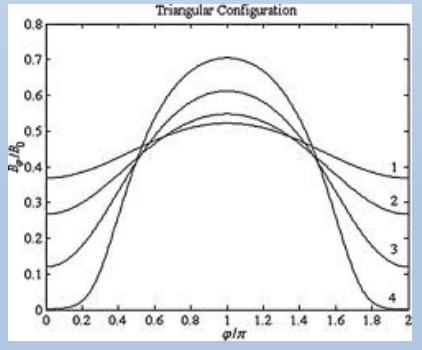
Fundamental Electromagnetic (EM) Detection Principles



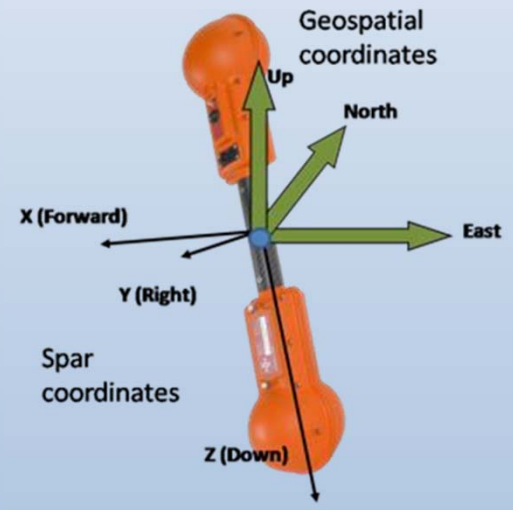








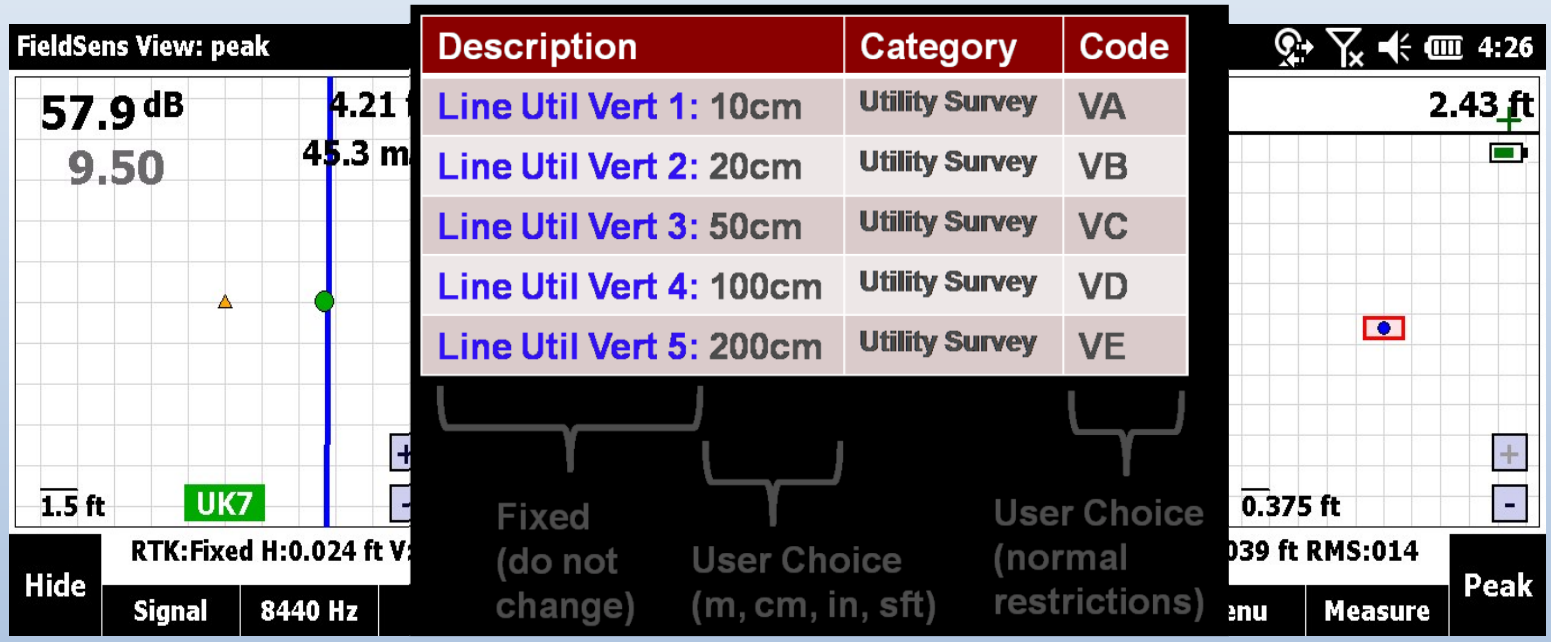
SPAR 300 – 3D QL B EM Tool



- 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

