Putting UAS to the Test for Substation Construction, Monitoring, and Operations

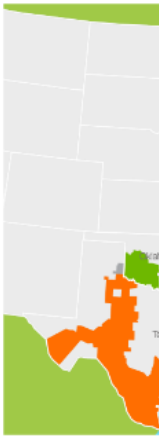
Xuan Wu, PE
Engineer Sr
American Electric Power
xwu@aep.com
614.933.2665

Joe Moore
Designer Prin
American Electric Power
jlmoore@aep.com
614.933.2195

Daniel Michalec, GISP, PMP
Geospatial Program Director | Energy
Woolpert
daniel.michalec@woolpert.com
614.596.7663

Overview

- Introductions
- AEP Station Standards pilot project; Why UAS?
- Brief UAS overview
- Logistics
  - Pre-acquisition
  - Acquisition
  - Post-processing
- Limitations of traditional 2D datasets
- Unlocking 3D
  - Change detection, construction monitoring
  - Next steps
- Lessons learned
- Data demonstration
- Q&A



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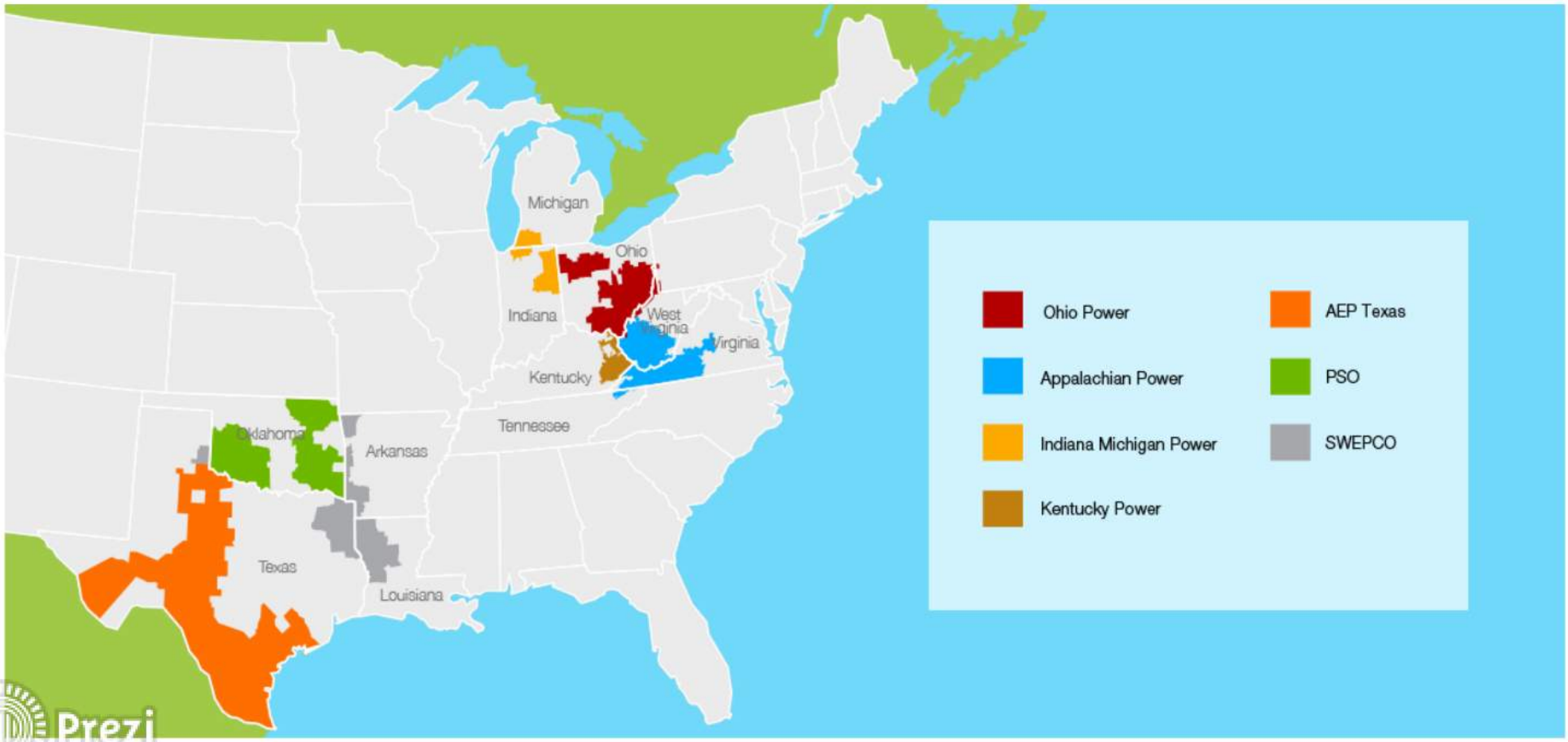
AMERICAN ELECTRIC POWER℠

