Investigating New Underground Utility Location Technologies and Novel Methods to Improve the Safety and Efficiency of Highway Construction

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The Problem

- Precise location of underground utilities is a major challenge for highway design and construction
- In many instances, position of the utilities is unknown or incompatible with existing records

Project Objectives

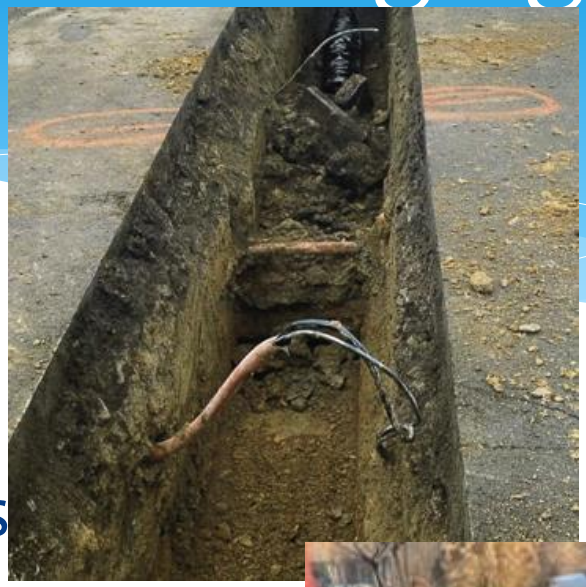
- To investigate emerging technologies that could more accurately determine lateral position and depth of both known and unknown utilities to improve safety and optimize schedules for highway construction

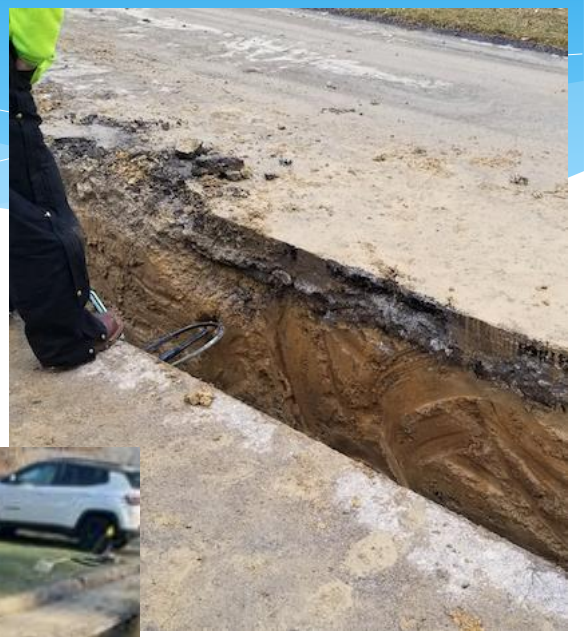
Current Practices

- Highly dependable on tracer wires and pavement marks
- Use expensive vacuum truck

Common & Challenging Scenarios

- Unmarked cables
- Abandoned lines
- Plastic conductors
- Unreliable depth data
- Utilities in various subgrade materials





Requirements

- Provide fast, accurate and easy to interpret results.
- Provide accurate lateral and depth information of underground utilities.
- Locate plastic pipes with and without tracer wires.
- Scan a whole project segment in case of potential unmarked or abandoned utilities.
- Present accurate results in various subgrade materials, especially considering Pennsylvania's "blue slab" subgrade.

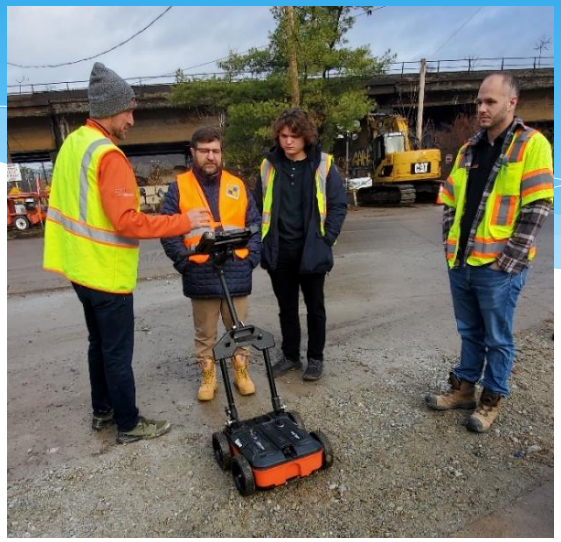
Technologies Scanned

- Ground Penetrating radar
  - Number of antennas
    - Single anthena
    - Array system
  - Signal type
    - Single frequency GPRs
    - Stepped Frequency Continuous Wave (SFCW) GPRs