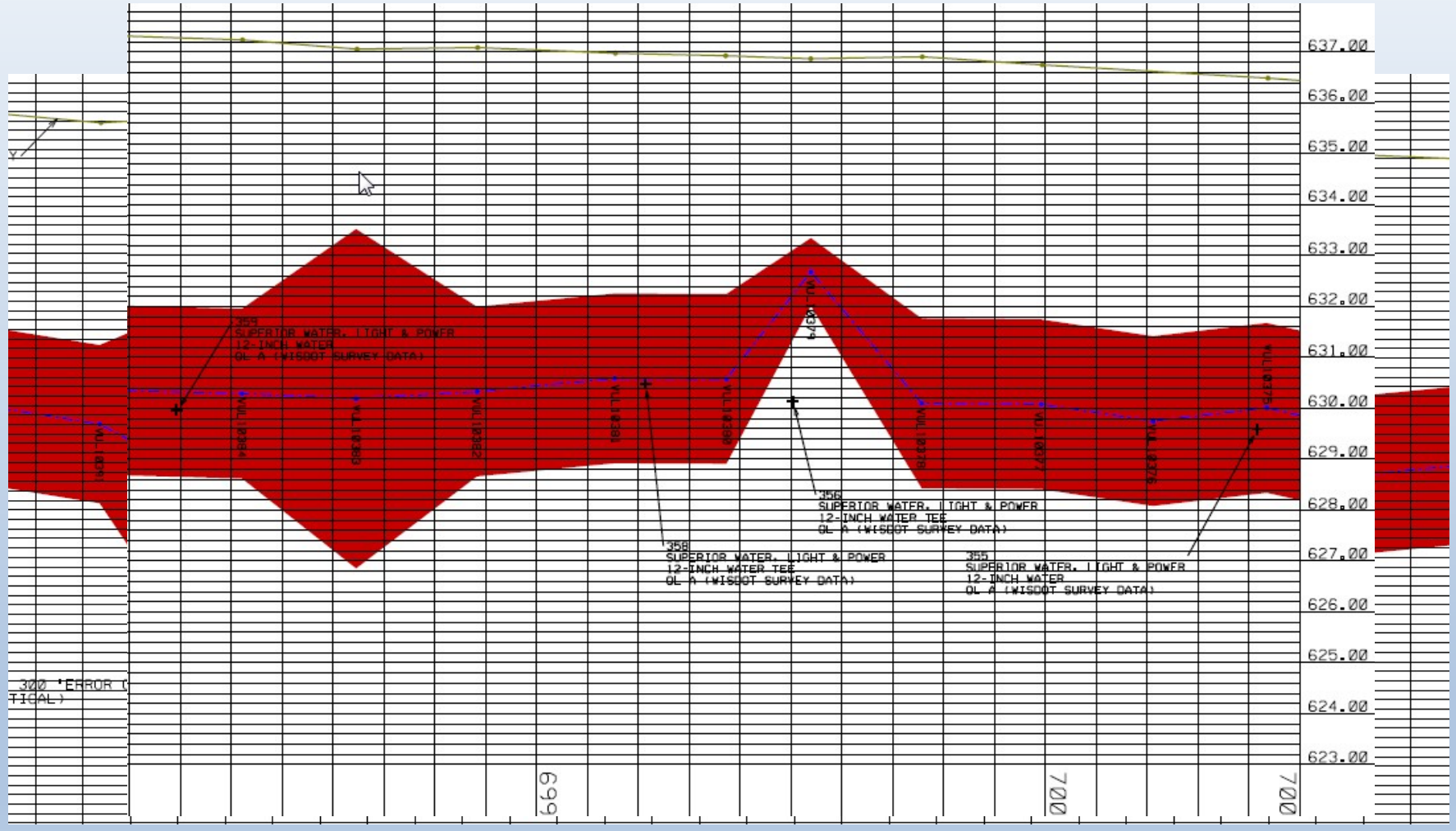
22

SPAR 300 Data Monitoring and Management



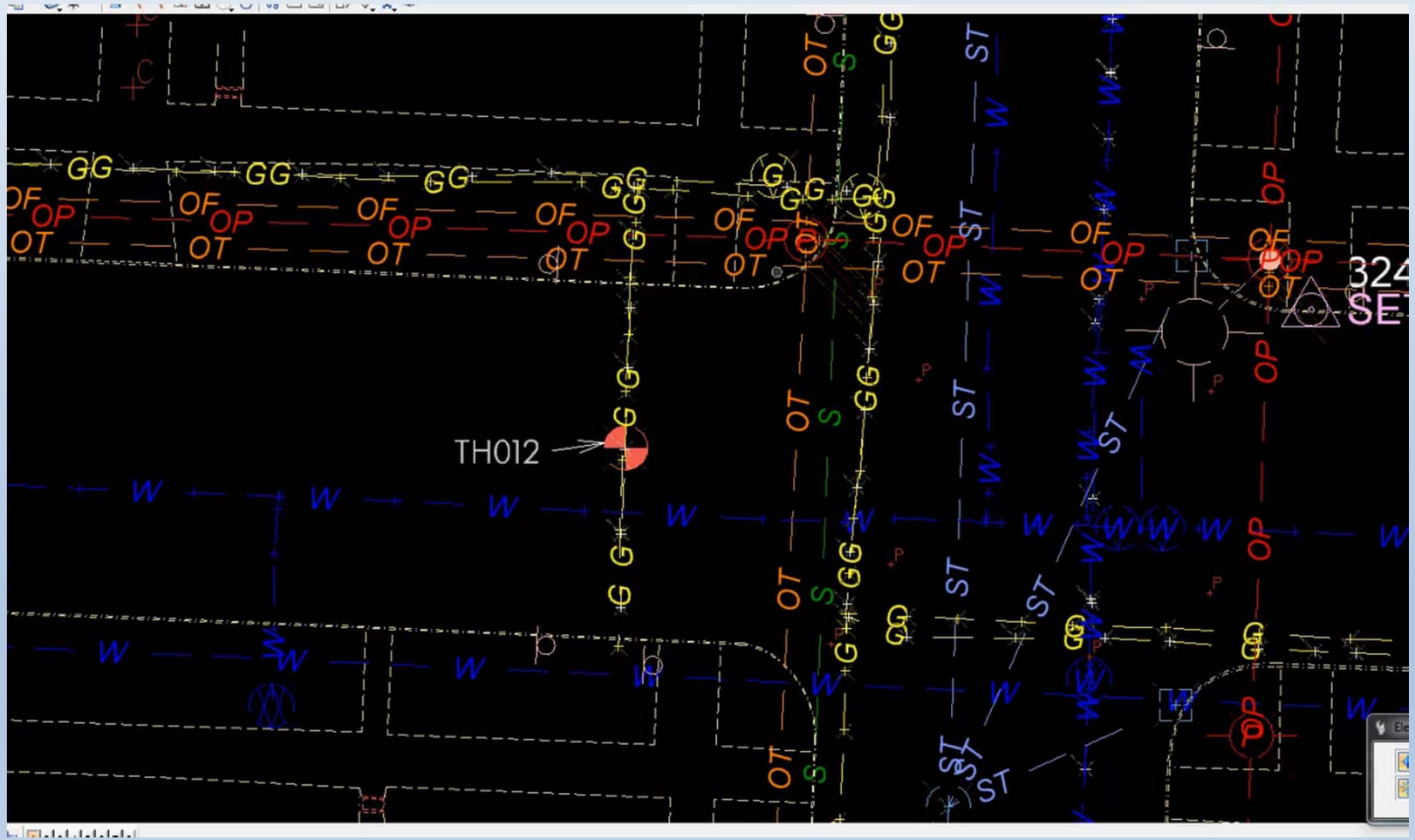
Possible to determine when observations are good or suspect; record and quantify result accuracy.

