AM Gradiometer (AMG) Technology
Underground Utility/Substructure Detection

Charbel Khoury, PhD, PE
Geotechnical Practice

SUE Association Conference
9/25/2019

ISO 9001:2015 Certified | Employee-owned Since 1988
AM Gradiometer (AMG) Technology

- Table for Operation & Visualization
- PRISM for AMG Tracking with Total Station
- Leica Data Collector for GPS
- Antennas
Cart System
AMG Technology Equipment

Portable System
Total Station Setup
Typical Peak Signal/Detection
In general, AMG can detect the following subsurface items:
Typical depths-of-detection range up to 30 feet.

Some large objects can be detected 30 to 50 feet with Antennas Adjustments.

AMG is NOT able to do the following:

- Identify the specific object detected
- Evaluate the diameter of the object detected
- Determine the contents of a pipe or conduit
- Differentiate between objects stacked in vertical
- Differentiate between two/multiple closely spaced Utilities; will “see” the bundle of pipes as a signal complex conductor.
- Provide accurate depth estimate for closely spaced utilities
<table>
<thead>
<tr>
<th>GPR</th>
<th>AMG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can detect anomalies regardless of their material types (e.g.,...</td>
<td>Cannot penetrate through materials like surface reinforced concrete, moist/wet surfaces or when clay soils are encountered</td>
</tr>
<tr>
<td>Cannot penetrate through materials like surface reinforced concrete, moist/wet surfaces or when clay soils are encountered</td>
<td>Not limited by built-up surface such as concrete, thin water, granite or subsurface soil with high clay or moisture/water content</td>
</tr>
<tr>
<td>Operates at higher frequencies between 100 MHz to 2GHZ</td>
<td>Operates passively at a very low frequency (200 KHz to 1 MHz)</td>
</tr>
<tr>
<td>Typical depths-of-detection up to 10 feet</td>
<td>Typical depths-of-detection up to 30 feet; however, can detect at 30-50 foot depths with antenna configuration adjustments</td>
</tr>
<tr>
<td>Typically does not provide GPS locations or depth data, but relies on 3rd party surveying</td>
<td>Maps and provides detections with GPS coordinates/locations and depths, which are easily and readily available for underground 3D models</td>
</tr>
</tbody>
</table>
Example Projects

- Regulator Stations
- Sinkhole @ Howard St. & Pratt St.
- Gas Gate Station
- KCI North Ave.
- Electric Substations (Sinkhole & Utilities)
**Sept 2018 Columbia Gas Incident – Merimack Valley, MA**

- System over-pressure damaged 131 structures
- One person was killed and at least 21 individuals taken to the hospital
Regulator Stations

Example of Typical Plan Drawing – Location 1
KCI Objectives/Approach

- Updated 2D drawing in “standard” Client’s format
- 3D BIM model of utilities and structures
- Augmented Reality (AR)

KCI Practices Involved
1. Environmental (Project Management)
2. Geotech (AMG Technology, GPR coordination)
3. Utility Design (2D drawings in “standard” format)
4. Survey (Traditional survey & LaserScan)
5. SUE (Traditional mark out)
6. MEP (3D Modeling)
7. Geospatial (AR)
Pre-Field Work Activities
Field Work / Data Collection

SUE

LiDAR & Traditional Survey

GPR

AMG
Regulator Station - 1
AMG Data Collection Grid Pattern/Transects – Location 1
2D Deliverable - Regulator Station 1
KCI DOES NOT GUARANTEE UNDERGROUND UTILITIES & OBSTRUCTIONS ARE CORRECT.
IT SHALL BE THE RESPONSIBILITY OF BGE AMG/ OR THE CONTRACTOR(S) TO VERIFY LOCATION & DEPTH OF ALL UNDERGROUND OBSTRUCTIONS BEFORE PROCEEDING WITH CONSTRUCTION.

