THE POWER OF YOU - Delivering Right-Of-Way Solutions to Texas

UE Status, Trends and Opportunities

Cesar Quiroga, PhD, P.E., F.ASCE
Manager, Utility Engineering Program, Texas A&M Transportation Institute

Day 3 – 1:30pm-2:30pm
12/14/2023

Presenter: Cesar Quiroga, Ph.D.

- Cesar started and currently leads the Utility Engineering Program at the Texas A&M Transportation Institute. He has been working on utility engineering topics since the early 1980s.
- Cesar is a Civil Engineer with master's and Ph.D. degrees from LSU in Baton Rouge. He is a registered P.E. in Texas and Louisiana.
- He has been a member of several organizations, including the Transportation Research Board (where he served as Chair of the Utilities Committee), ASCE, IRWA, and APWA.
- At ASCE, he is a founding member of UESI and TxUESI. At UESI, he has been a member of several committees, including the committees that developed the 38-22 and 75-22 standards.

Topics

- Sample of current initiatives
- Emerging trends, challenges, and opportunities
  - Digital twins and building information modeling (BIM)
  - Utility investigations
  - Utility conflict management (UCM)
  - Construction and utility inspections
  - Artificial intelligence

Utility Engineering and Engineering Surveying

- Utility Engineering is a branch of engineering that focuses on the planning, design, construction, operation, maintenance, and asset management of all utility systems, **as well as the interaction (and interdependence) between utility infrastructure and other infrastructure**
- Engineering surveying includes surveying activities required to support the conception, planning, design, construction, maintenance, and operation of engineered projects

Utility-Related Risks During Project Delivery

Failure to recognize, address, and manage utility risks early

Results in impacts during

- Preliminary Design
- Final Design
- Construction
- Post Construction

Impacts during Preliminary Design

- Insufficient ROW assessment
- Inadequate assessment of utility needs
- Inadequate environmental review
- Suboptimal project alignment
- Insufficient project cost estimate
- Unrealistic project delivery schedule

Utility-Related Risks During Project Delivery

Failure to recognize, address, and manage utility risks early

Results in impacts during

- Preliminary Design
- Final Design
- Construction
- Post Construction

Impacts during Final Design

- Unnecessary utility relocations
- Suboptimal project design
- Utility process becomes part of critical path
- Letting date delays
- Insufficient project cost estimate
- Antagonistic relationship with utility owners

Utility-Related Risks During Project Delivery

Failure to recognize, address, and manage utility risks early

Results in impacts during

- Preliminary Design
- Final Design
- Construction
- Post Construction

Impacts during Construction

- Construction site disruptions
- Damage to utility installations
- Unplanned environmental corrective actions
- Unnecessary utility relocations
- Project delays and higher project costs
- Litigation by affected stakeholders
- Public complaints about project delivery

Utility-Related Risks During Project Delivery

Failure to recognize, address, and manage utility risks early

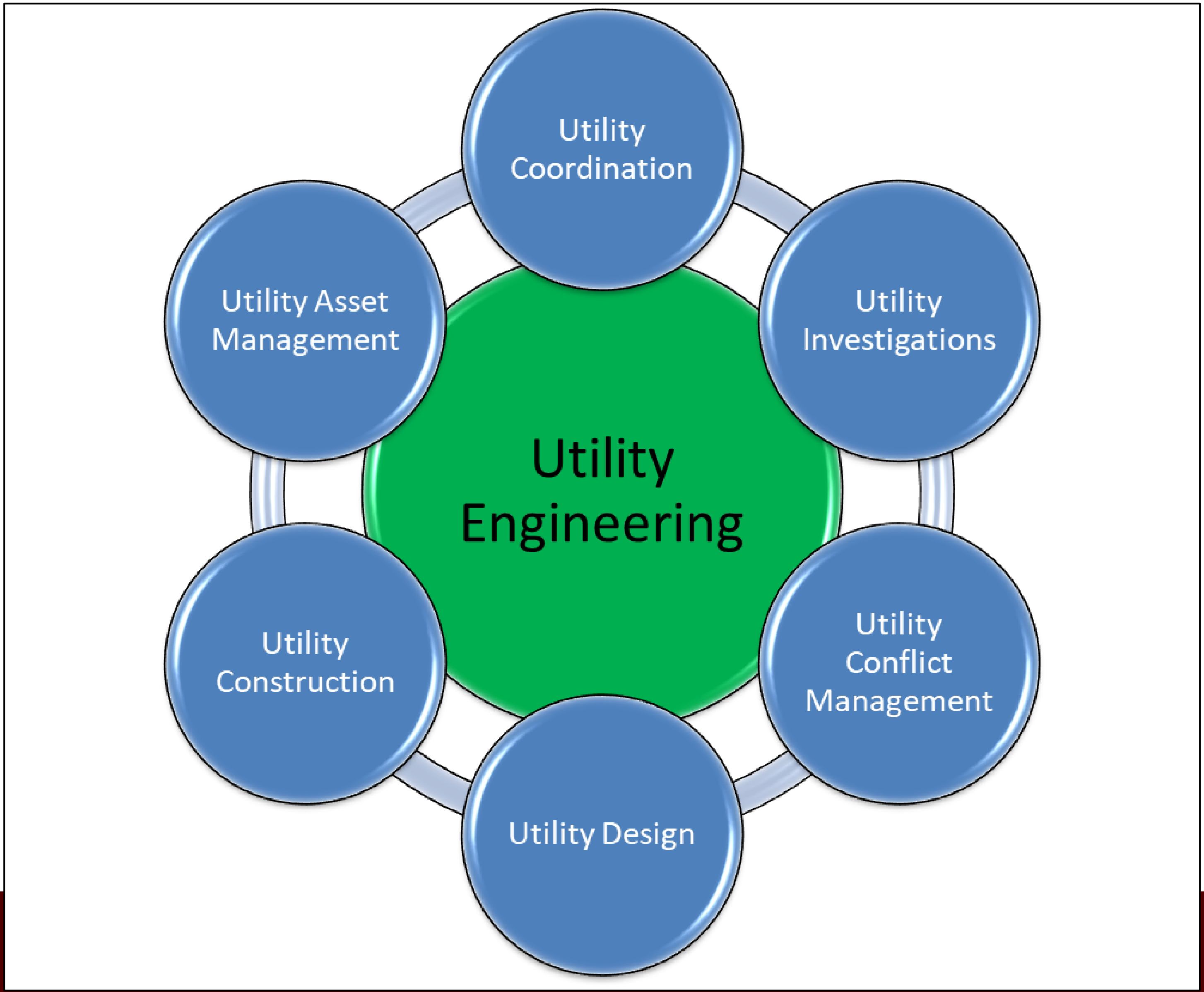
Results in impacts during

- Preliminary Design
- Final Design
- Construction
- Post Construction

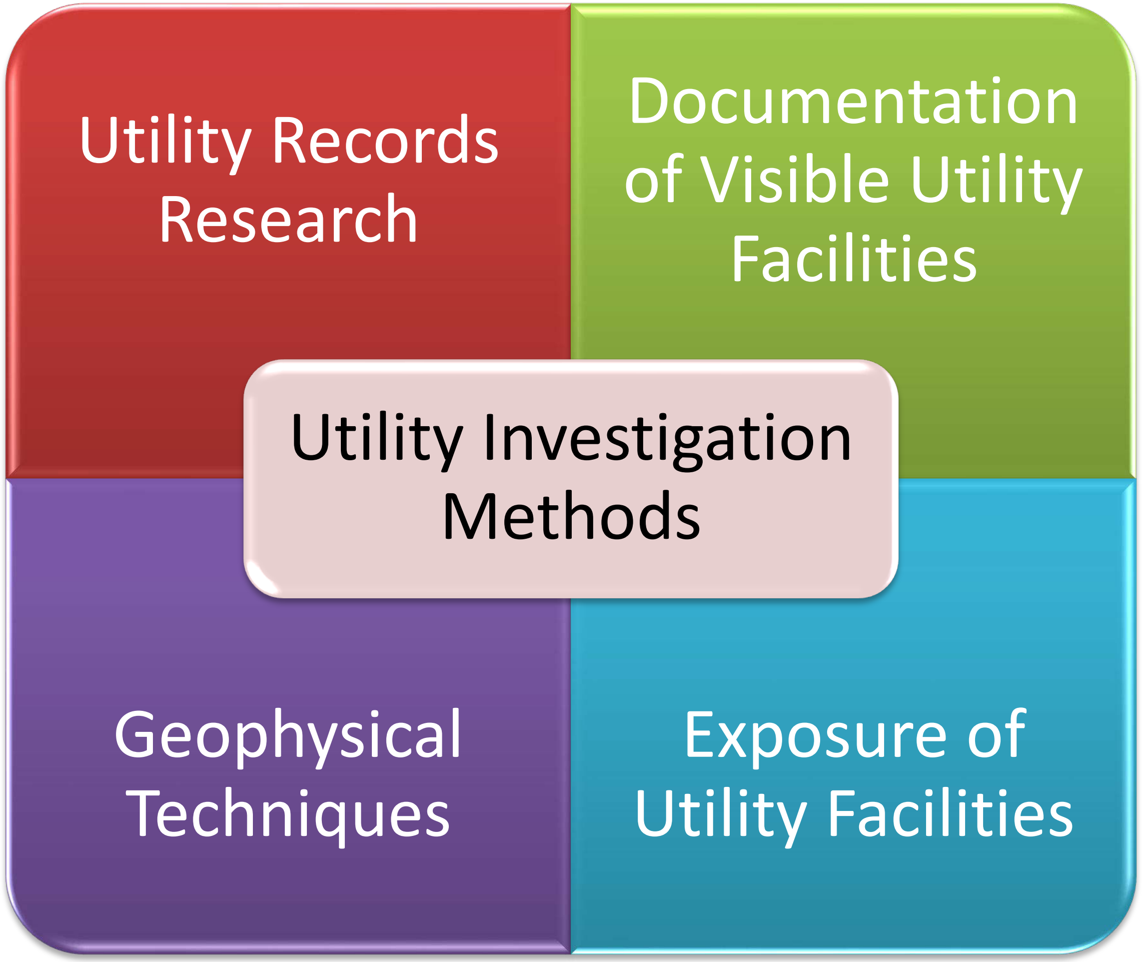
Impacts during Post Construction

- Outstanding utility invoices and payments
- Unsupported actual utility relocation costs
- Delays getting federal-aid reimbursements
- Litigation by affected stakeholders
- Unplanned environmental corrective actions

Utility Engineering Framework



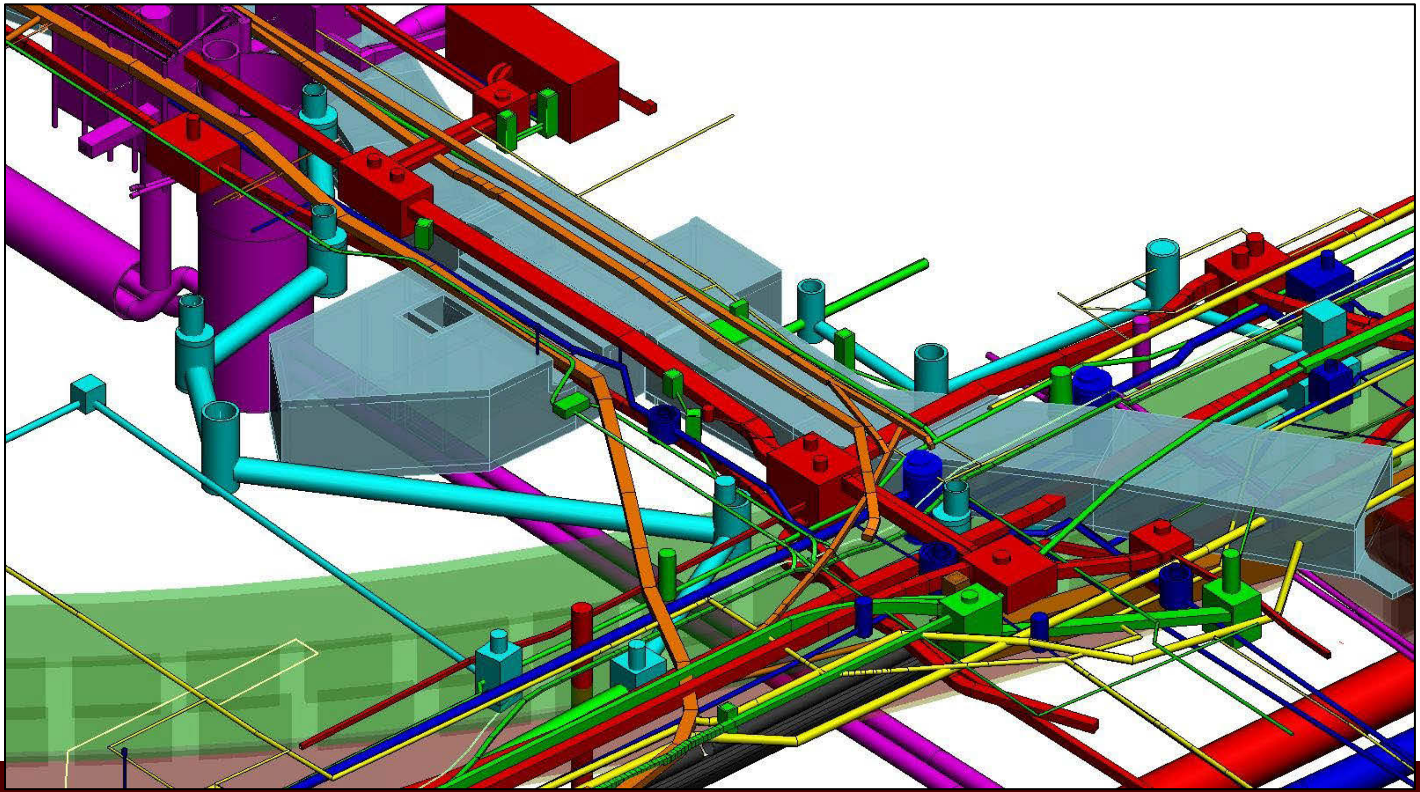
Utility Investigation Methods



- Quality levels:
  - QLD, QLC, QLB, QLA
- Standard Guideline for Investigating and Documenting Existing Utilities
  - ASCE/UESI/CI 38-22