SPAR 300 Data Management

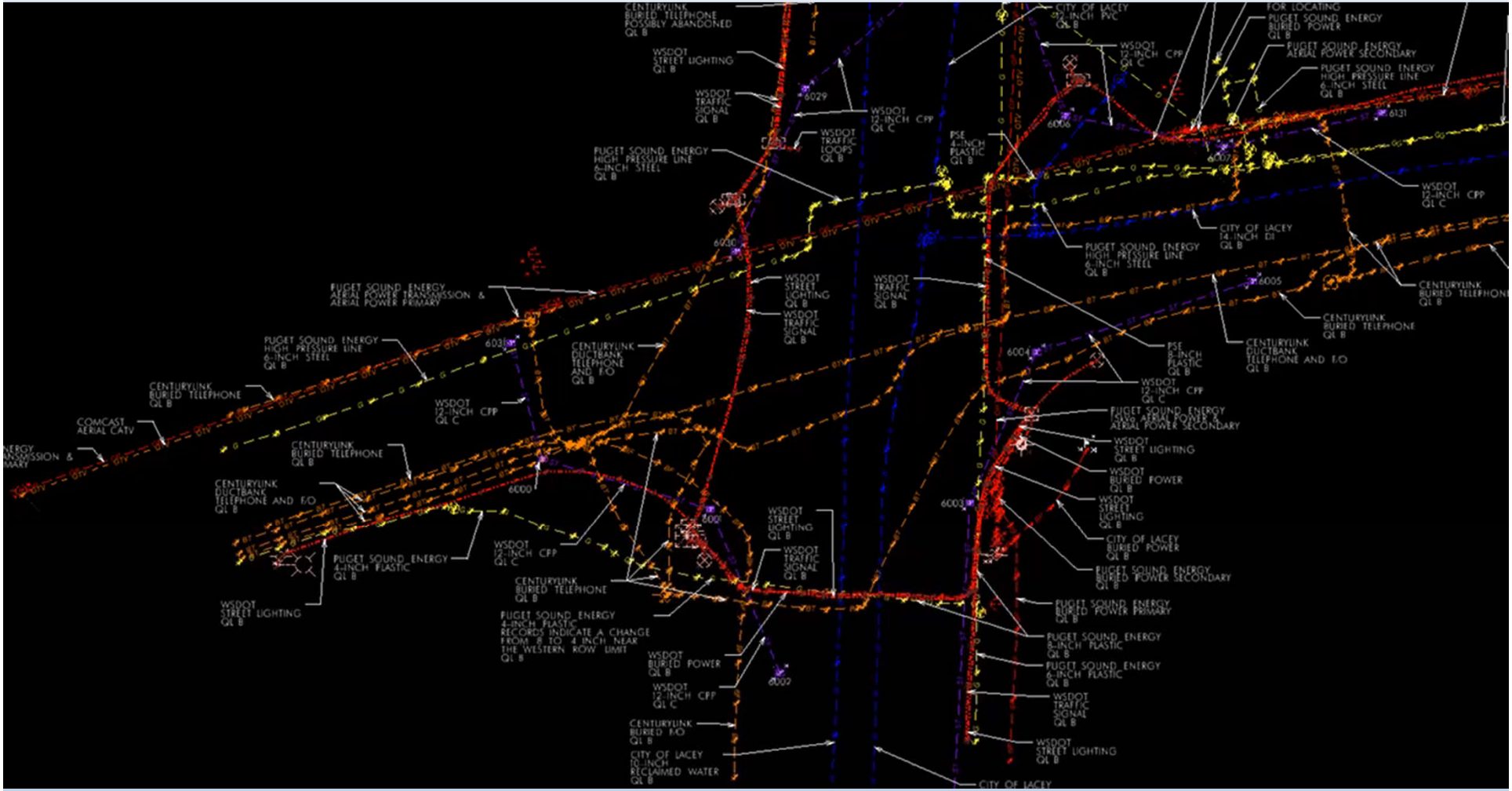


Much Data to Manage and Interpret

3D Cross Section Superior to Single Test Hole for Design



Full 3D Model Depiction for Design



GEOworks

Recommend Four Phase Approach

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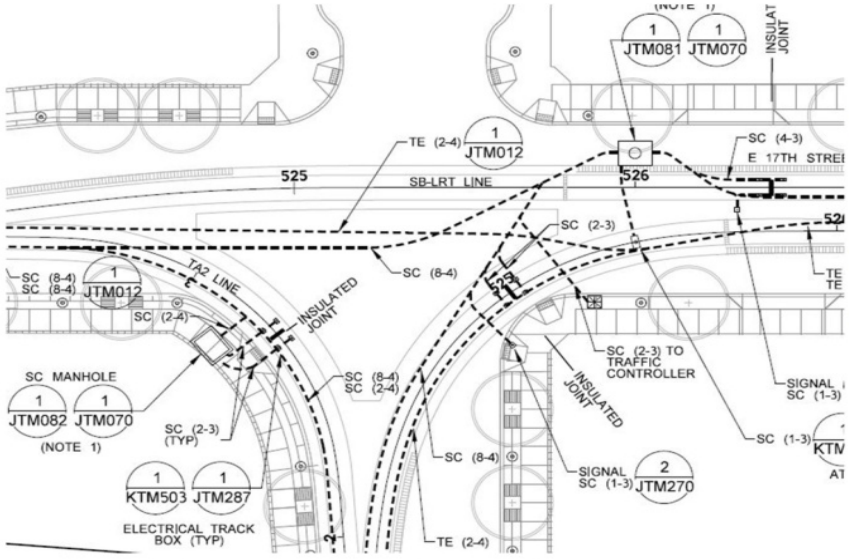
Importance of Data Management for Utility Conflicts and Solutions

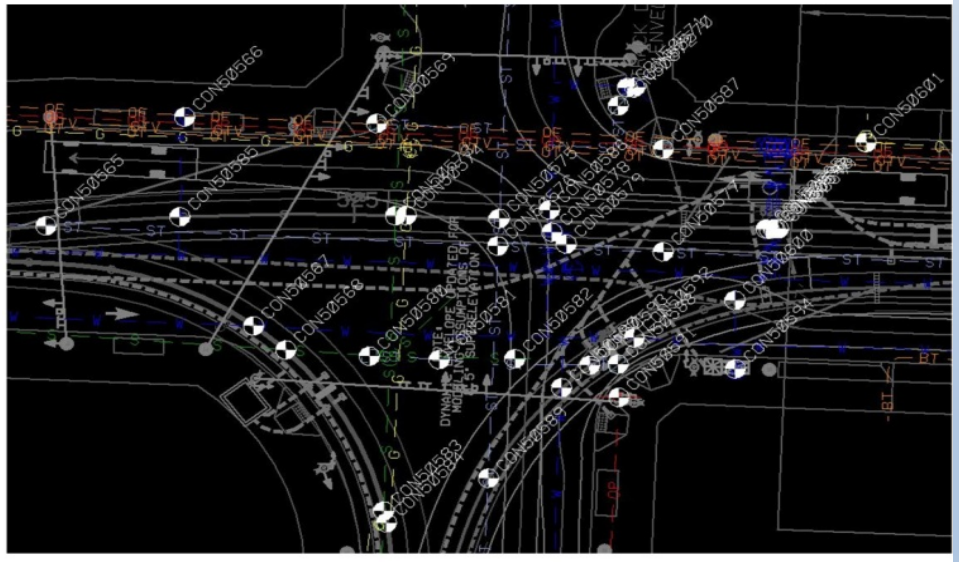
- Manage the **complexity of utility infrastructure** data (spatial, attribute, metadata) in a structured, secure, readily accessible offsite (cloud) repository
- Itemize, manage and coordinate **clash detection and conflict analyses** results with project design and utility teams for efficient design 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**

UIM Application

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.

