Underground Data Collection and Data Management Techniques

April 2017

Data Approach

Users

Municipalities
Utilities
Plan/Design Firms
Engineering Contractors
Construction Workers
Emergency Responders

Security and Access Management

Visualization/Applications

UIM Interface

Visualize data on a map
Upload CAD data
Download data into CAD format

Other Systems & Applications

Data Management

Common 3D Asset Database

GIS & attribute data management
Data processing
Data organization
Cloud-based hosting & storage
Security

APIs

Data Inputs

CAD files: DWG, SHP, DGN formats

CAD Submission Standards

To ensure that the Underground Mapping platform contains updated, complete, and accurate data, we are enforcing CAD submission standards. All incoming CAD files should comply with the following standards:

1. **File must contain a basemap reference point**

2. **Utility lines and pipes should have the following attributes:**
   - OWNER
   - SOURCE
   - STATE
   - CONDUIT_SIZE
   - PACKAGE_SIZE
   - PACKAGE_CONFIG
   - TYPE
   - MATERIAL
   - DATE_INSTALLED
   - SUE_LEVEL
   - COVER DEPTH

3. **Utility manholes should have the following attributes:**
   - OWNER
   - SOURCE
   - STATE
   - SIZE
   - TYPE
   - MATERIAL
   - DATE_INSTALLED
   - NUMBER
   - OFFSET
   - SUE_LEVEL

4. **Colors and lines for all CAD files submitted regardless of submitting entity should follow a set of standard guidelines For example:**

UTILITY	COLOR IN CAD FILE	LINE TYPES	NODE TYPES
ELECTRIC	RED		
WATER	CYAN		
GAS	GRAY		
TELCO	ORANGE		

Ground Scanning & Sensing Technology to Capture Data

In addition to consuming CAD (DWG, DGN) files, the mapping platform should also be able to ingest data from scanning technologies and sensing technologies. This enables engineers to verify the location of the asset as indicated in the design files against the 'ground-truthing' data from the scanning & sensing technologies. Below is a non-exhaustive list of these technologies.

Value (Accuracy / Information)

#	Sensor Technology	Description
1	Radio-Acoustic	Locate and detect underground water pipes by inserting a mobile acoustic sensor into the pipe, which moves with the water and wirelessly sends data to base station
2	Magnetic Induction	Deploy sensors along the pipelines that transmit data using MI-based communication mechanism; the system is best used for detecting and locating pipe leakages.

#	Scanning Technology	Description
1	LiDAR	Measures distance by illuminating a target with a laser and analyzing the reflected light
2	Infrared	Identify underground structures by detecting temperature differentials between the structure and surrounding environment
3	High definition cameras	Point cloud and geo-referencing solution using lower cost cameras. Also includes conversion to design ready vector formats
4	Handheld laser scanners (e.g. FARO)	Handheld devices that scans structures and objects and creates high-definition 3D point clouds, but need extensions to geo-reference the data
6	Mobile laser scanners	Scans structures and objects and creates high-definition 3D point clouds with camera system and GIS capabilities

#	Survey Technology	Description
1	GPR	Sends continuous electromagnetic pulses, receives the reflected waves back from subsurface structures, and displays the results to construct a "picture"
2	Electromagnetic	Receiver combined with an EM transmitter with a signal either applied to a line or induced via the soils

On-the-field Scanning Technology

Use multiple rapid mapping technologies including mobile laser scanning and high definition cameras to collect (or verify) 3D data of the underground assets