New ASCE Standard Guideline

- Standard Guideline for Recording and Exchanging Utility Infrastructure Data (ASCE/UESI/CI 75-22)
  - Utility infrastructure data content and accuracy
  - Data stewardship



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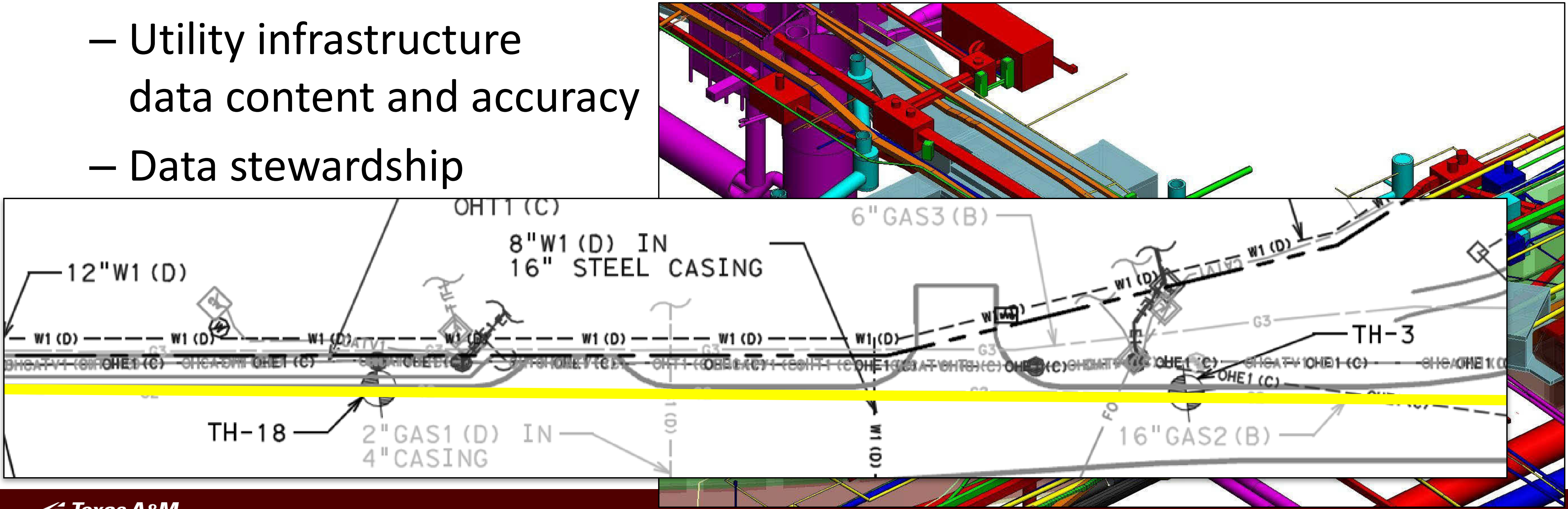

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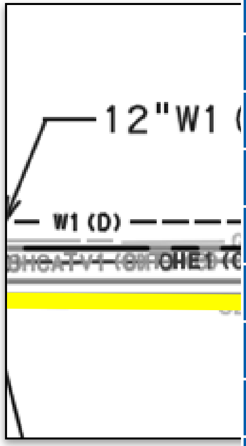
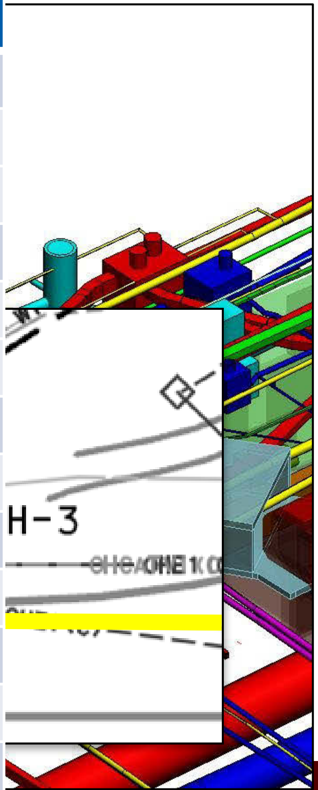
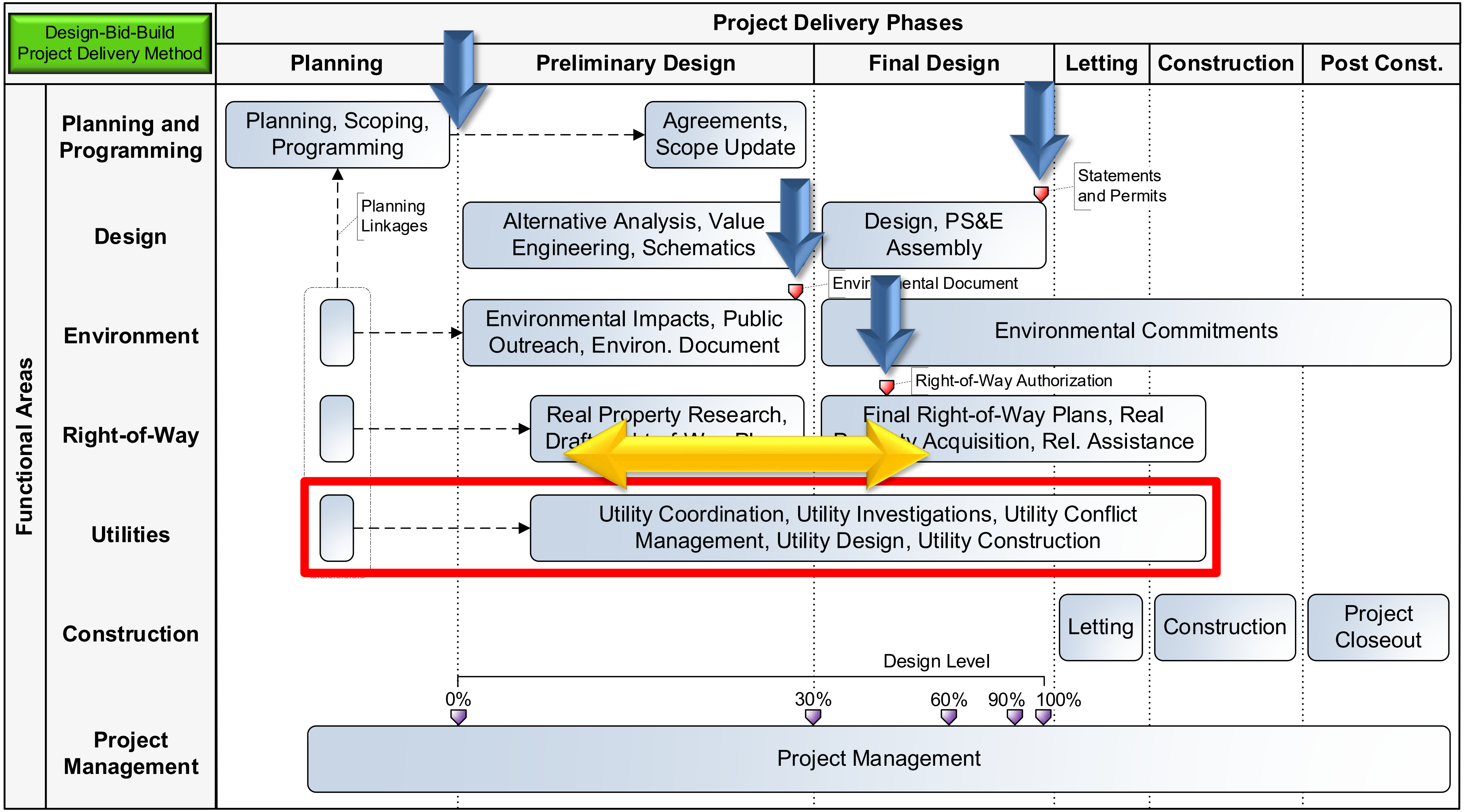


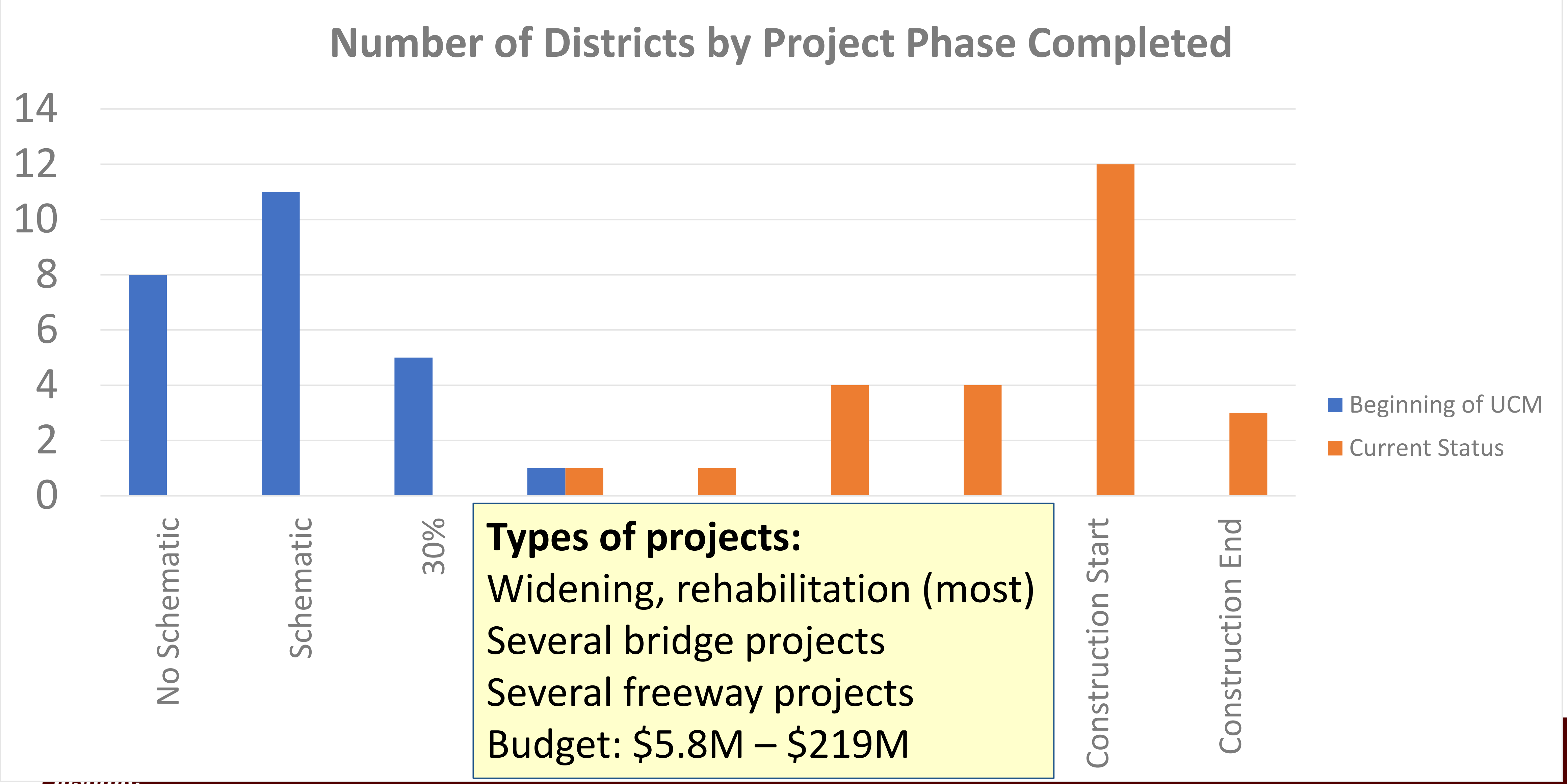
Attribute	Value
ID	23415
Owner	Gas and Electric, Inc.
Utility Type	Petroleum and Gaseous Materials
Utility Subtype	Natural Gas
Conveyance Category	Transmission
Underground Status	Underground
Operational Status	In-Service
Horizontal Spatial Reference	NAD 83, State Plane Central Zone 4203 Epoch 2010
Vertical Spatial Reference	NAVD88
Horizontal Accuracy	0.18
Vertical Accuracy	0.06
Accuracy Units	Feet
Quality Level	QLB
Material	Steel