Selected Technologies

Screening Eagle

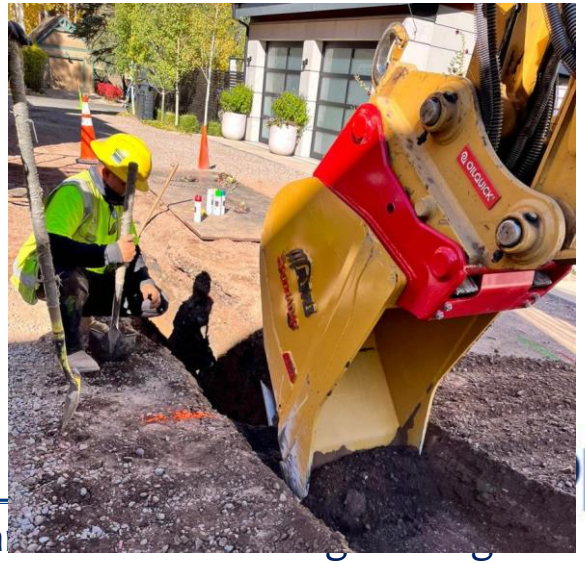
GSSI



IDS GeoRadar

Kontur

RodRadar



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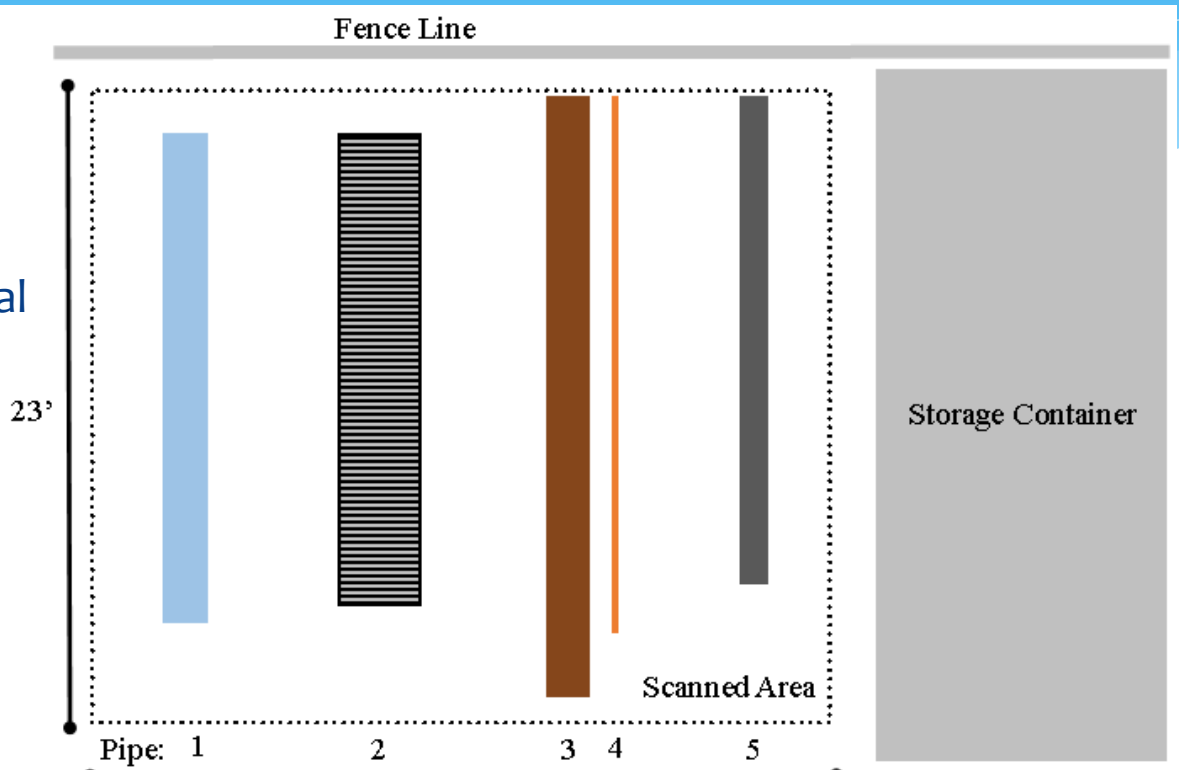
Side-by-Side Field Testing of Selected Technologies

- Controlled Site
- Construction Site
  - 16 inch ductile iron pipe 4 feet deep
  - Unmapped 1 inch electrical conduit 6 feet deep
  - 6 inch diameter pipe running parallel to a section of the 16”, 4 feet deep
  - Unmapped gas main running parallel to a section of 16”
- Drivable Site
  - Ductile iron waterline 4 feet deep



Pipe Label	Material	Diameter (inch)	Length (feet)	Depth (feet)
Pipe 1	PVC	6.5	12	6
Pipe 2	Corrugated	10	15	3.5
Pipe 3	Ductile Iron	6.5	20	6.5
Pipe 4	Plastic Speed Duct	1	17	3
Pipe 5	HDPE	4	12	4.5

Results

* In the last several years, ground-penetrating radar (GPR) technology has improved dramatically in terms of data collection and data analysis.
* The selection of the optimal tool depends on the stages of the project:
  * Design stage: The use of array systems like Kontour is recommended.
    * Pros: High resolution; High productivity; Compatible with BIM models.
    * Cons: High cost of the device; Data analysis requires significant expertise and is relatively time-consuming.
  * Pre-construing stage:
    * step frequency GPRs like Screening Eagle
      * Pros: Relatively cheap, easy to operate
      * Cons: Line-evaluation, resolution limitations
    * Excavation stage: RodRadar
      * the last line of defense, easy to use(?)
      * Cons: not fully tested and expensive