BOUNDLESS ENERGY℠

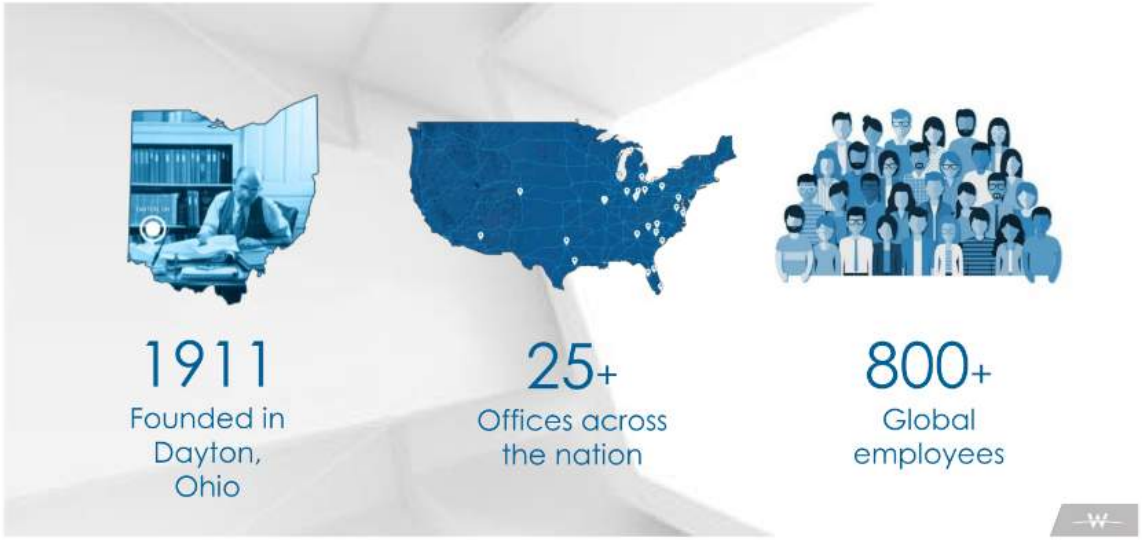
- 5.4M Customers in 11 states
- 40K+ mi electricity transmission network - largest in the nation
- 26K megawatts of generating capacity



WOOLPERT

ARCHITECTURE | ENGINEERING | GEOSPATIAL

- **First company in the US to receive FAA exemption for UAS mapping**
- **Survey history**
- **Extensive experience with manned aerial platforms and sensors**

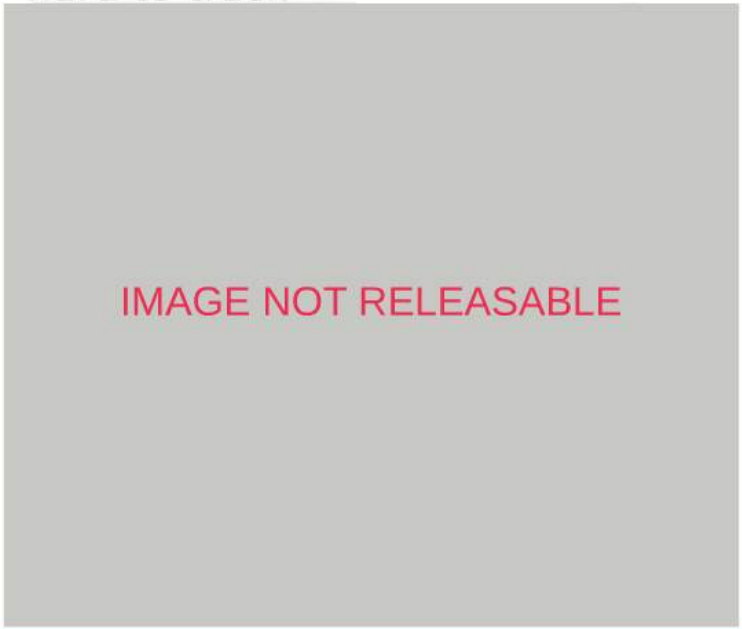


AEP Station Standards: UAS Case Study

- Station Standards
- Substation construction projects:
  - Span months
  - Complex
  - Expensive
- Traditional monitoring:
  - Reporting
  - Site visits
- Traditional concerns:
  - Alignment
  - Timing
  - Position
- Can UAS help?

Constraints

- Construction is very paper intensive task
- Schedules, reports, planning, and progress are all very subjective
- Delay, liability, and overscheduling are often problems
- Project milestones and cash flows are hard to track



Mitigations

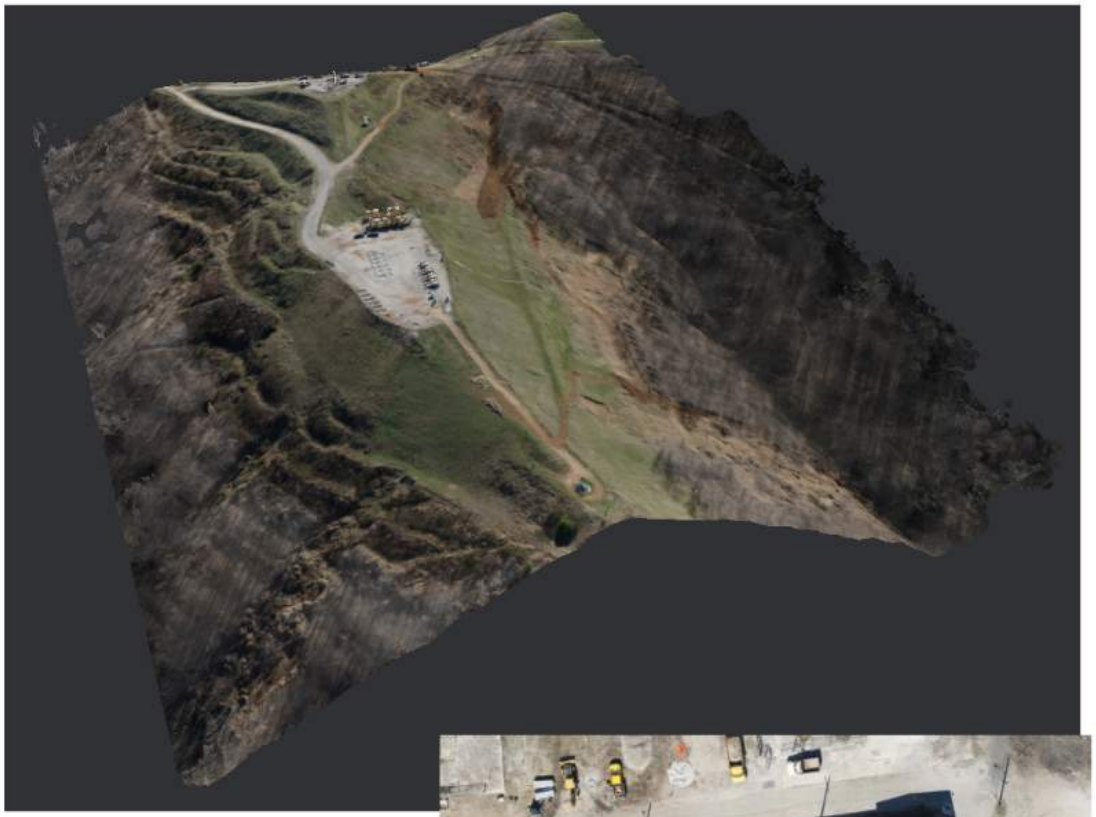
- Construction progress visualization (Short Term)
- Validating accuracy of equipment placement to design and reporting variances automatically (Long Term)
- Tracking major construction milestones automatically for updated cash flow (Short Term)
- As-build model (Long Term)