Utility Investigation Methods



Pilot UCM Implementation at TxDOT



Types of projects:
Widening, rehabilitation (most)
Several bridge projects
Several freeway projects
Budget: $5.8M – $219M

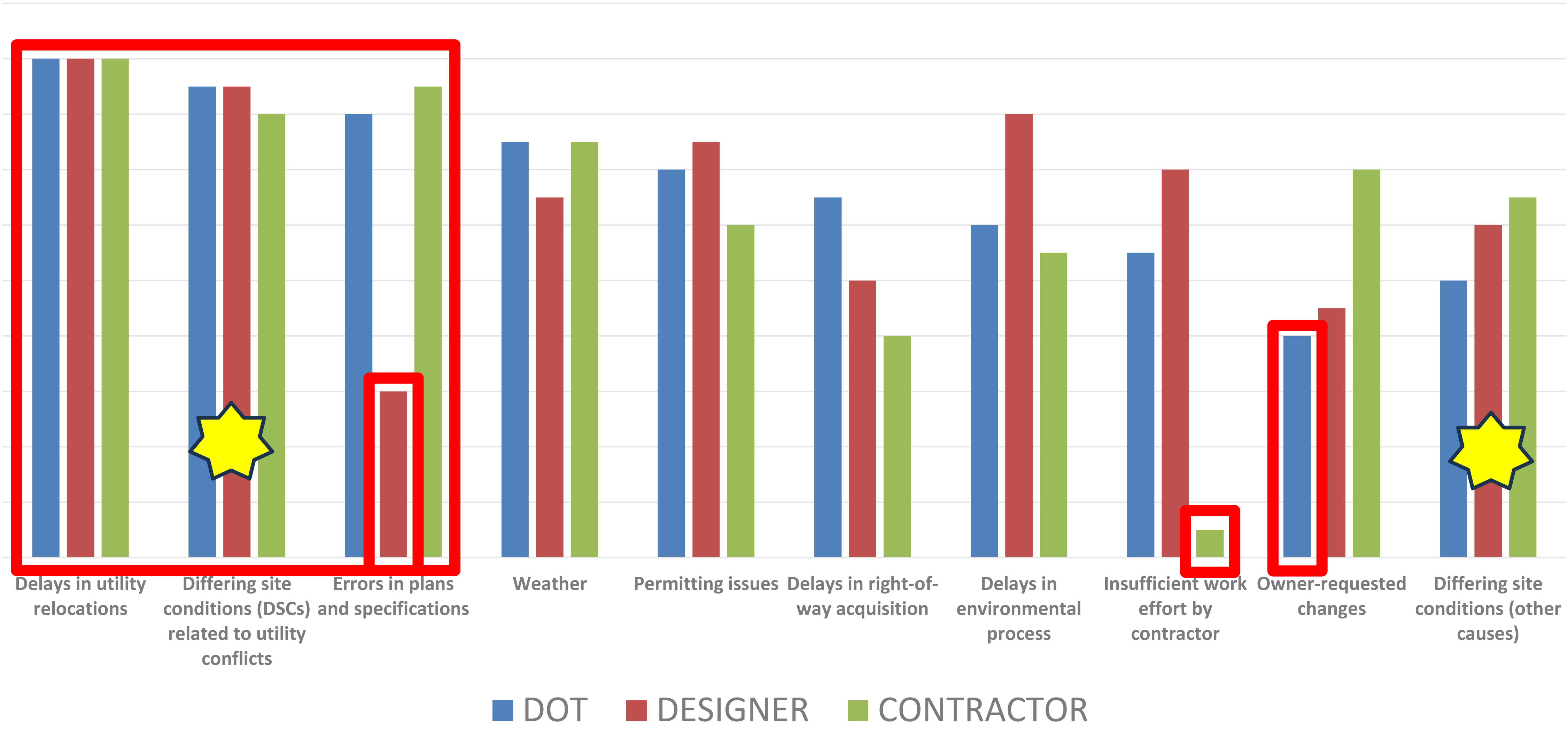
UCM Lessons Learned

- Benefits of an earlier identification of utility conflicts:
  - More effective coordination with utility owners
  - Fewer unnecessary utility relocations
  - Fewer disruptions during construction
  - Fewer utility-related change orders
- Tangible time delivery and economic savings:
  - Phase 2: 38 months and $11M (+$13M elsewhere)
  - Phase 3: 2 years and $24M (partial results)

Best Practices for Utility Conflict Management

- Use utility layout to:
  - Identify and show utility conflict locations
  - Assign unique utility conflict IDs
- Update utility conflict list after updating utility layout
- Track utility conflicts at the utility facility level
- Start early (best during preliminary design)
- Involve stakeholders in review of utility conflicts and solutions
  - Regardless of reimbursement eligibility

2001 Study–Top Causes of Project Delays



UR Change Orders by Disaggregated Reason

Disaggregated Change Order Reason	Average
Errors and omissions in PS&E	33%
Inaccurate or incomplete data about existing or relocated utility facilities	23%
Changes initiated by project owner, contractor, or utility owner	12%
Delays getting utility owners to schedule utility relocations	11%
Differing site conditions	4%
Difficult or inadequate constructability of highway work or utility relocation	4%
Inaccurate or deficient utility relocation work	2%
Delays acquiring or clearing right-of-way or utility relocation sites	2%
Other	9%
Total	**100%**

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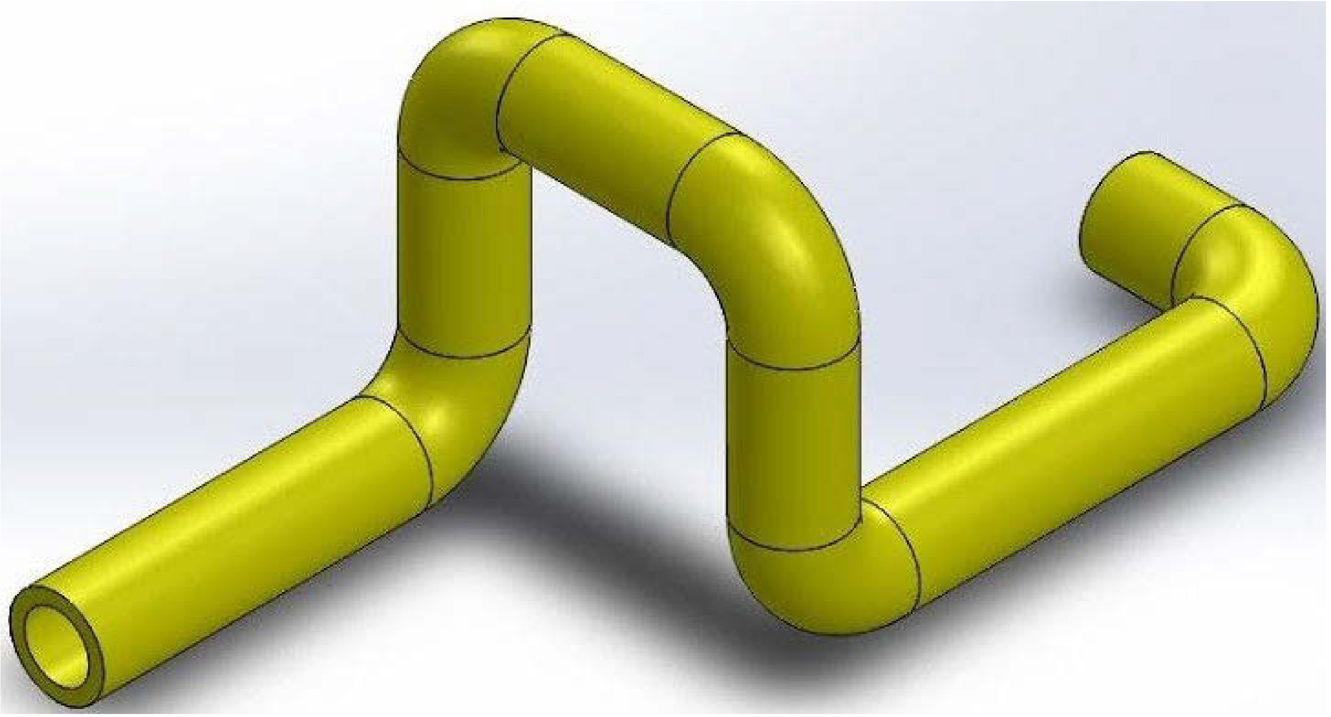
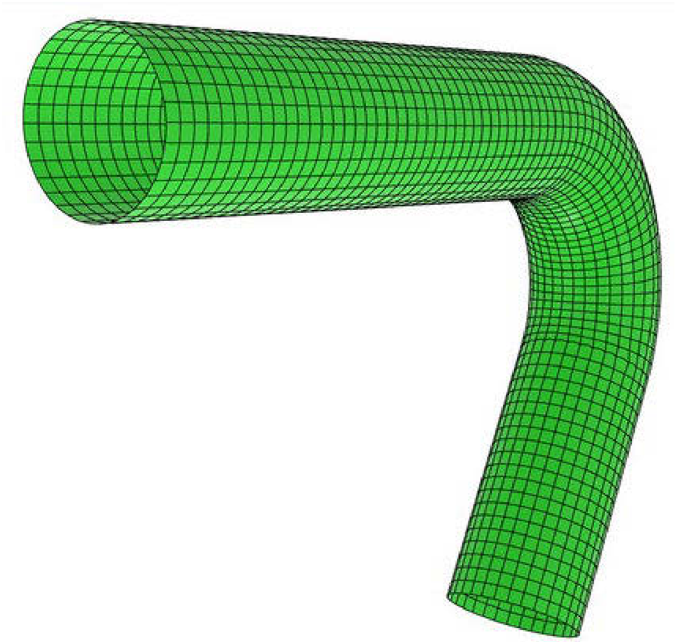
Digital Twins and BIM

- Simple, regular objects (straightforward parametric models):
  - Pipelines: Centerline vertices (X-Y-Z), diameter, thickness
  - Rectangular boxes: Corners (X-Y-Z), thickness
  - Compact data requirements
- Complex, irregular objects (non-parametric models):
  - 3D meshes: Vertices (X-Y-Z), edges, and faces
  - More demanding data requirements
  - Best for specific objects within the utility network
- Use ASCE/UESI/CI 75-22 to anchor and add attributes to objects