AMG DATA:
- HIGH CONFIDENCE
- MEDIUM CONFIDENCE
- LOW CONFIDENCE

SURVEY DATA
GPR Deliverable

GPR Results
Combining All of the Data – 3D Model
Test Pits – Regulator Station 1
## Comparisons – Location 1

**Variance \((x,y)\) from surveyed utility as determined by Test Pits (feet)**

<table>
<thead>
<tr>
<th>Location ID</th>
<th>Description</th>
<th>Client Plan</th>
<th>SUE</th>
<th>AMG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16” C.I. Main</td>
<td>1.0</td>
<td>1.0</td>
<td>N/A(^1)</td>
</tr>
<tr>
<td>2</td>
<td>8” Water Main</td>
<td>N/A</td>
<td>N/A</td>
<td>0.5</td>
</tr>
<tr>
<td>2A</td>
<td>16” C.I. Main</td>
<td>0.5</td>
<td>3.6</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>1” Control Line</td>
<td>1.5</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>1” Control Line</td>
<td>0.7</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>4A</td>
<td>1” Control Line</td>
<td>3.3</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>2 x 1” Control Lines</td>
<td>0.5 - 3.0</td>
<td>1.3 – 1.5</td>
<td>0.6 – 0.9</td>
</tr>
<tr>
<td>6</td>
<td>2 x 1” Control Lines</td>
<td>0.8 - 1.2</td>
<td>2.5 - 2.8</td>
<td>0.6 – 0.9</td>
</tr>
<tr>
<td>7</td>
<td>1” Control Line</td>
<td>2.25</td>
<td>0.8</td>
<td>0.3</td>
</tr>
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\(^1\) Outside the area of AMG scanning
Location 1 – Variance Examples

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<tr>
<td>Description</td>
<td>SUE Mark Out</td>
<td>Test Pits</td>
<td>GPR</td>
<td>AMG</td>
</tr>
<tr>
<td>------------------------------------------------------------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>--------------------</td>
<td>------</td>
</tr>
<tr>
<td>Identified known as well as unknown utilities</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>Yes</td>
</tr>
<tr>
<td>Not limited by site conditions such as moisture, clay, and concrete</td>
<td>Yes</td>
<td>Yes, but location must be known</td>
<td>No</td>
<td>Yes</td>
</tr>
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<td>Not dependent on tracing wires or conductive materials</td>
<td>No</td>
<td>Yes, but location must be known</td>
<td>Yes, if not limited by site conditions</td>
<td>Yes</td>
</tr>
<tr>
<td>Works on all types of utilities (cast iron, steel, Non-metallic with or without tracer)</td>
<td>No</td>
<td>Yes, but location must be known</td>
<td>Maybe</td>
<td>Yes</td>
</tr>
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<td>Allows pinpointing of utilities for vacuum excavation</td>
<td>No</td>
<td>No</td>
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SINKHOLE @ Howard St. & Pratt. St.

Monday Afternoon
July 8, 2019
SINKHOLE @ Howard St. & Pratt. St.

Monday Evening
July 8, 2019
SINKHOLE @ Howard St. & Pratt. St.
SINKHOLE @ Howard St. & Pratt. St.
SINKHOLE @ Howard St. & Pratt. St.
GPR Scanning

GPR Survey Grid
GPR Scanning
No underground or subsurface features were imaged below a depth of about 5 feet.
AMG - Sinkhole Investigation

Tuesday morning
July 9, 2019
AMG Transects
Wednesday morning July 10, 2019
KCI SUE Plans
CSX Tunnel
Test Pit
Success Points

- Rapid response to this emergency, and commitment of our Team

- *Risk Mitigation*: evidence that no significant void concerns are present along the Howard Street that may impact the roadway or the CSX Tunnel.

- KCI findings allowed on-going operation of emergency construction activities along the roadway
Augmented Reality
3-D Field Visualization
CONTACT
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Charbel.khoury@kci.com
THE MOST INCREDIBLE THING WE’VE ENGINEERED IS OUR TEAM