Benefits

- Improve transparency
- Improve efficiency
- Improve scheduling
- Reduce delays, liability, and overscheduling
- Improve updating cash flow

UAS Overview

- Pre-planning / Control
- Acquisition
- Post-processing
- Dataset creation
  - Images
  - Orthoimage
  - Autocorrelated 3D point cloud
  - Surface
  - Image/textured mesh
- "Typical" area of interest
- "Typical" site infrastructure
- But.....



...Electric Substation is NOT your "typical" environment

Energized environment

PPE

Complex infrastructure

Close quarters

Small site

6,000+ Stations
100's of Concurrent Projects

Active construction

Limits of orthoimagery

Control / PIDs

Liability / Insurance

Step back a bit...

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Step back a bit...

Pre-planning

- ***Insurance concerns***
  - *Draft WO submittal*
  - *Liability $$ limit*
  - *Success!!!*
- ***Landowner notification***
  - *Door hangers*
  - *Specific language*
- ***Deconfliction policy***
- ***Risk / Safety Mitigation*****
  - *FAA*
  - *Staff credentials*
  - *Situational awareness*
  - *JSA/JHA*
  - *Device limitations*
  - *Weather concerns*

Acquisition

- ***Survey control***
  - *a **MUST***
- ***Electrical interference***
- ***Onsite staff notification***
- ***Approach***
  - *Altitude*
  - *Pre-programmed vs. manual*
- ***Battery life***
- ***Flight time***
- ***Heat***


Data Creation / Monitoring

- Datasets
  - Frames
  - Orthoimage
  - 3D Colorized Point Clouds
  - Image/textured mesh
- Orthoimagery for complex infrastructure
- Obscured control
- Accuracies:
  - x/y is simple
  - z is more complicated
- NOISE - confidence in change detection and monitoring

... need good data to make good decisions



Pre-planning

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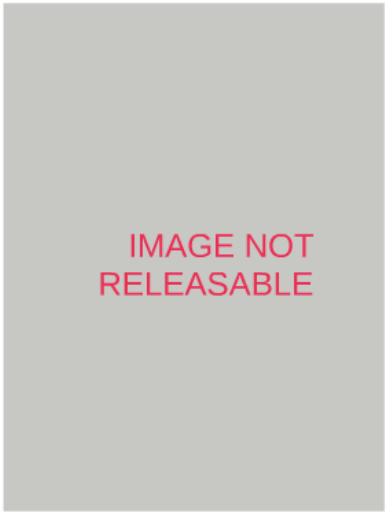