Digital Twins and BIM





Digital Twins and BIM

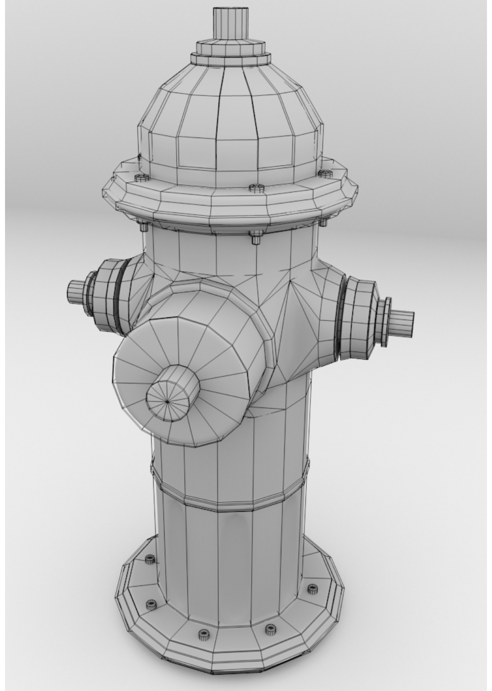
DSM

Picture

DSM

Digital Twin

Digital Twin



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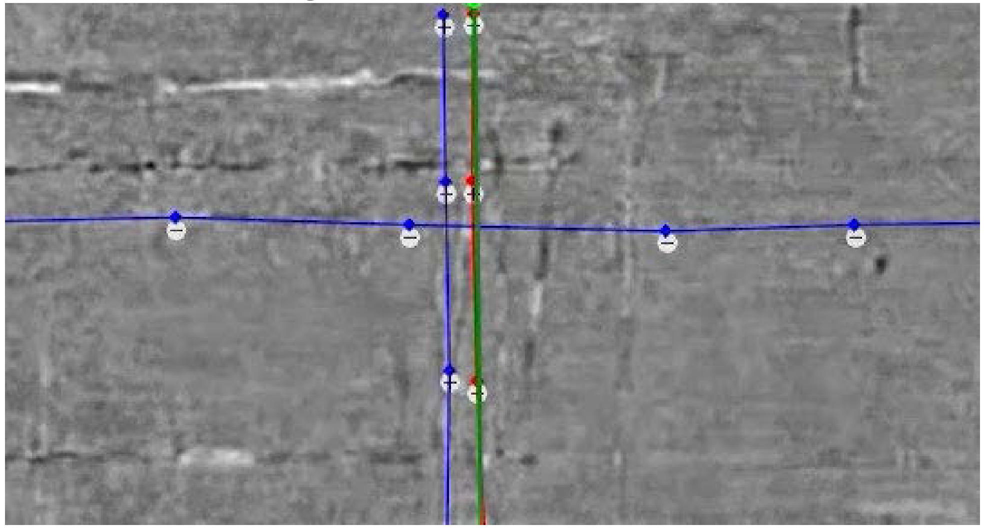
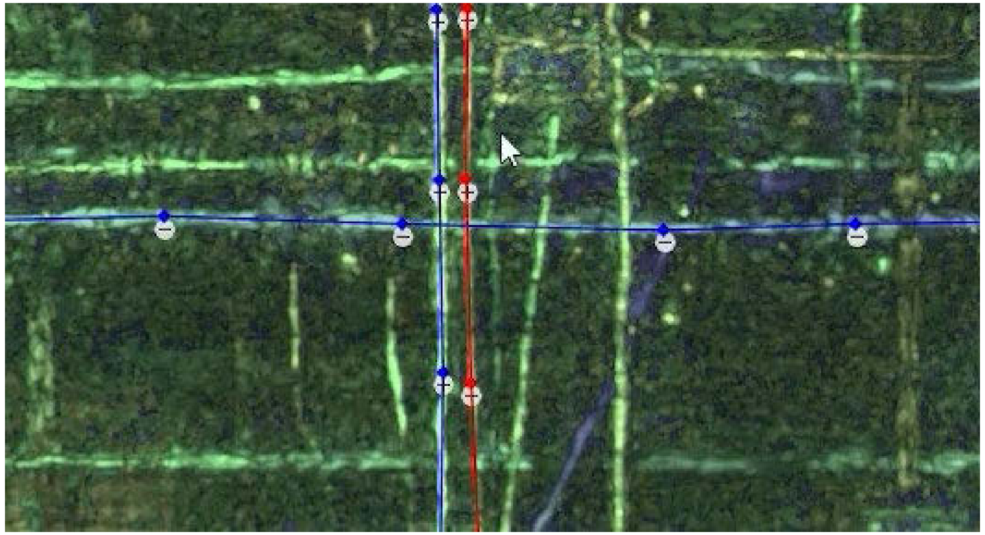
GPR and TDEMI Arrays