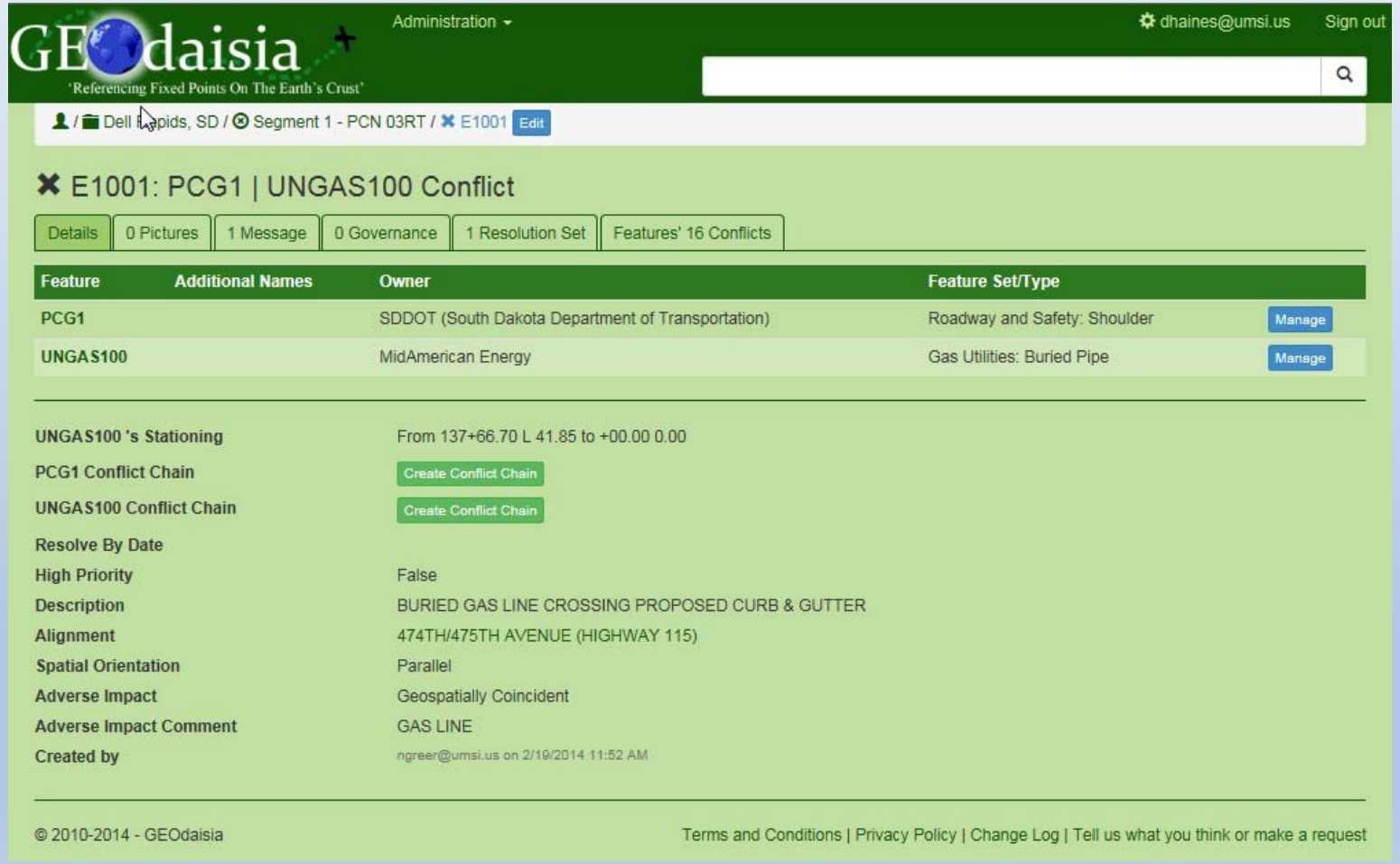


LIGHT RAIL ALIGNMENT
w/ SYSTEM DUCT BANKS



LIGHT RAIL ALIGNMENT
w/ SYSTEM DUCT BANKS
& EXISTING UTILITY CONFLICTS

Ex. – Proposed Curb and Gutter and Existing Gas Pipe



Conflict Resolution

Existing Conditions | Conflict Analysis | Resolution

Existing Conditions | Conflict Analysis | 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 Design along G Street. 3D QL-B data and Test Hole data has been obtained.

Conflicts

0 Conflict Pictures

Conflict Number	Resolve By Date	Conflict Zone	Alignment	Features in Conflict		Description
51339		CRC Project (Portland - Vancouver Bridge): Segment 5	G Street	GST | WSDOT (Washington Department of Transportation) | Roadway and Safety: Pavement Section	GVLVNW_16042 | Northwest Natural | Gas Utilities: Valve	Conflict imported without a description.
40915		CRC Project (Portland - Vancouver Bridge): Segment 4	McLoughlin Blvd	PSD562 | WSDOT (Washington Department of Transportation) | Storm Drainage: Gravity Pipe	GASNW705 | Northwest Natural | Gas Utilities: Buried Pipe	Line crosses proposed storm drainage
40005		CRC Project (Portland - Vancouver Bridge): Segment 4	SB-LRT Light Rail Transit South Bound	DUCT BANK45 | C-Tran | Rail: Duct Bank	GASNW705 | Northwest Natural | Gas Utilities: Buried Pipe	Conflict imported without a description.
40907		CRC Project (Portland - Vancouver Bridge): Segment 4	McLoughlin Blvd	PSD562 | WSDOT (Washington Department of Transportation) | Storm Drainage: Gravity Pipe	GASNW705 | Northwest Natural | Gas Utilities: Buried Pipe	Line crosses proposed storm drainage. Due to the amount of excavation (cut) to have the Light Rail undercrossing it appears that this gas line will need to be lowered or relocated.
40908		CRC Project (Portland - Vancouver Bridge): Segment 4	McLoughlin Blvd	PSD444 | WSDOT (Washington Department of Transportation) | Storm Drainage: Gravity Pipe	GASNW705 | Northwest Natural | Gas Utilities: Buried Pipe	Line crosses proposed storm drainage. Due to the amount of excavation (cut) to have the Light Rail undercrossing it appears that this gas line will need to be lowered or relocated.