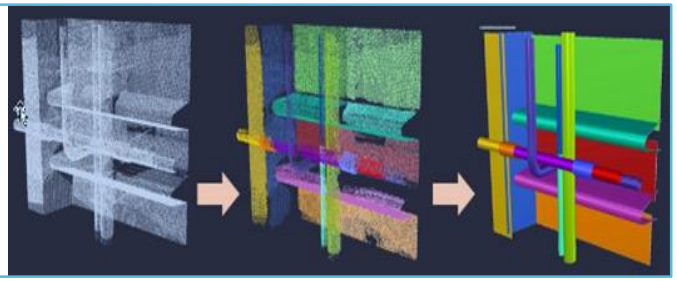
Scanning Technologies

Handheld/ Mobile lidar

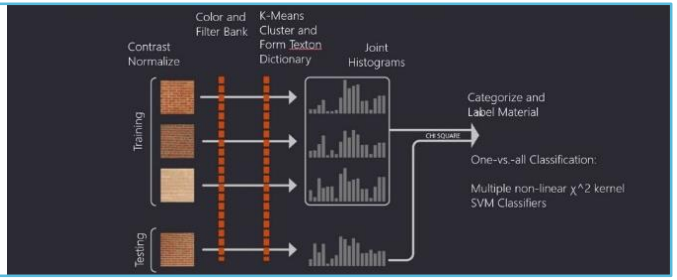
HD Cameras

3D Point Cloud Generation

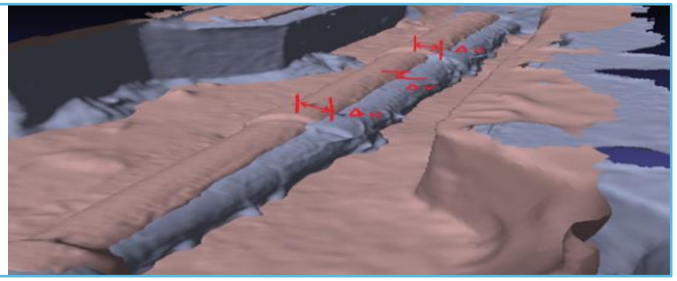
Conversion to CAD file (vector)



Probabilistic Material Assessment

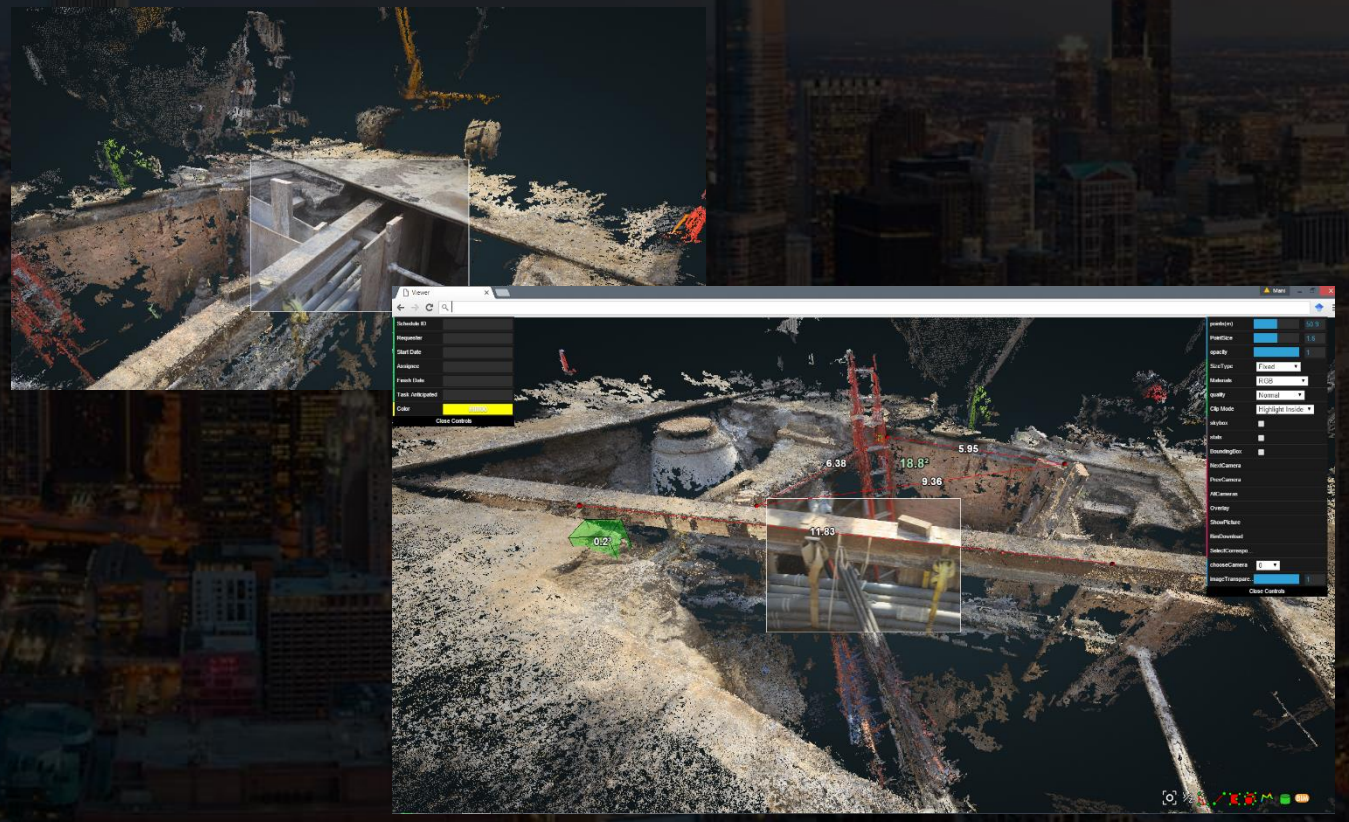


Design vs. Scanned Image Reconciliation



Scanning in Chicago

Photo shows a street opening by Chicago Department of Water Management to replace a valve on their infrastructure. Electric and telco infrastructure were found during excavation, revealing the complexity of urban excavation and the need for better information to speed up construction.