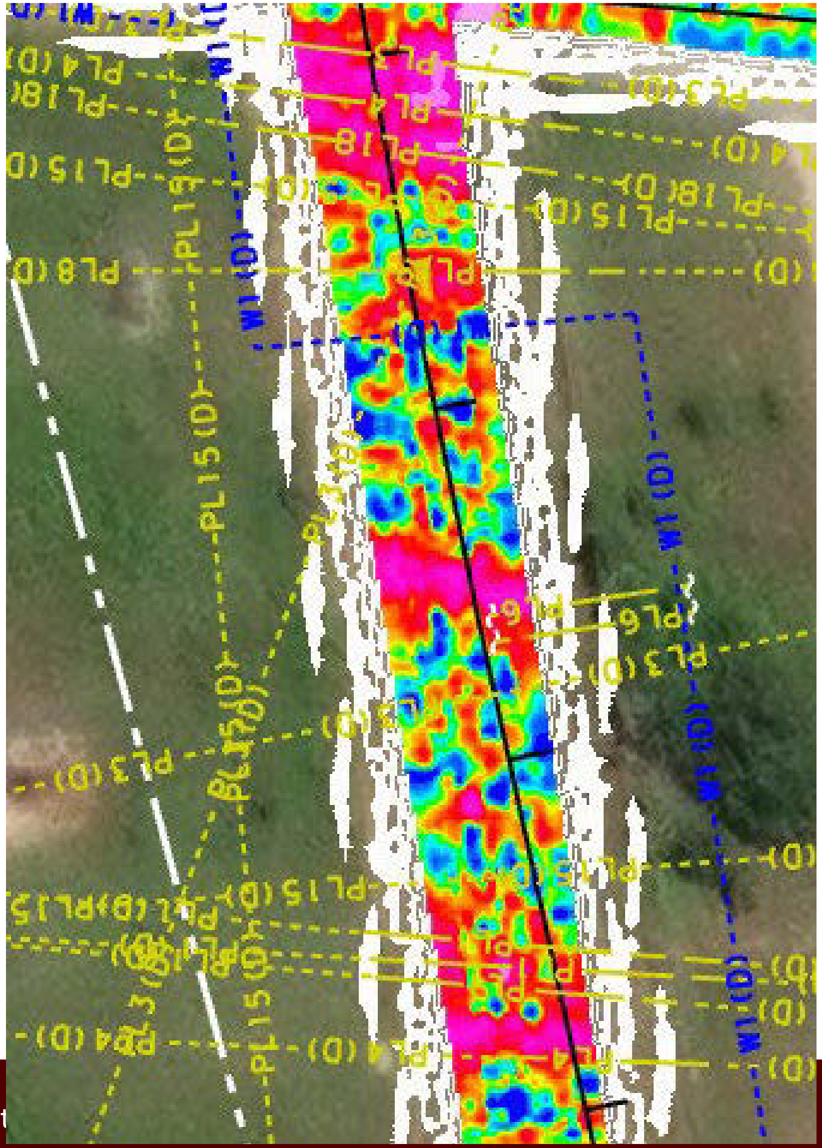
3D GPR





GPR and TDEMI Arrays

TDEMI

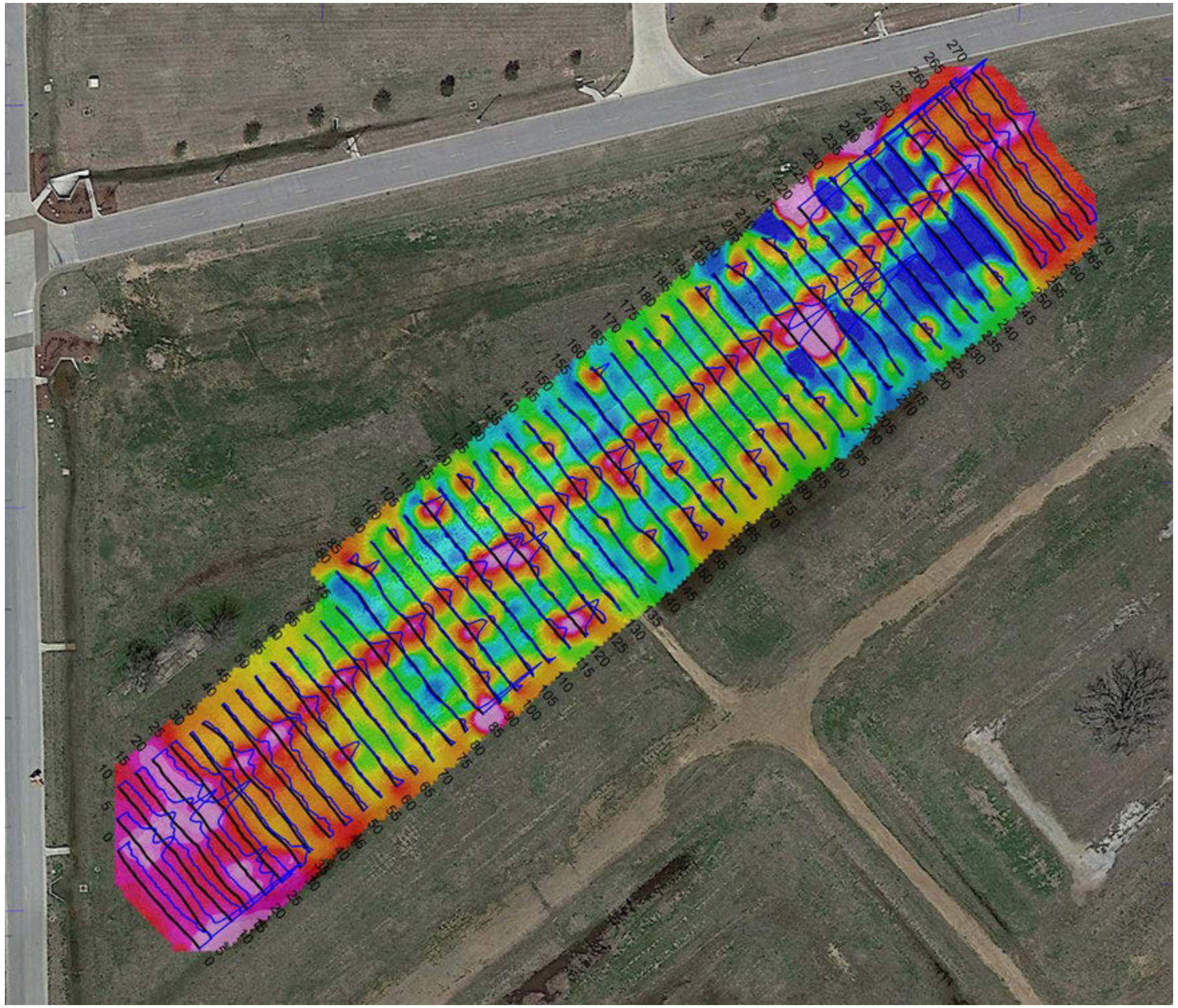



PL 13

UAS-Based Metal Detector

UAS-Based Metal Detection

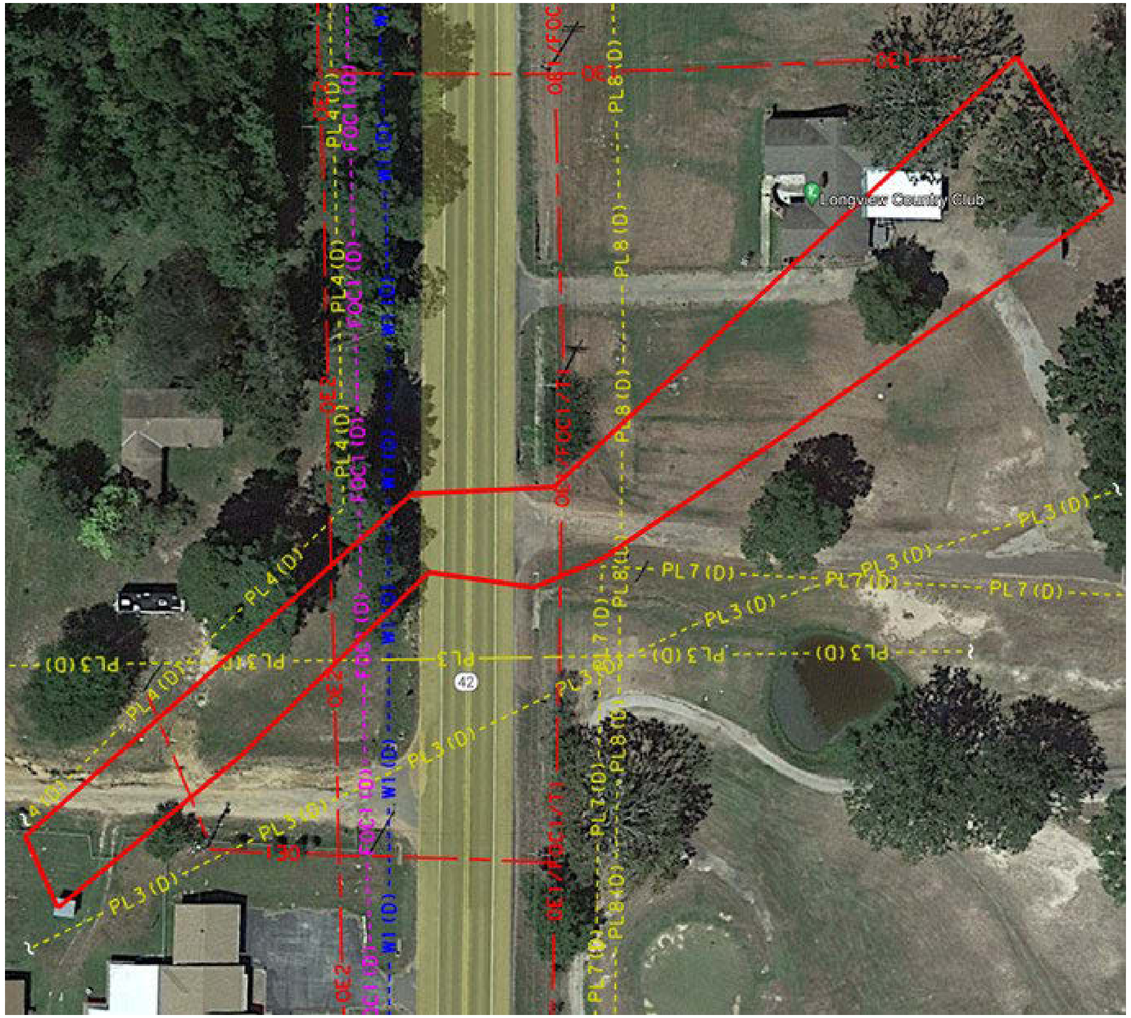
UAS-Based Metal Detection

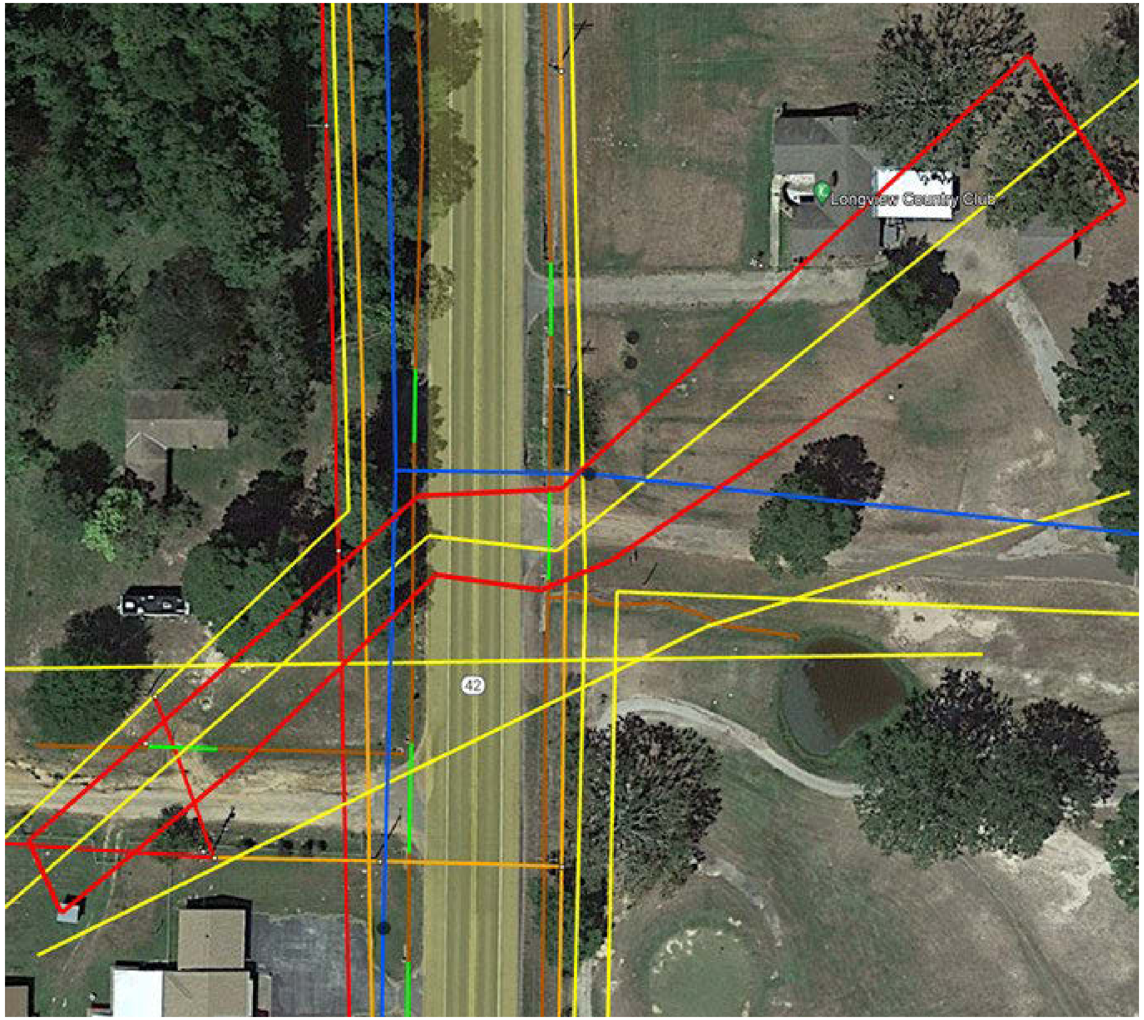


Utility Data Aggregators

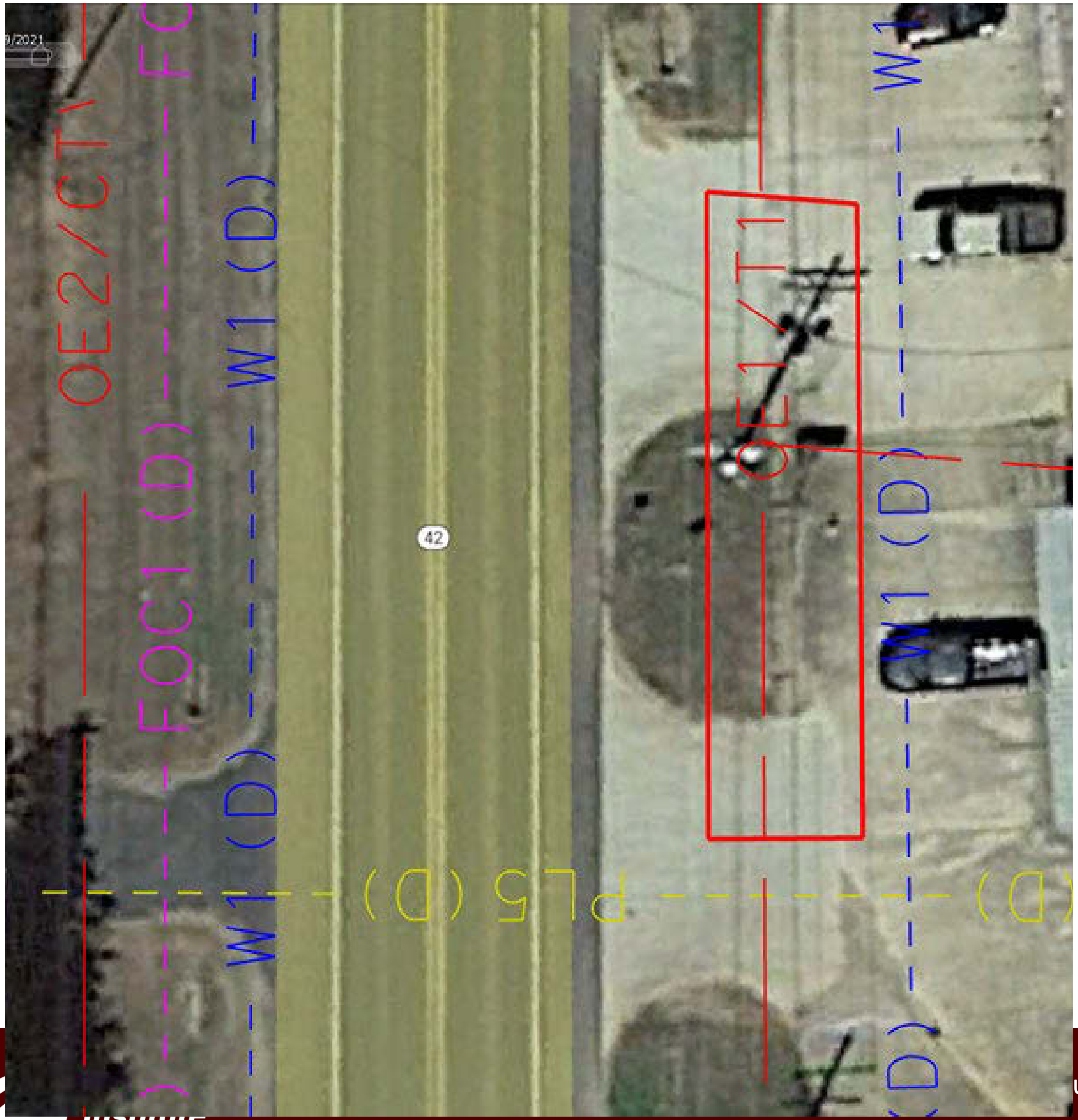
- Available historical imagery and data mining of online records
- Utility map without going to the field
- Many data sources with differing levels of completeness/quality
  - No metadata associated with data sources
- Use during preliminary design phase before or as part of QLD
- Does not replace QLC, QLB, or QLA data