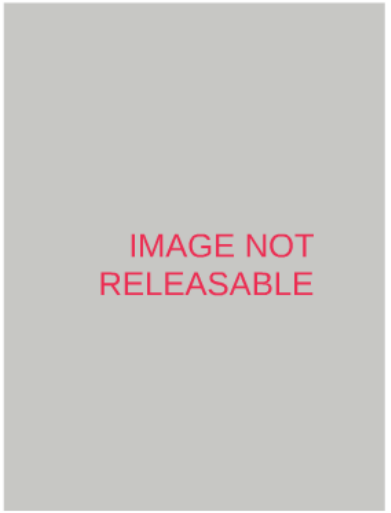

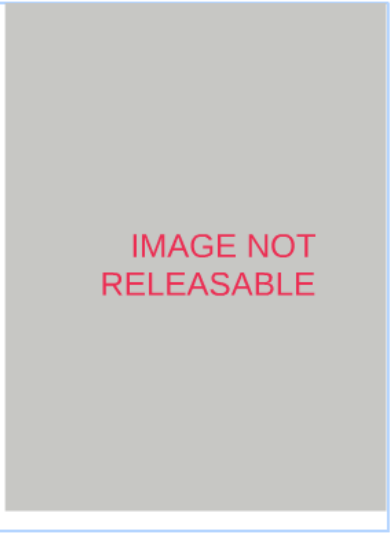

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