In the Pilot project, images are captured from around the excavation hole using high definition cameras, and rendered into a 3D model. This model becomes a data input into the Underground Mapping platform.

Scanning Technology - Lessons learned from the pilot

- Technology to automatically convert imagery to 3D models is still in early stages
- Capturing high quality data of an excavation site from photos can be challenge due to:
  - A trench can be opened and closed in a matter of minutes
  - Photos need to capture a 360 degree view of the trench, therefore a crew member needs to walk around the trench. This may not be possible due to nearby passing traffic
  - The utility pipes and conduits are typically covered in dirt, making it difficult to automatically/semi-automatically detect the pipe to develop the 3D model
  - If in low light, the photographer needs to a tripod and to know how to increase exposure on the camera

- Multiple pictures need to be taken in order to create a good vector model. Photos must overlap by at least 60%. At least 200 photos were recommended for the pilot site.
- Photos can be used to create a point cloud file, which can be uploaded to UIM and overlaid on top of the GIS data as a method to verify and adjust the GIS data

GIS Data Storage Approach

Standardized Data

- CAD metadata submission standards
- Optional metadata fields
- Encourage electronic data exchange

Integrate, Single Platform

- Become a source of authoritative information
- Integrate data from multiple sources
- Remove inefficiencies associated with requesting information from multiple parties
- Interoperable with other geospatial systems

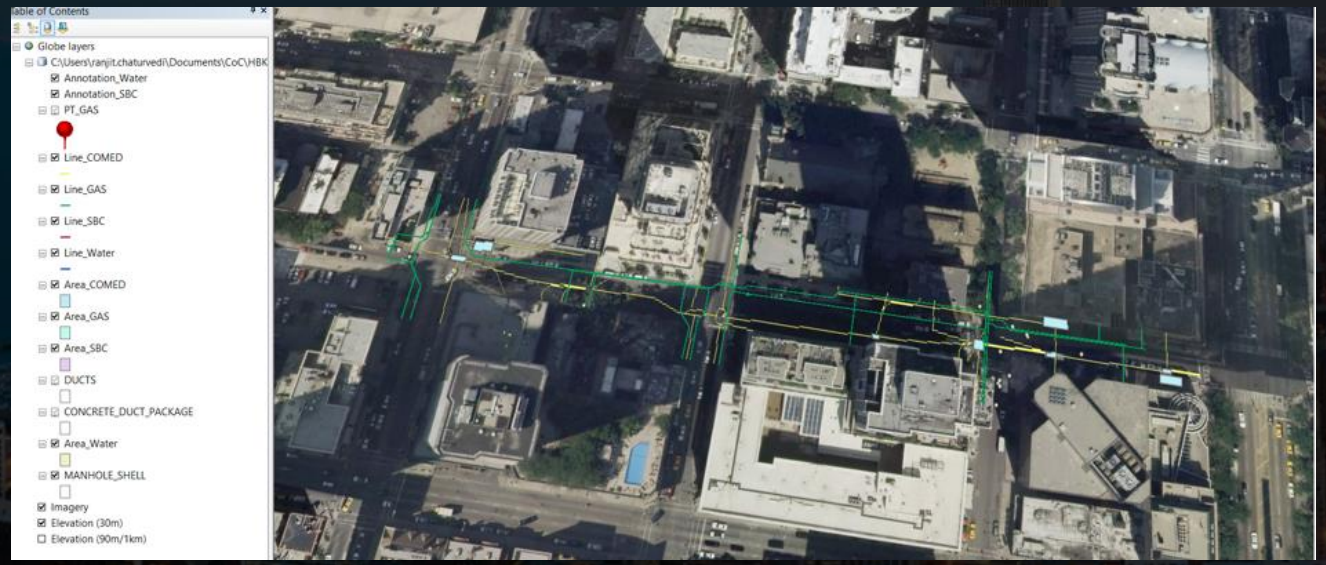
Cloud-Based

- View from a web-browser
- Scalable from individual field crew to enterprise-wide implementations

Secure

- Secure Microsoft Azure cloud platform
- Role-based access control
- Archive
- Store backup
- Track version history and changes

Visualization



Web-based

Users log on to the UIM platform to review underground data, upload a CAD file, or download a CAD file to support their design/construction work

Mobile: 3D Augmented Reality Display (beta)

Users can super-impose 3D utility data on the live view from the rear-facing camera on mobile device