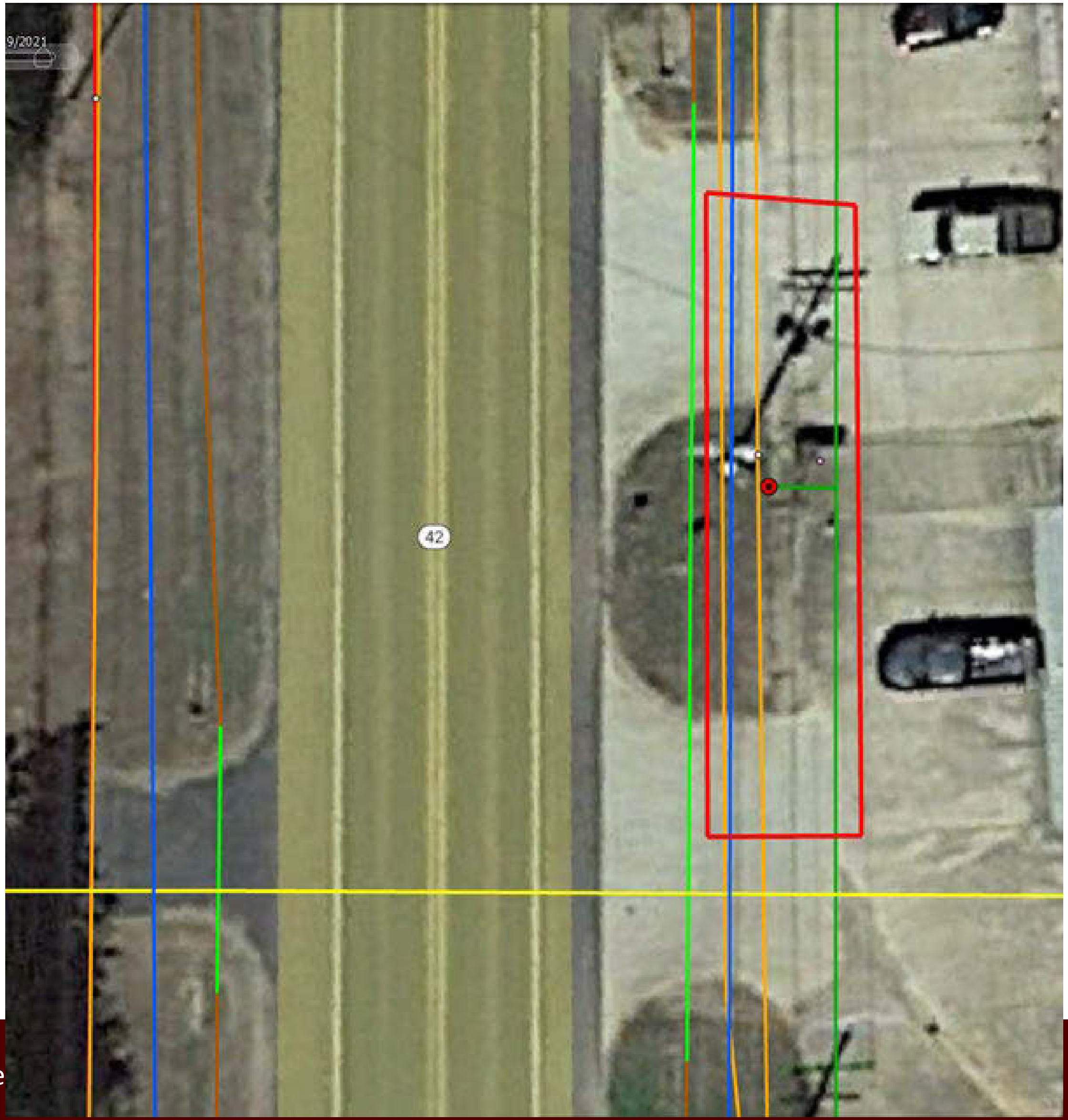
Additional Pipeline Crossing





Shifted Water and Sewer Locations

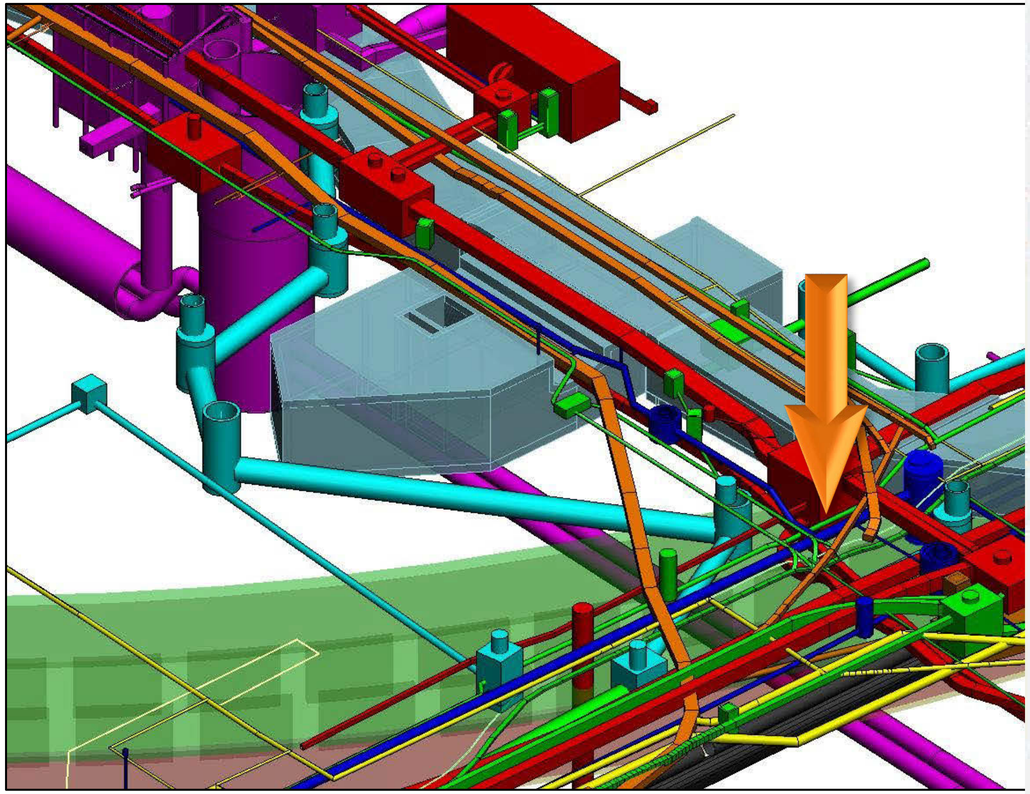


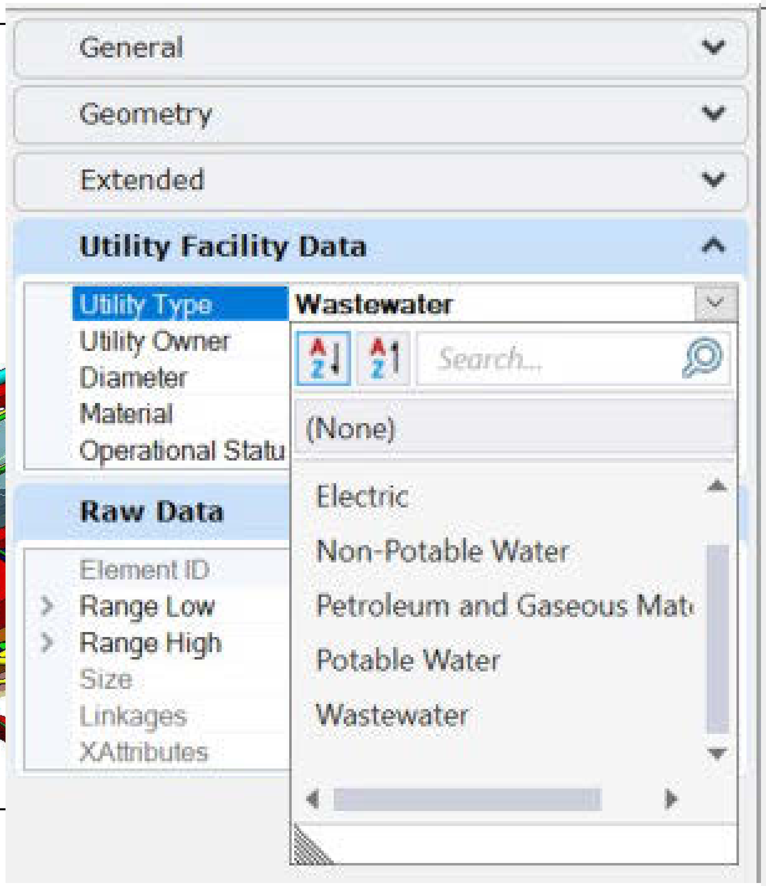


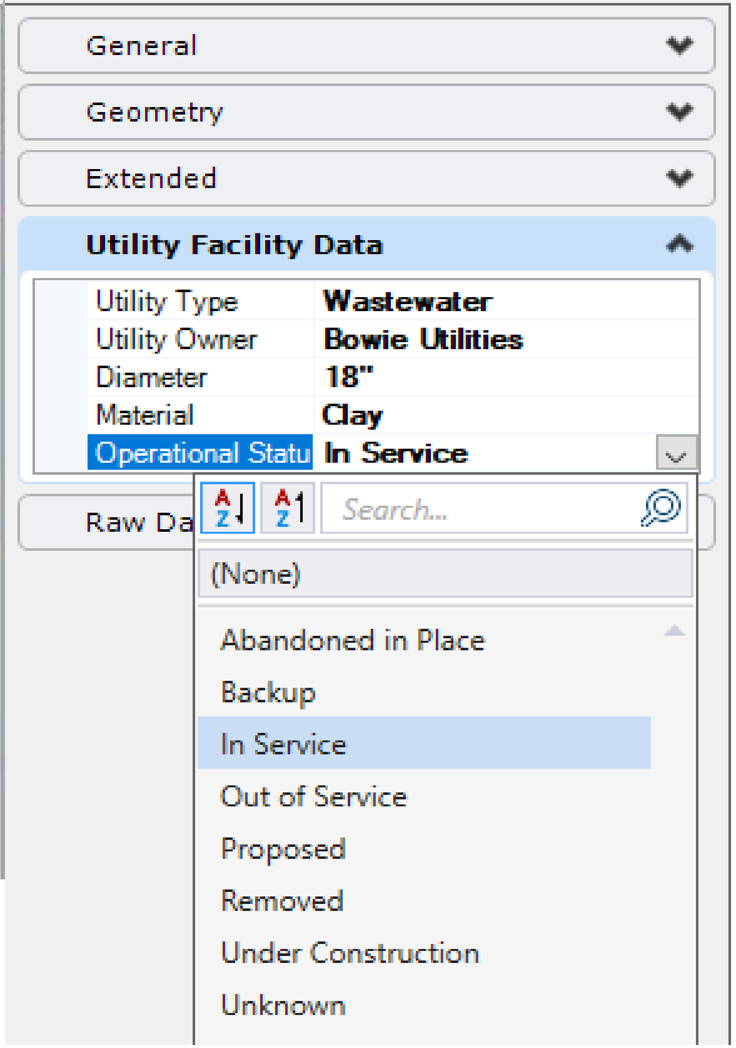
Emerging Trends for Utility Investigations

- MicroStation/OpenRoads Designer:
  - 3D deliverables that are digital twins of utility features
    - Optimized use of parametric and nonparametric objects
  - Use item types and properties to document utility features
  - Use annotations/call outs based on property values
  - Do not type in annotations/callouts to document utility features

Emerging Trends for Utility Investigations







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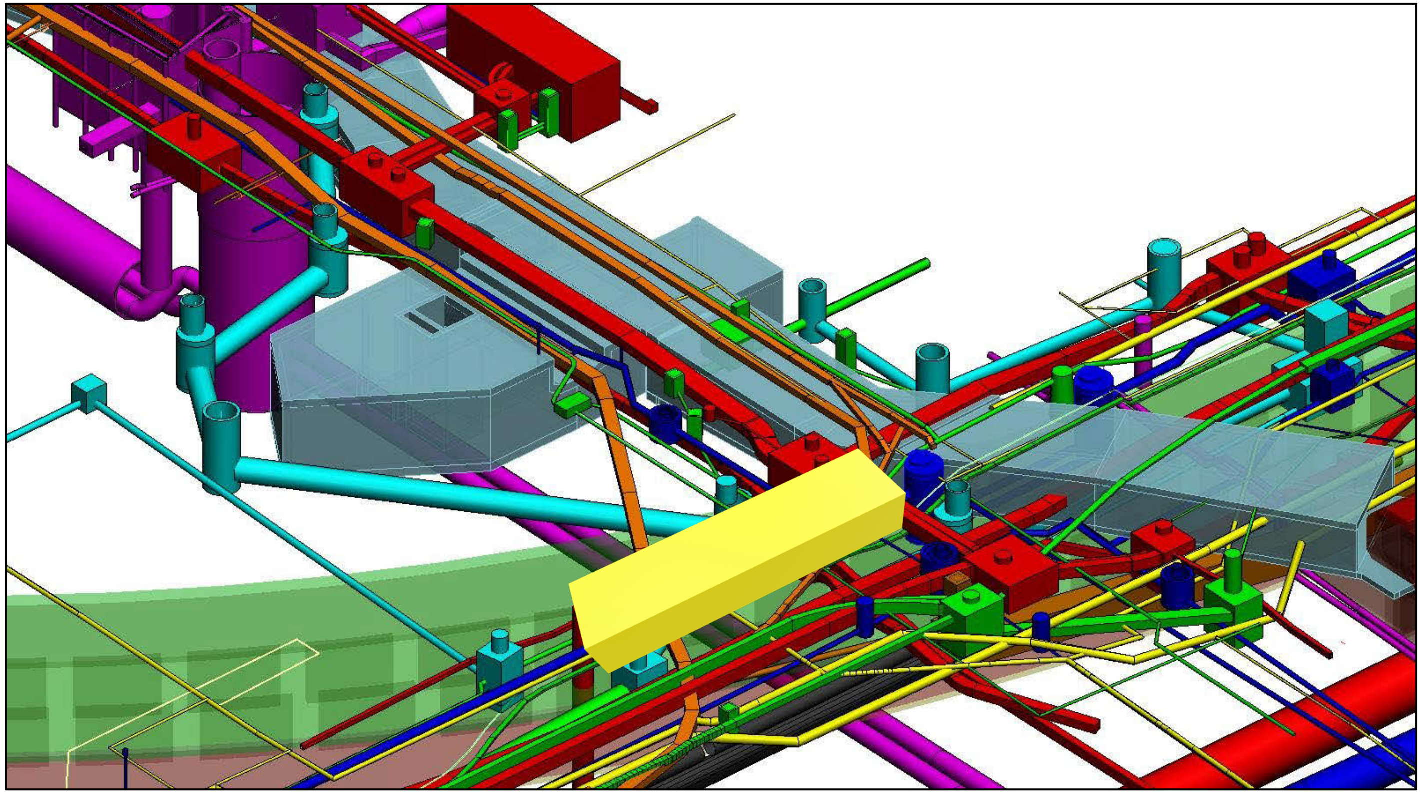
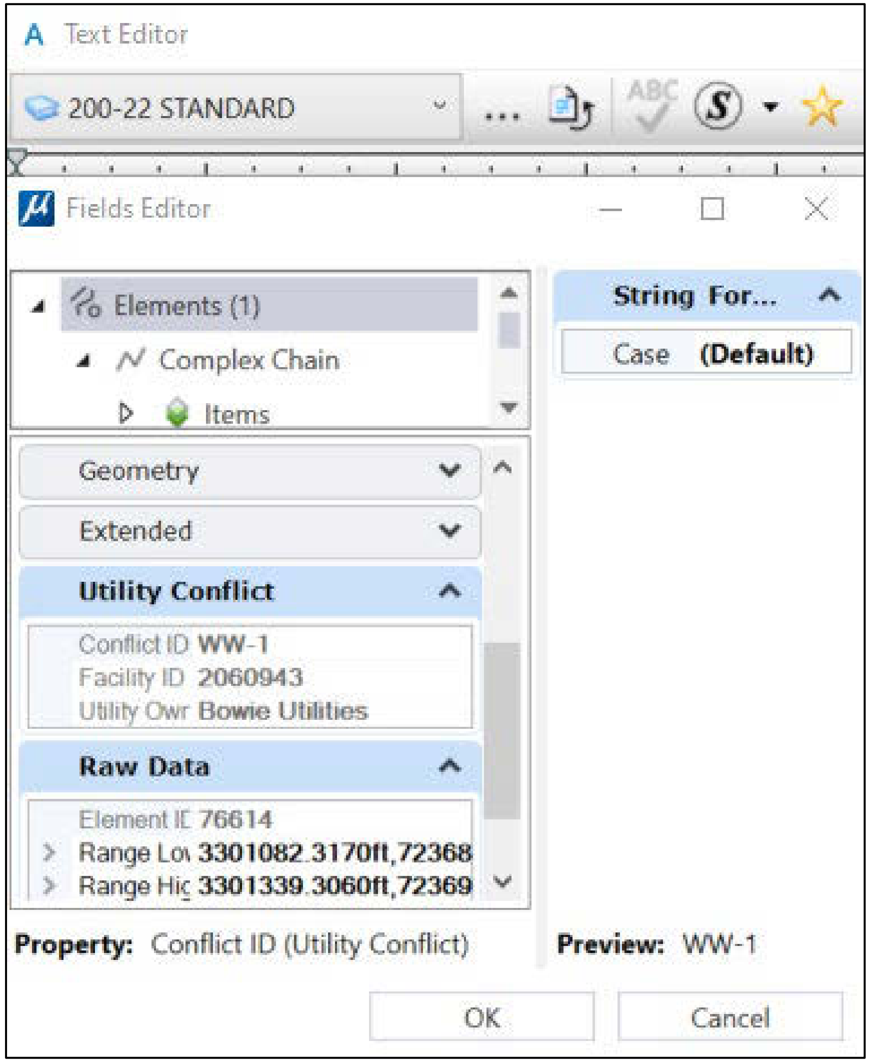
Emerging Trends for Utility Conflict Management