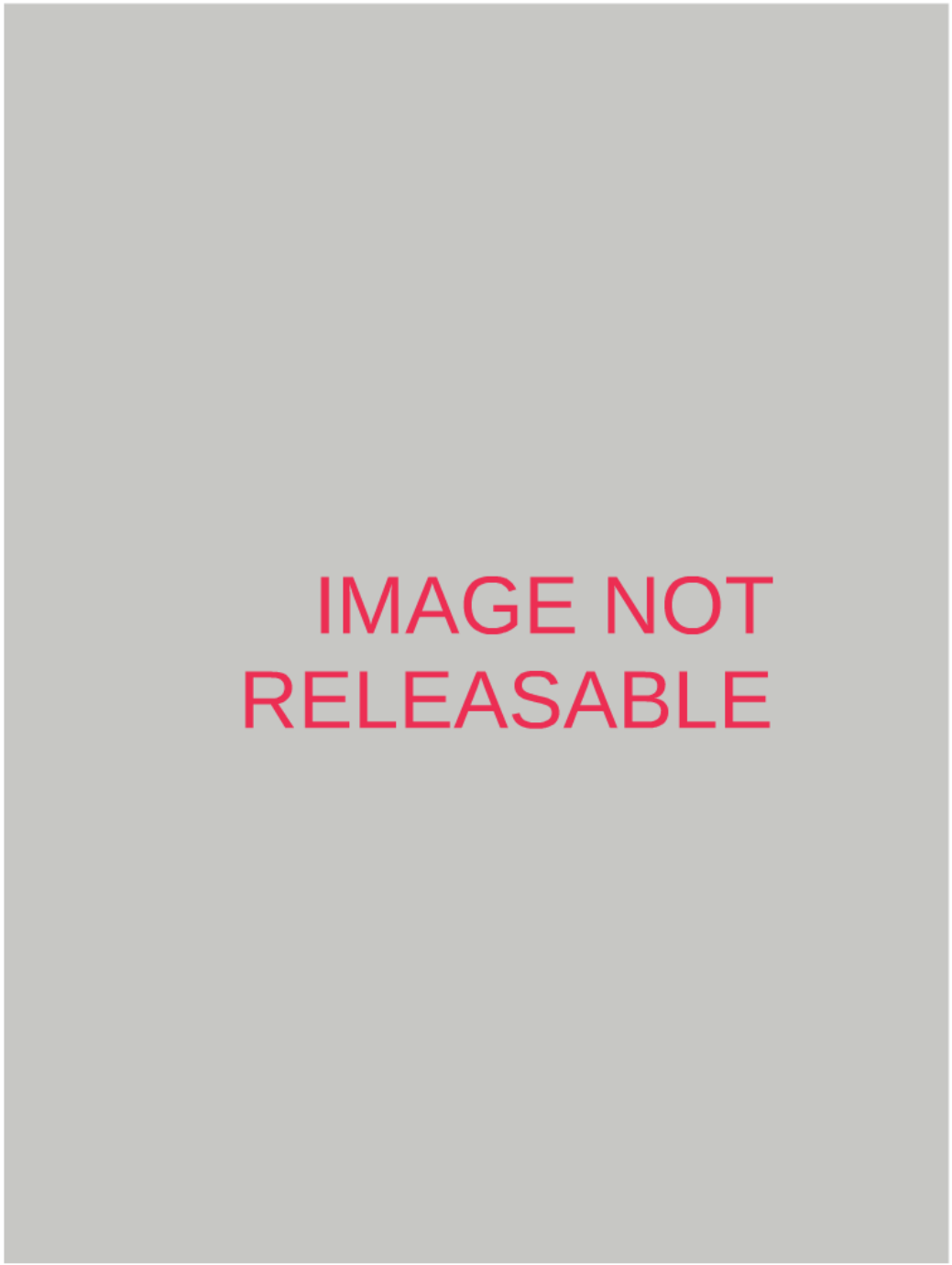

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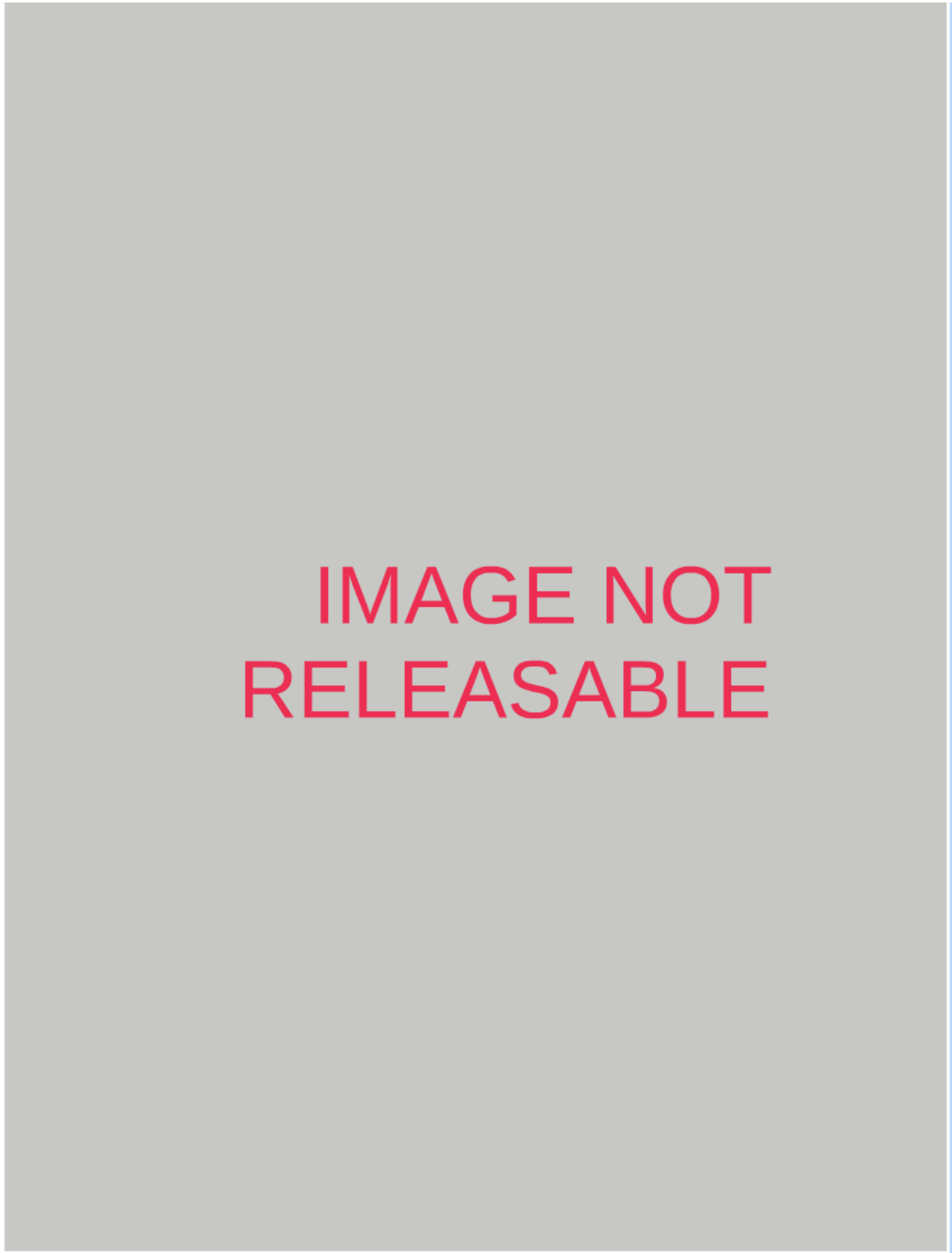