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-builts

Terra Move™

Cost effective and time sensitive alternatives to utility relocation needs.

Terra Shield™

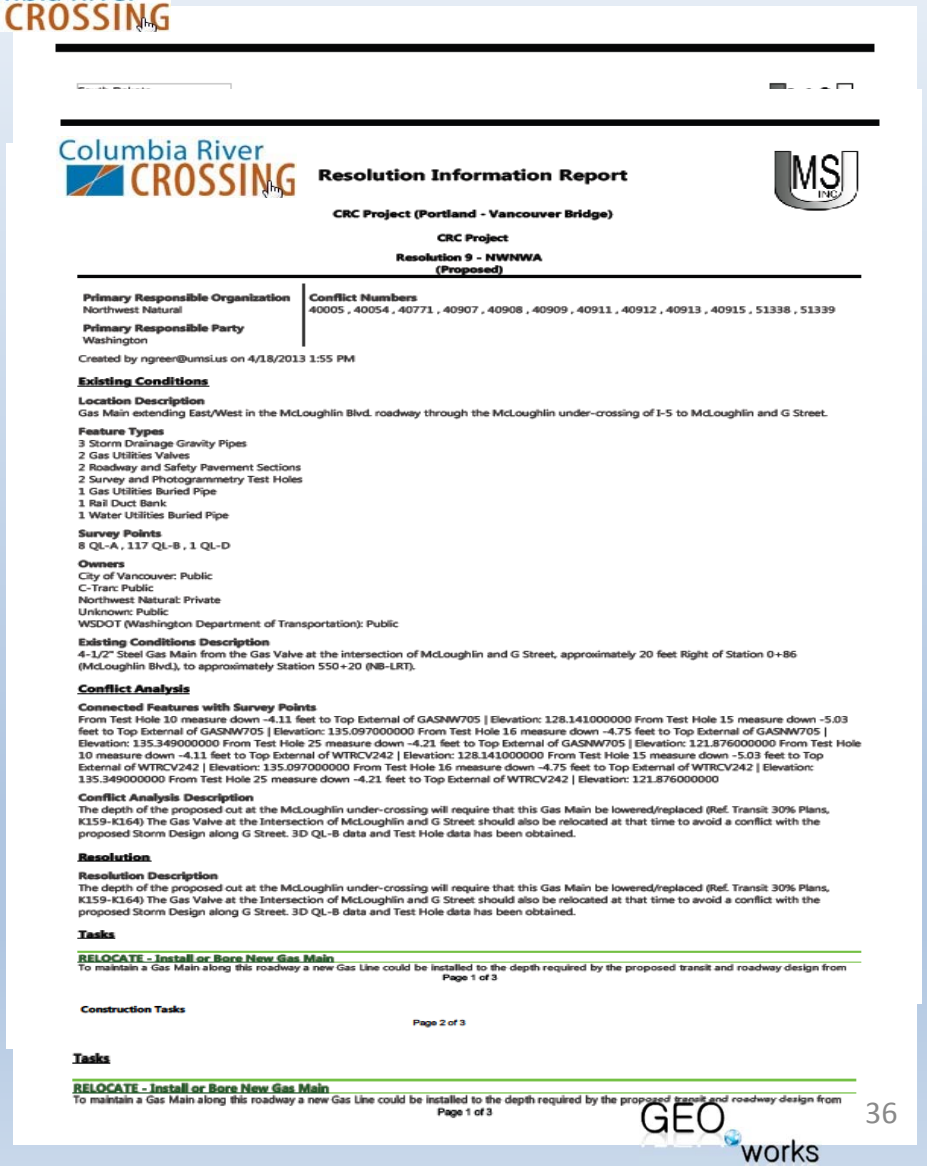
The industry's new standard for utility support and protect projects

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



Columbia River CROSSING

Resolution Information Report

UMS INC

CRC Project (Portland - Vancouver Bridge)

CRC Project

Resolution 9 - NWNWA
(Proposed)

Primary Responsible Organization
Northwest Natural

Primary Responsible Party
Washington

Conflict Numbers
40005 , 40054 , 40771 , 40907 , 40908 , 40909 , 40911 , 40912 , 40913 , 40915 , 51338 , 51339

Created by ngreer@umsi.us on 4/18/2013 1:55 PM

Existing Conditions

Location Description
Gas Main extending East/West in the McLoughlin Blvd. roadway through the McLoughlin under-crossing of I-5 to McLoughlin and G Street.