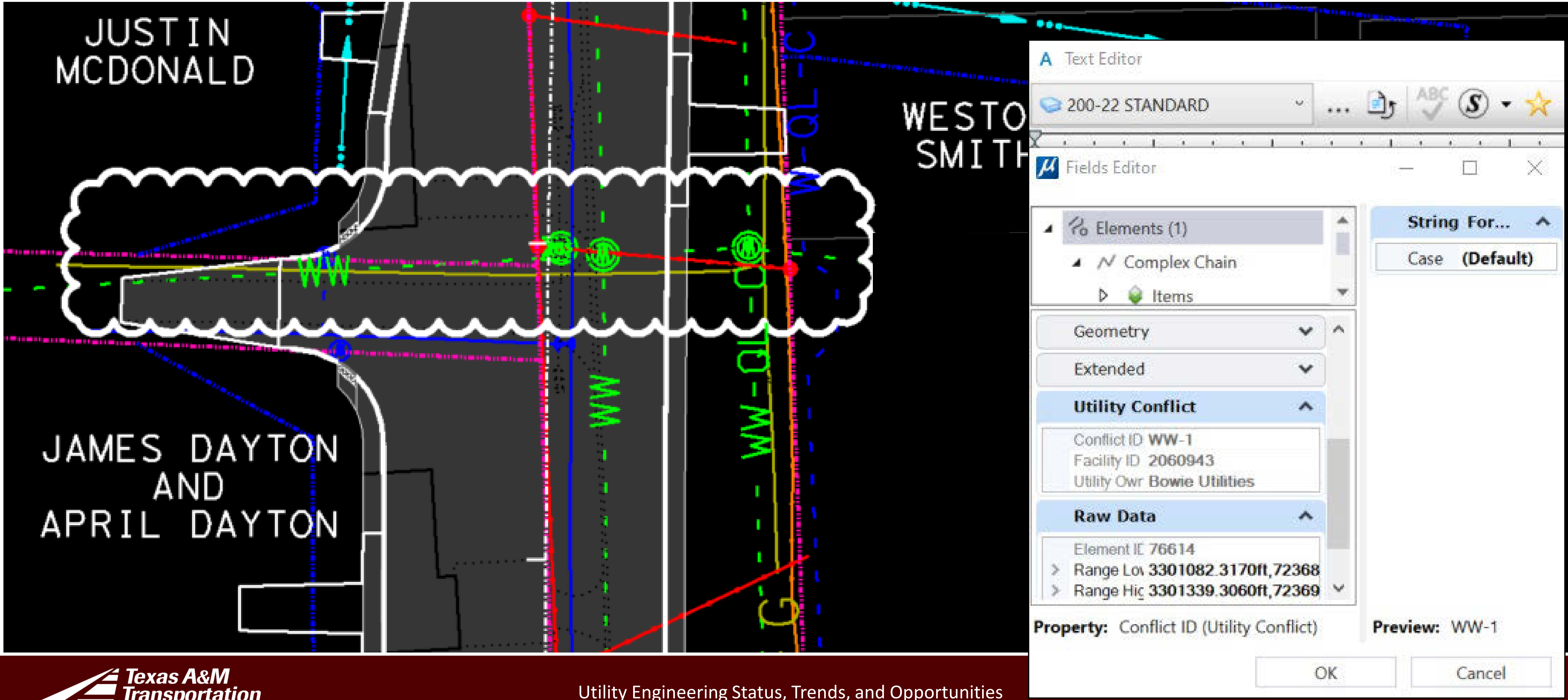
- Use utility layout in MicroStation/OpenRoads Designer to:
  - Identify utility conflicts
  - Show utility conflict locations
  - Assign unique utility conflict IDs
- Integrate utility layout with utility conflict list/matrix to:
  - Prepare/maintain list of utility conflicts
  - Document utility conflict resolution alternatives

Emerging Trends for Utility Conflict Management





Emerging Trends for Utility Conflict Management



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Emerging Trends for Construction and Utility Inspections

- Focus on low-cost, high-accuracy technologies

Devices
Samsung Galaxy S22
Samsung Tab Active3
Apple iPhone 14 Pro Max
Apple iPad Pro 11
Bad Elf Flex
Leica Zeno FLX100 Plus
Trimble DA2
viDoc RTK Rover
Skydio X2E (Color): • Quadcopter • NDAA compliant
REDUCT ABM-30 and ABM-40/DR-2 Probes

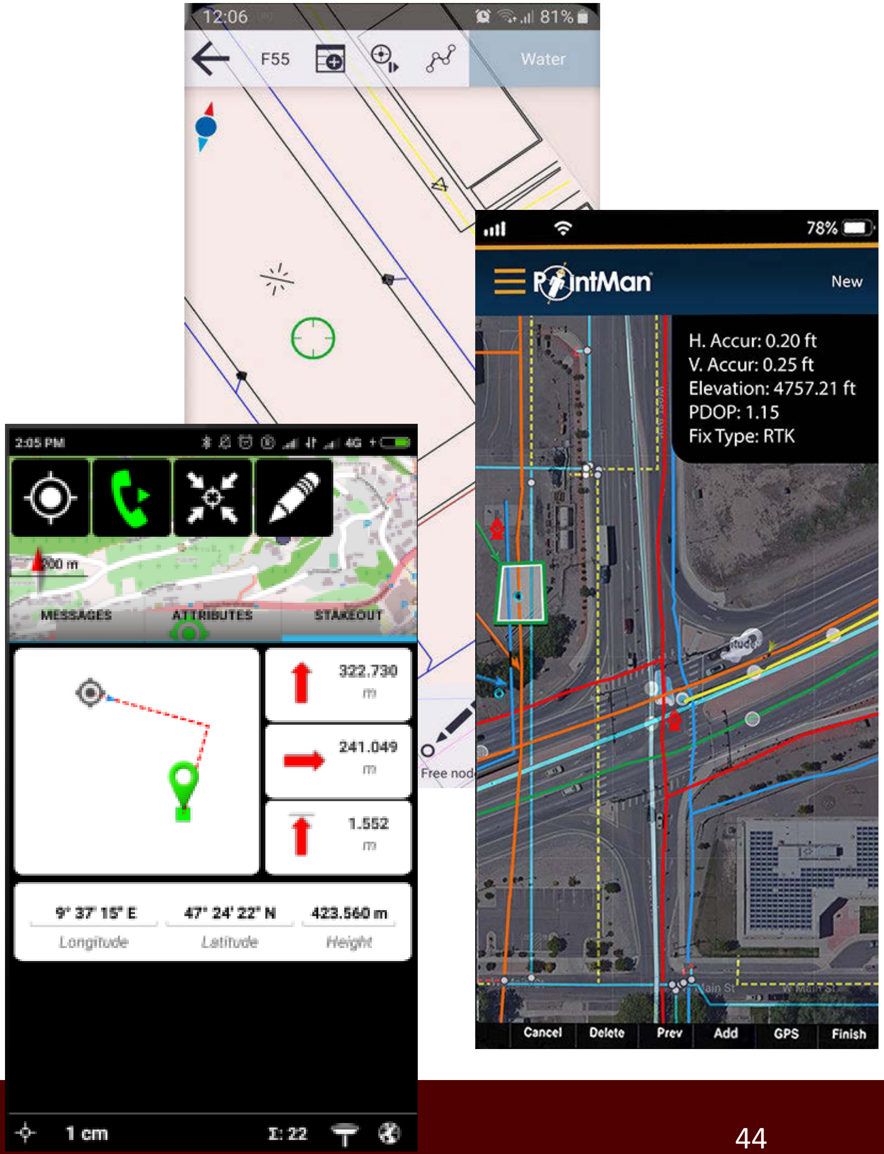
Software
Trimble Penmap
Leica Zeno Mobile
ArcGIS Field Maps
ProStar PointMan
PIX4D PIX4Dcatch
PIX4D PIX4Dmapper
PIX4D PIX4Dmatic
Bentley iTwin Capture Modeler

Benchmark Tests—Lessons Learned

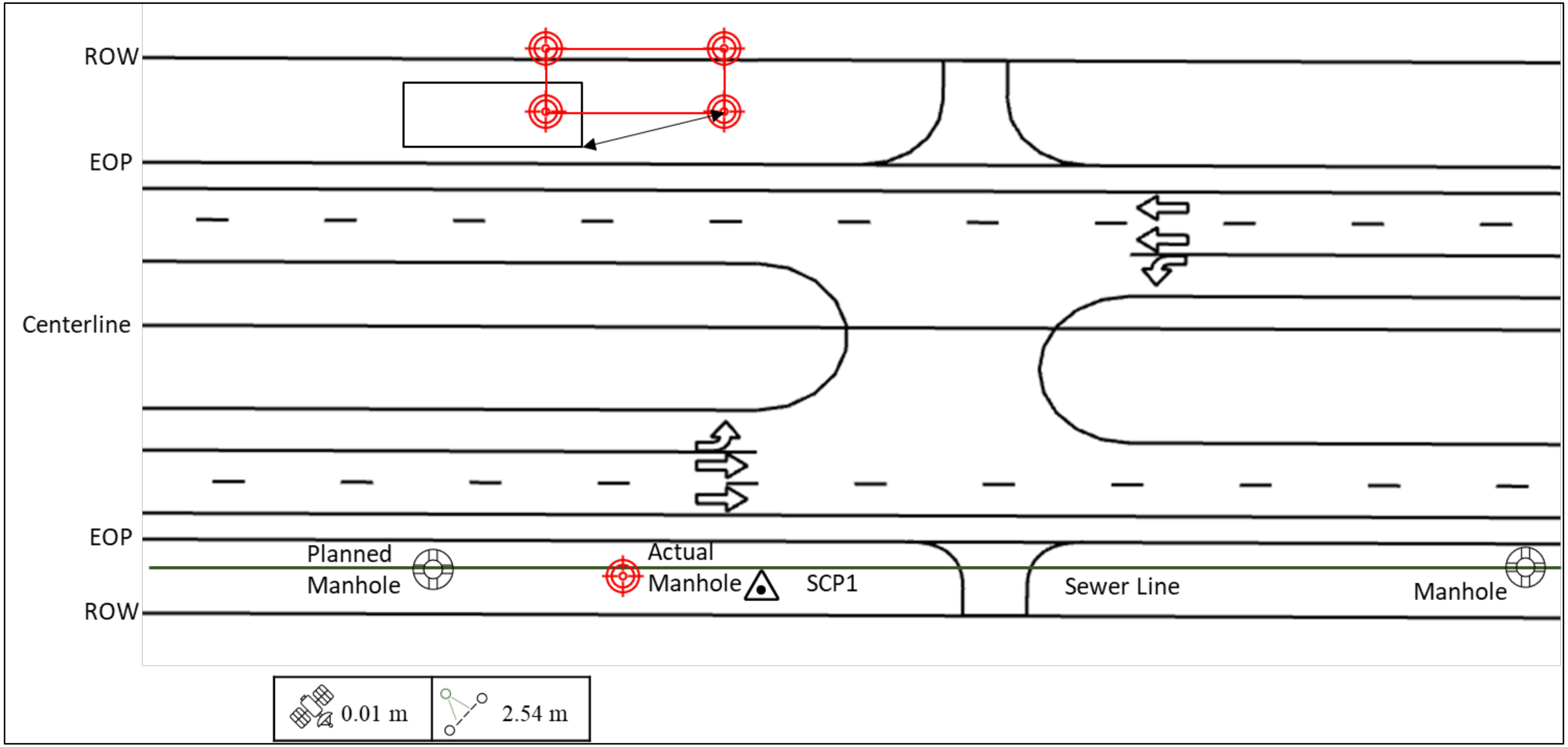
- Low-cost GNSS antennas – Autonomous mode:
  - 1–2 m horizontal, 0.2–9 m vertical
- Low-cost GNSS antennas – RTK:
  - 1–4 cm horizontal, 1–10 cm vertical
- TxDOT RTN better positional accuracy than commercial RTK
- Unlocking fee for low-cost GNSS antenna to achieve RTK accuracy
- Smartphones or tablets equipped with data collection apps