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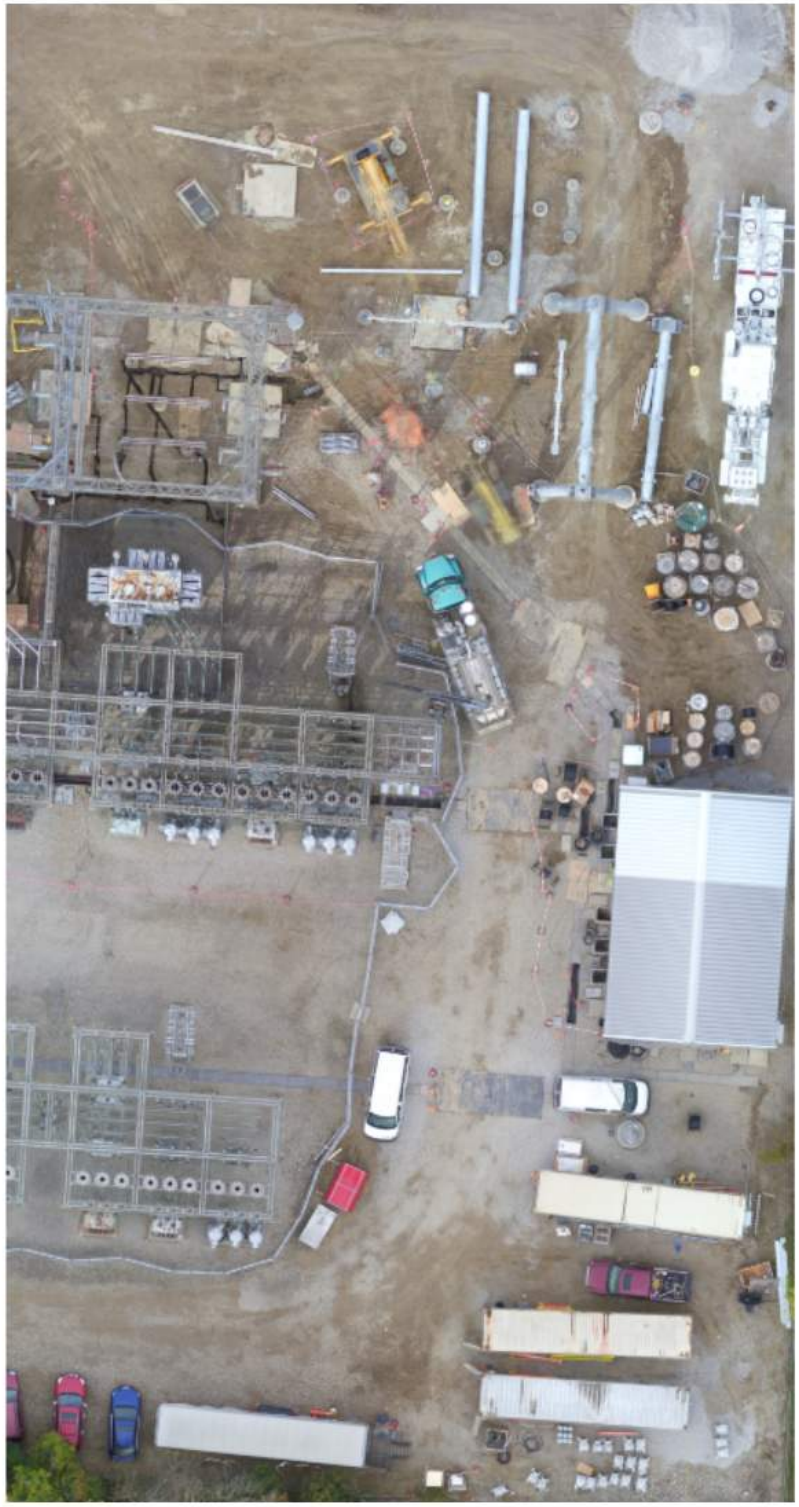
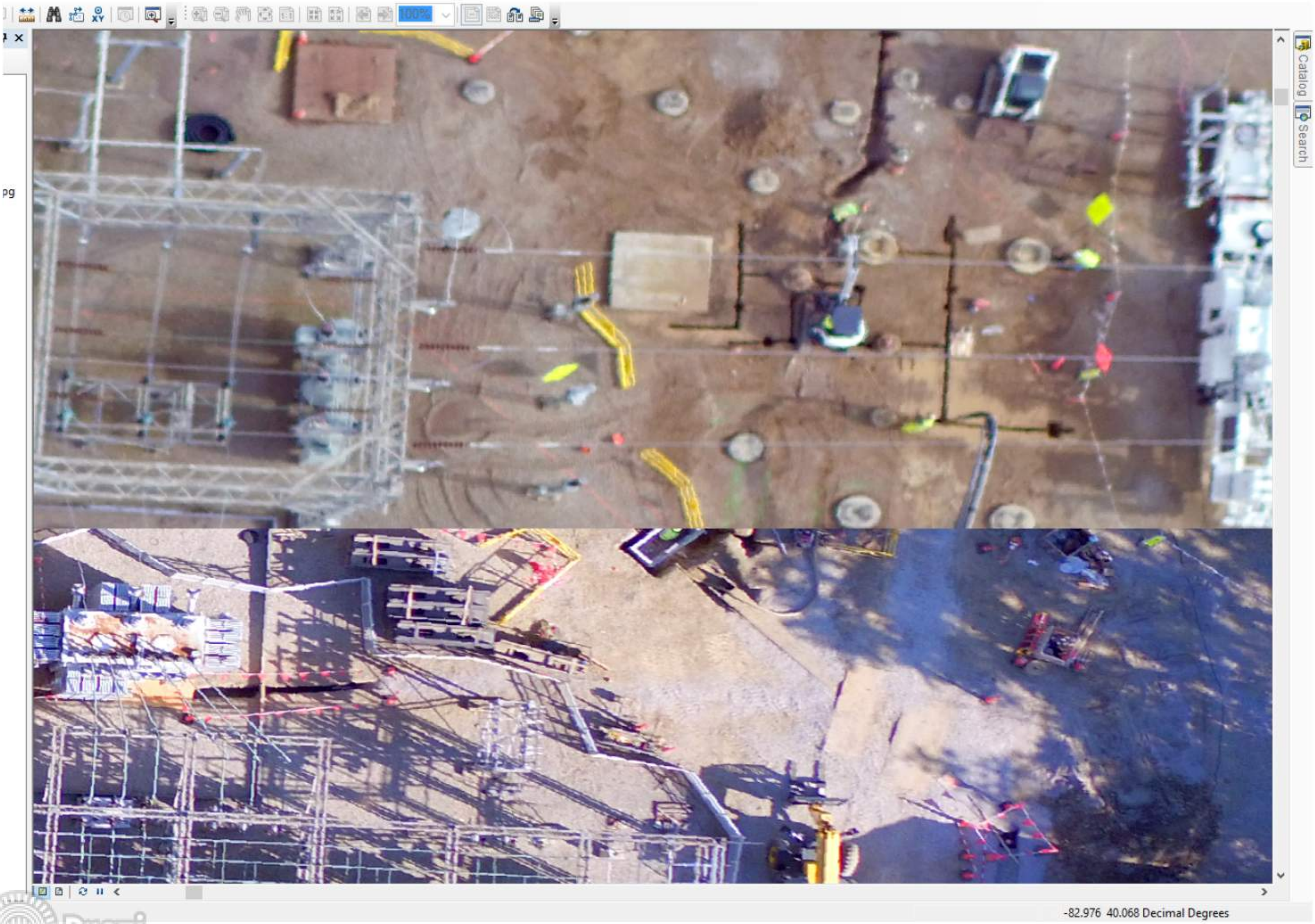
Imagery