Feature Types
3 Storm Drainage Gravity Pipes
2 Gas Utilities Valves
2 Roadway and Safety Pavement Sections
2 Survey and Photogrammetry Test Holes
1 Gas Utilities Buried Pipe
1 Rail Duct Bank
1 Water Utilities Buried Pipe

Survey Points
8 QL-A , 117 QL-B , 1 QL-D

Owners
City of Vancouver: Public
C-Tran: Public
Northwest Natural: Private
Unknown: Public
WSDOT (Washington Department of Transportation): Public

Existing Conditions Description
4-1/2" Steel Gas Main from the Gas Valve at the intersection of McLoughlin and G Street, approximately 20 feet Right of Station 0+86 (McLoughlin Blvd.), to approximately Station 550+20 (NB-LRT).

Conflict Analysis

Connected Features with Survey Points
From Test Hole 10 measure down -4.11 feet to Top External of GASNW705 | Elevation: 128.141000000 From Test Hole 15 measure down -5.03 feet to Top External of GASNW705 | Elevation: 135.097000000 From Test Hole 16 measure down -4.75 feet to Top External of GASNW705 | Elevation: 135.349000000 From Test Hole 25 measure down -4.21 feet to Top External of GASNW705 | Elevation: 121.876000000 From Test Hole 10 measure down -4.11 feet to Top External of WTRCV242 | Elevation: 128.141000000 From Test Hole 15 measure down -5.03 feet to Top External of WTRCV242 | Elevation: 135.097000000 From Test Hole 16 measure down -4.75 feet to Top External of WTRCV242 | Elevation: 135.349000000 From Test Hole 25 measure down -4.21 feet to Top External of WTRCV242 | Elevation: 121.876000000

Conflict Analysis Description
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 Design along G Street. 3D QL-B data and Test Hole data has been obtained.

Resolution

Resolution Description
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 Design along G Street. 3D QL-B data and Test Hole data has been obtained.

Tasks

RELOCATE - Install or Bore New Gas Main
To maintain a Gas Main along this roadway a new Gas Line could be installed to the depth required by the proposed transit and roadway design from

Page 1 of 3

Construction Tasks

Page 2 of 3

Tasks

RELOCATE - Install or Bore New Gas Main
To maintain a Gas Main along this roadway a new Gas Line could be installed to the depth required by the proposed transit and roadway design from

Page 1 of 3

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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.)

