Presentation Outline

> Utility Engineering (UE) Brief Overview

> Subsurface Utility Engineering (S.U.E.) Conventional Methods

> Advanced Technology for S.U.E.
  - Radar Tomography for 3-D Modeling
  - Multi-Channel Time-Domain Electromagnetic Imaging (MCTDEMI)
  - Vault Investigations – LiDAR and other techniques

> 3-D Modeling
INTRODUCTION
How does UE help Manage Utility Risk?

- Accurate, reliable Utility Drawings – ASCE 38-02
- Knowledgeable Utility Coordination
What Happens with Projects that Have Uncertainties?

• Nothing, *If You’re Lucky*

• Most Likely to Some Degree…
  > Project Delays
  > Cost Overruns
  > Change Orders
  > Accidental Environmental Releases
  > Higher Bids for Construction
  > Damages to Property
  > Injury or worse to people
  > Bad Press

*NYC 1971 - Broadway Subway Station Project*
Ways to Reduce Uncertainties

Thorough Utility Site Investigations

> Records
> Topography / Visual / Geomorphology
> Test Holes / Bores
> Geophysics / Remote Sensing

Professional Judgment
Last Century Engineering Practices

Use Records to guide locations for Test Holes / Pot Holes

Problems with records:

- Never made
- Incorrect and incomplete
- Site repurposing / abandonment
- Hard to find positional reference
- Lost

Results in:

- Holes with no data
- <Data> where no holes
Utility Engineering
- Foundation of success

- Subsurface Utility Engineering
- Utility Coordination
- Utility Design
Utility Engineering

A branch of engineering practice that involves managing certain risks associated with utility mapping at appropriate quality levels, utility coordination, utility relocation design and coordination, utility condition assessment, communication of utility data to concerned parties, utility relocation cost estimates, implementation of utility accommodation policies and utility design.
Subsurface Utility Engineering - Risk Mitigation

“A specialty practice of civil engineering that investigates and depicts existing underground utilities through the collection and analysis of records, visual, geophysical, and/or exposure methods, and assigns achieved Utility Quality Levels to the Utility Segments based upon the integration of all the analyzed data with professional judgement at a defined point in time. SUE has evolved as a subset of Utility Engineering.”

C-I /ASCE 38-02

Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data
SUE: Return on Investment  A Proven Solution

Purdue University – Jan. 2000
Commissioned by FHWA
$4.62 Return on $1.00 Investment
Estimated $1B National Savings/Year

University of Toronto – 2005
> Commissioned by Ontario Sewer & Watermain Contractors Association
> $3.41 Return on $1.00 Investment

Penn State University – 2008
> Commissioned by PENNDOT
> $21.00 Return on $1.00 Investment

COST SAVINGS ON HIGHWAY PROJECTS UTILIZING SUBSURFACE UTILITY ENGINEERING

Prepared by
Purdue University
Department of Building Construction Management

January 2000

Prepared for the
Federal Highway Administration
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Washington, D.C.
FHWA Contract Number DTFH61-96-C-40058

SUBSURFACE UTILITY ENGINEERING IN ONTARIO: CHALLENGES & OPPORTUNITIES

Center for Infrastructure Systems on Infrastructure & Construction (CIC)
Department of Civil Engineering, University of Toronto

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THE STANDARD
- ASCE 38-02
ASCE Standard 38 – SUE Quality Levels

Quality Level D

Quality Level C

Quality Level B

Quality Level A
Conventional SUE Process

- Determine the project scope and which areas will be impacted
- Contact Utilities to Gather Records Data for entire project area (QL-D)
- Survey area to pick-up surface features -typically part of topo survey (QL-C)
- Determine which areas are sensitive to the presence of existing Utilities
- Designate true horizontal location of Utilities in sensitive areas. (QL-B)
- Identify where potential conflicts are – build a conflict matrix
- Perform test holes to determine horizontal and vertical location of utilities at key conflict areas. (QL-A)
- Investigate manholes to get vault sizes and inverts.
BUILDING THE 3D MODEL
Why 3D?

- Conflict detection - Identify utility conflicts against design
- Identify area(s) of interest for designers
- Create cross sections and profiles quickly
- Eventually skip 2D plans and go straight to 3D models
- Project and on-site managers can utilize 3D interactive pdfs
Inputs

- Digital Terrain Model (DTM)
- Conventional Quality Level B Designating (per ASCE 38)
- Inverts / Top of Pipe / Measure-downs
- Vault Dimensions (may include LiDAR)
- Point Depths from Conventional Geophysics
- Line Depths from Multi-Channel GPR (SHRP R01B)
- Quality Level A Test Holes (per ASCE 38)
- GIS / As Built Records for Sizes and Typical Depths
- Professional Judgement to Fill in the Gaps
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Conventional Geophysical Methods

> Pipe & Cable Designating Equipment
> Sonde
> CCTV Camera with Sonde
> Ground Penetrating Radar (GPR)
> Sonic
Metallic Utilities (including cut/abandoned) and other structures

No Direct Connect Location (i.e. electric box, meter, valve, hydrant, signal box)

Geo-referenced data for CAD overlay

Time-Domain Electromagnetic Imaging (TDEMI)
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Documentation Obtained:

- Invert
- Crown
- Top of Pipe
- Top of Nut
- Top of Dirt
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Vault Imaging & Measurements
Inputs

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• Line Depths from Multi-Channel GPR (SHRP R01B)
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• Professional Judgement to Fill in the Gaps
Field Depths
Inputs

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• **Line Depths from Multi-Channel GPR (SHRP R01B)**
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Multi-Channel 3D Radar Tomography

- Arrays of multi-frequency (200MHz and 600 MHz), multi-polarized antennas
- The use of massive arrays allows for fast scans of large areas
- The STREAM EM is a vehicle towed array
- The STREAM C is a compact array that can be towed or manually pushed
- Surveys only need to be performed in one direction to gather all the data
- Locate utilities, vaults, former building foundations, excavations, railroad ties
From 2D to 3D Imaging

Radiography → CAT (Tomography)

B-Scan → C-Scan (Tomography)
EXAMPLE RESULTS
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Subsurface Utility Engineering – 3D Mapping Video
Subsurface Utility Engineering – 3D Mapping with LiDAR Video
Contact Information

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