- Individual frames
  - Great resolution
  - Challenging to manage
- Single site-wide image
  - Limited by site size/shape
  - Radial displacement
- Orthoimage
  - Artifacts impact analysis
- **Horizontal Accuracy: +/- ~0.25 ft**

- Utilization
  - Visual inspection
  - Image comparison
  - Measurement
  - Automation is tough in 2D - only imaged based

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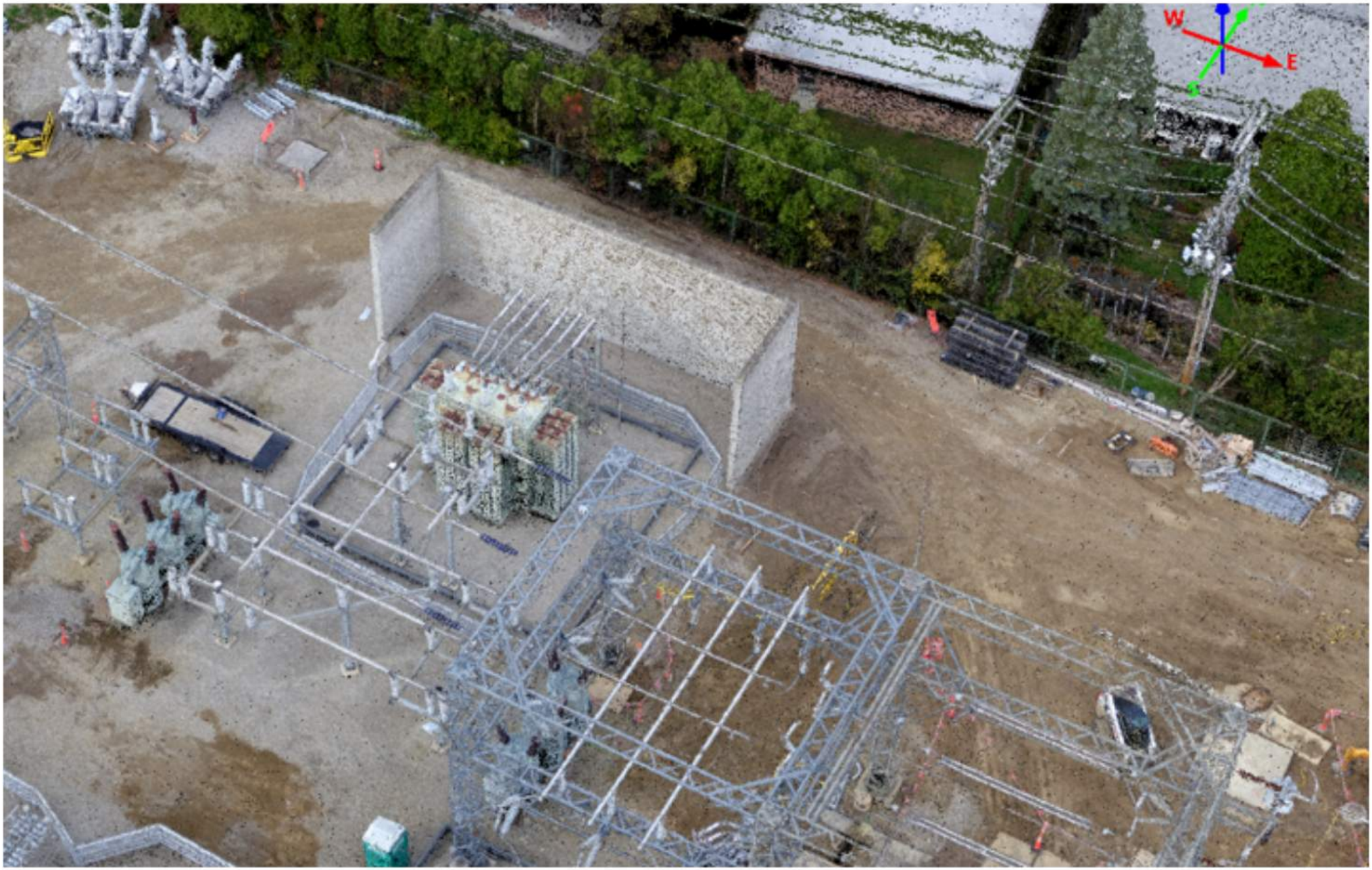
3D Colorized Point Cloud

- Flight planning provides for substantial image overlap
- Software processing creates 3D autocorrelated datasets
- Datasets:
  - Image/textured mesh
  - 3D point cloud (.las/.laz)
- **Horizontal Accuracy: +/- ~0.25 ft**
- **Initial Vertical Accuracy: +/- ~2.5 ft**
- **Vertical Accuracy: +/- ~0.25 ft**