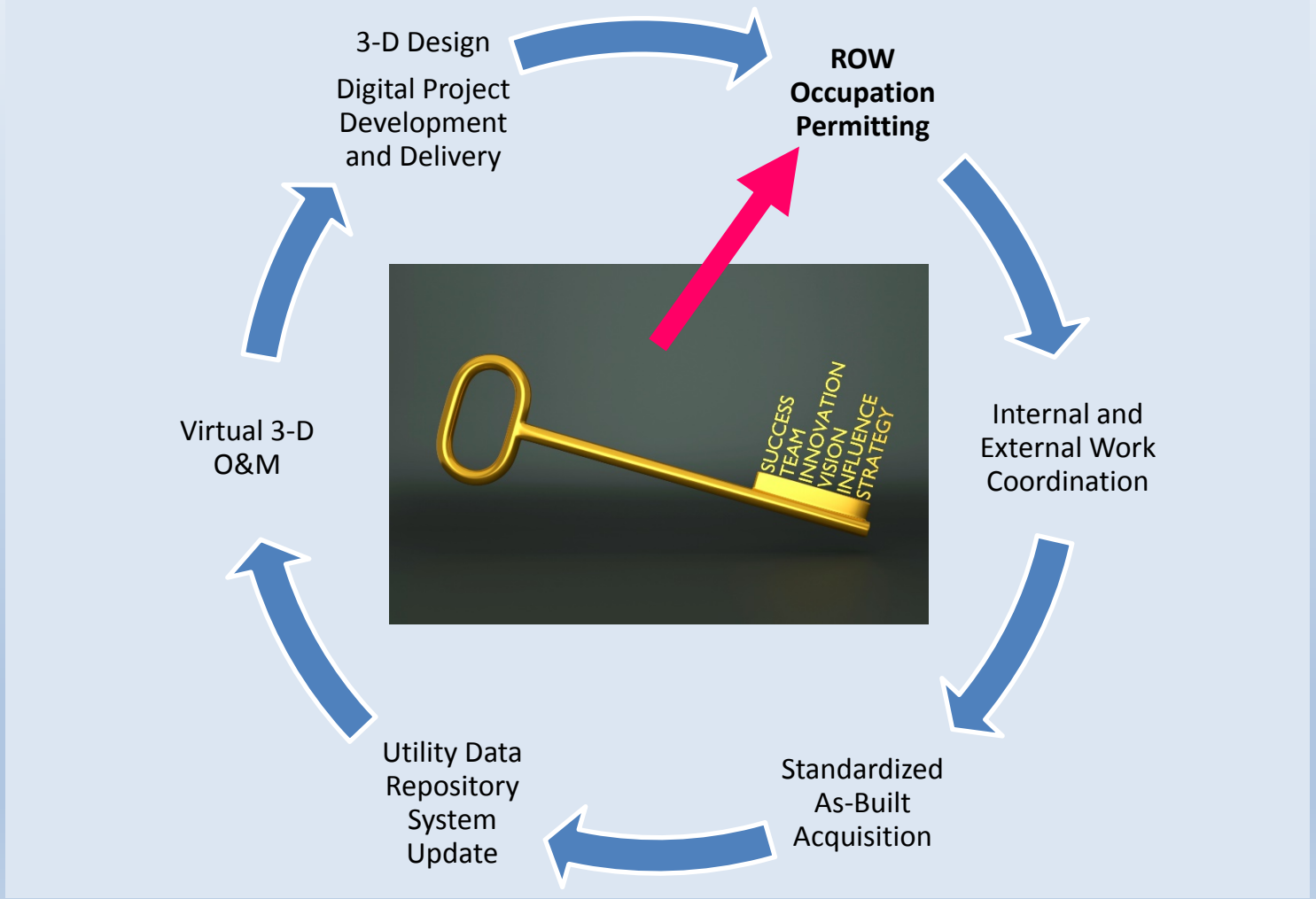
Strategy ROI and Merits

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



Utility Engineer Qualifications

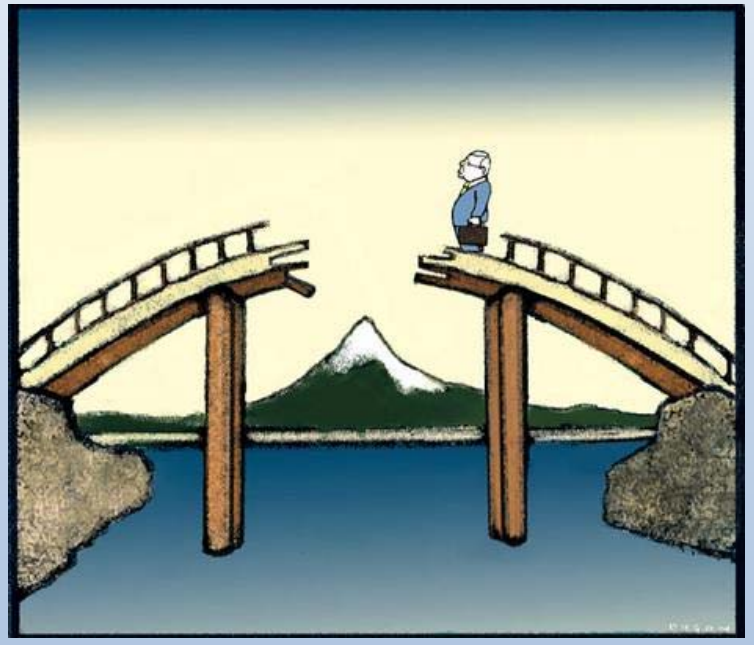
- Must Understand BOTH Agency and Utility Needs
- Be Knowledgeable in BOTH Agency and Utility Company Policies, Procedures, & Requirements
- Have "Cross Discipline" Design and Construction Experience in BOTH Transportation & Utilities
- Experienced in Identifying, Prioritizing, & Mitigating Risks for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