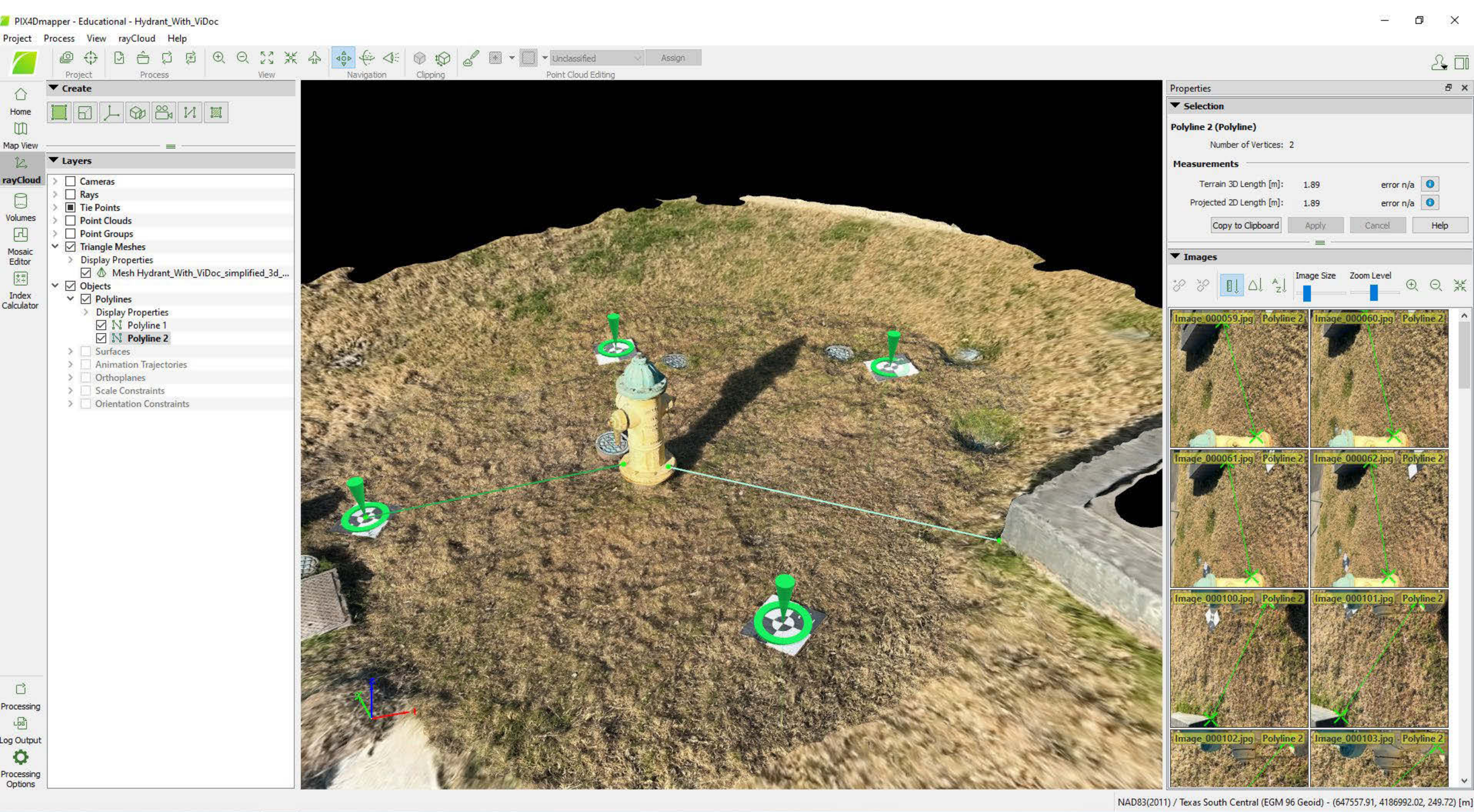
Emerging Trends for Construction and Utility Inspections

- Generalized use cases/requirements:
  - Project survey control point verification
  - Locations within the required tolerance
  - Locations outside of the required tolerance
  - 3D Objects—With ground control points
  - 3D Objects—With RTK
  - 3D Objects—Without ground control



Emerging Trends for Construction and Utility Inspections





PIX4Dmapper - Educational - Hydrant_With_ViDoc
Project
Process
View
rayCloud
Help
Project
Process
View
Navigation
Clipping
Unclassified
Assign
Point Cloud Editing
Home
Map View
rayCloud
Volumes
Mosaic Editor
Index Calculator
Processing
Log Output
Processing Options
Create
Layers
Cameras
Rays
Tie Points
Point Clouds
Point Groups
Triangle Meshes
Display Properties
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Polylines
Display Properties
Polyline 1
Polyline 2
Surfaces
Animation Trajectories
Orthoplanes
Scale Constraints
Orientation Constraints
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Measurements
Terrain 3D Length [m]: 1.89 error n/a
Projected 2D Length [m]: 1.89 error n/a
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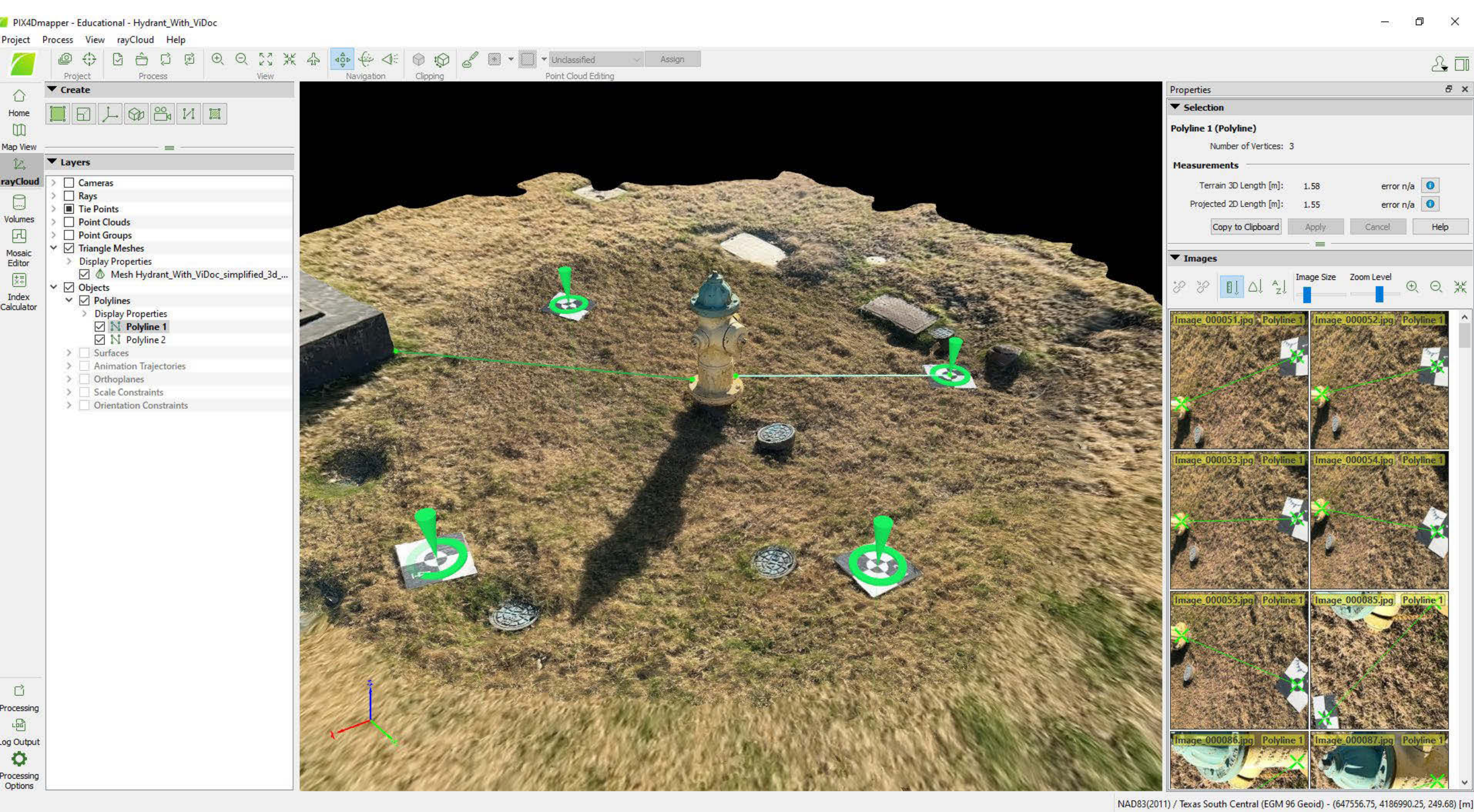
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Project Process View rayCloud Help
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Animation Trajectories
Orthoplanes
Scale Constraints
Orientation Constraints
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Map View
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Volumes
Mosaic Editor
Index Calculator
Processing
Log Output
Processing Options
Properties
Selection
Polyline 1 (Polyline)
Number of Vertices: 3
Measurements
Terrain 3D Length [m]: 1.58 error n/a
Projected 2D Length [m]: 1.55 error n/a
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Artificial Intelligence (AI)

- *"Ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings ... Processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience."*
- *"Theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."*
- *"Field in computer science that refers to computers or machines being able to simulate human intelligence to perform tasks or solve problems."*

Artificial Intelligence (AI)

- Best used or huge potential for:
  - Detecting trends from large amounts of data
  - Predicting responses based on data/trend correlations
  - Automating dangerous or repetitive tasks
- Not recommended for:
  - Situations that require creativity or unique engineering solutions
  - Situations for which emotional intelligence is critical
  - Documenting business processes only using AI algorithms

Utility-Related (UR) Change Orders

- Use of AI algorithms to classify change orders between utility related (UR) and non-utility related (NUR)
- 102,300 records with change order codes and descriptions
  - 4,000 UR records
  - Significant number of false positives and false negatives
  - Nine (9) AI algorithms trained, tested, and validated
  - Result: 3,000 additional UR records
  - Most promising AI algorithms: 88–92% UR accuracy

AI-Based Processing of Geophysical Data

- Goal: Generate X-Y-Z feature data
- Raw data: X-Y-Z plus measured intensity of magnetic response
- 150,000 scenario/location combinations:
  - Pipeline, block, combinations (features, horizontal, inclined)
  - Multiple X-Y-Z locations per scenario within a defined space
- Unique 3D response from each scenario/location combo
- AI algorithm learns from responses
- After AI training/testing, use real-world magnetic data
- Next: Use TDEMI data

Thank You!!!

For additional information:

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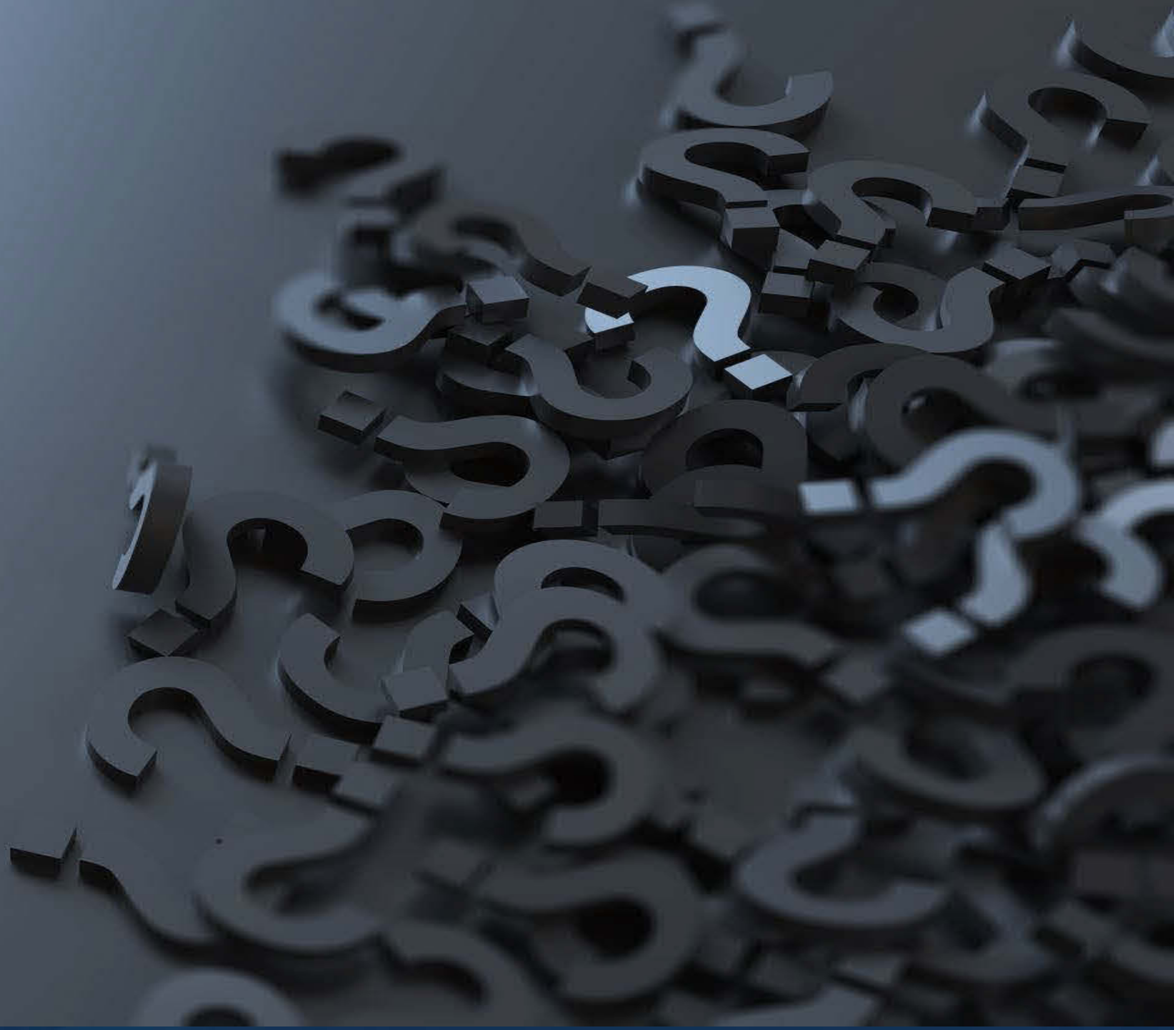
Questions



Thank You!