Need To Bridge the Gap

Utility Technical Discipline void

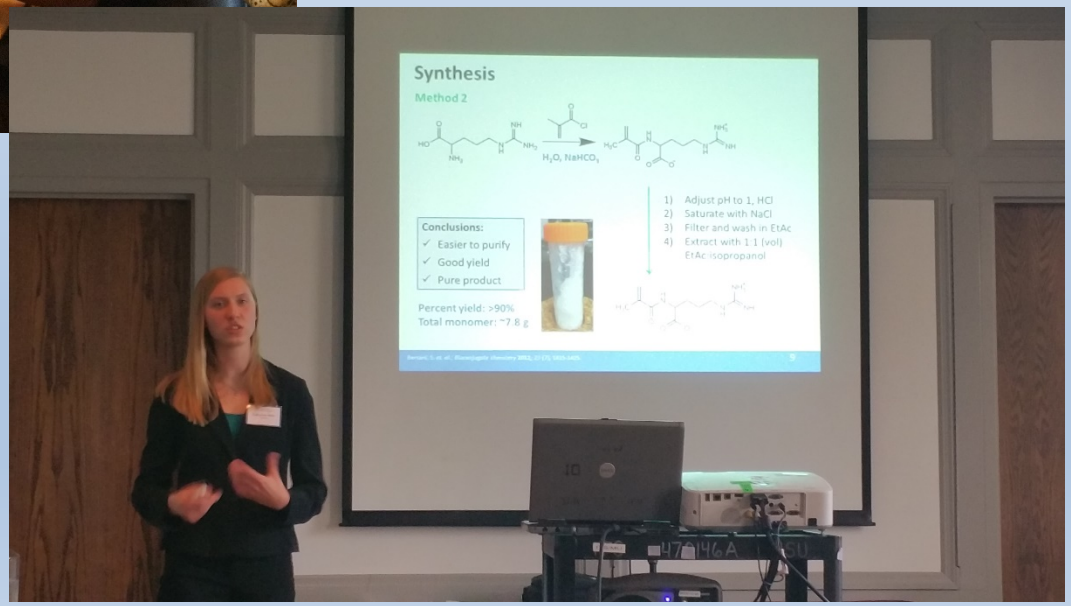
Utility Engineer Qualifications

- Ability to Establish Relationships, based on Mutual Understanding & Trust
- Ability to Recognize Time & Cost Innovative Utility Solutions



Address the Utility Technical Discipline void….

Some Meis's Currently at ISU



Your Time is Appreciated

Philip J. Meis, P.E.
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www.umsi.us & www.geo.works