- Utilization
  - Visual inspection
  - 3D Measurement
  - Comparison to model/design
  - automate change detection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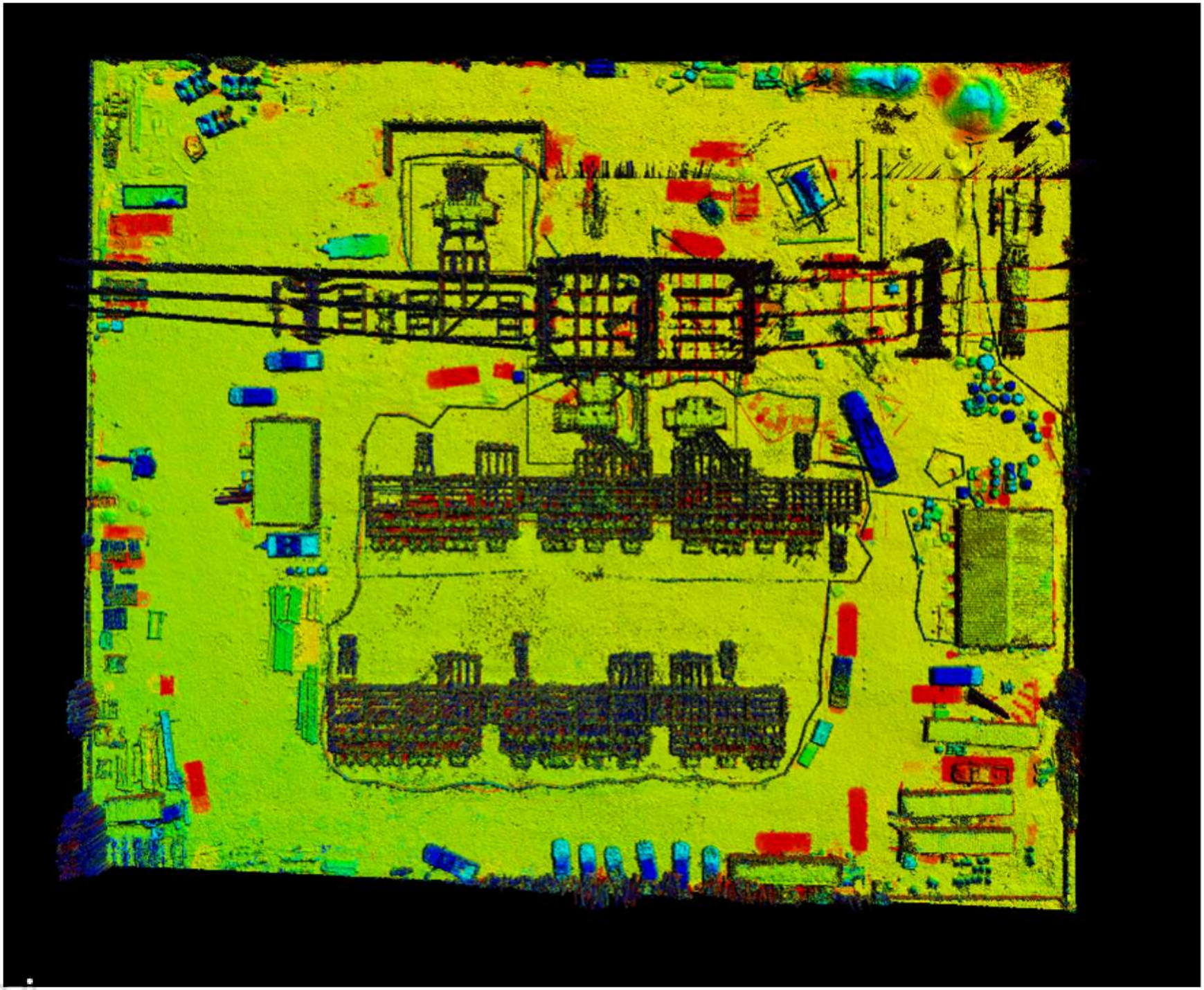
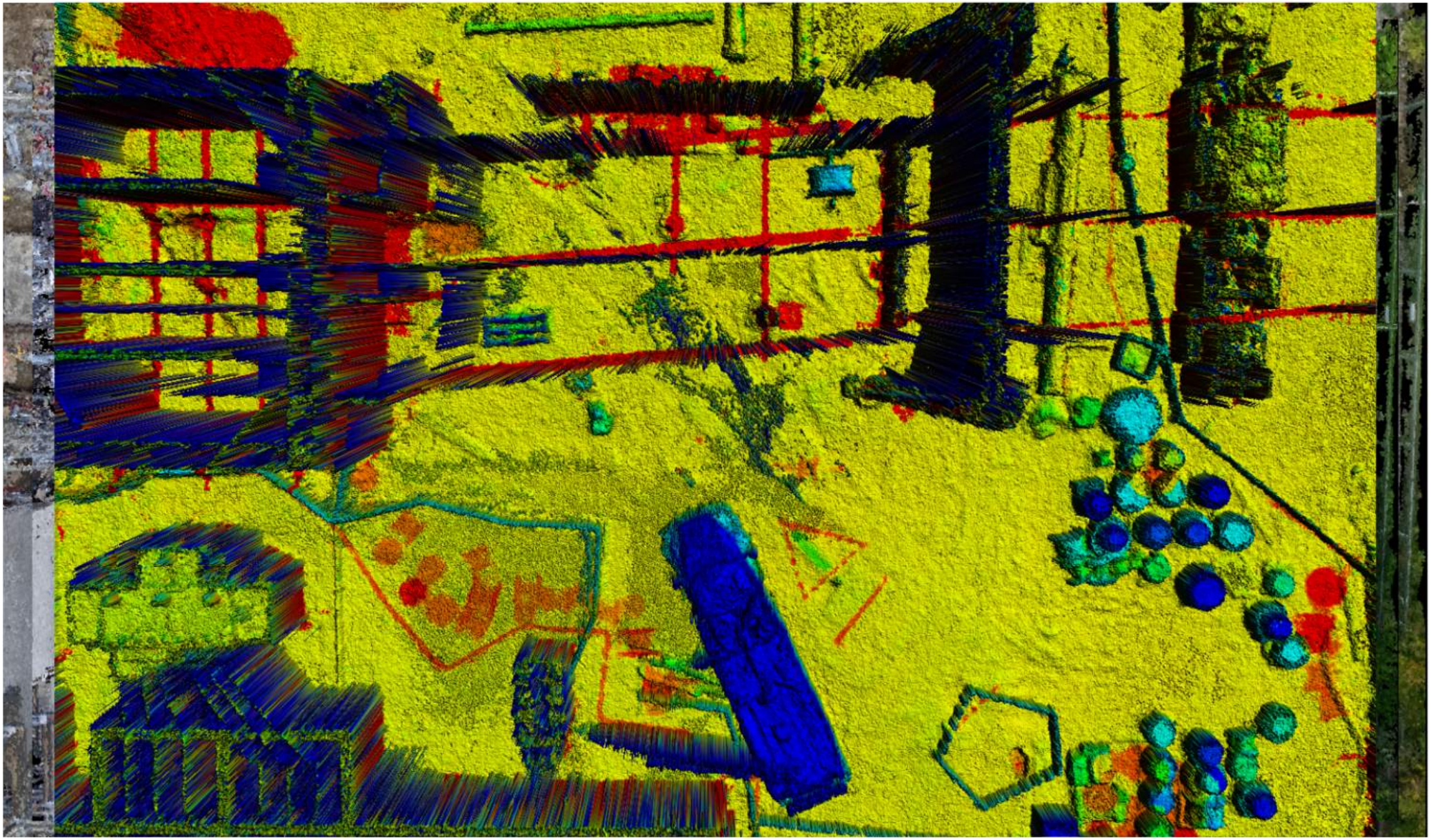
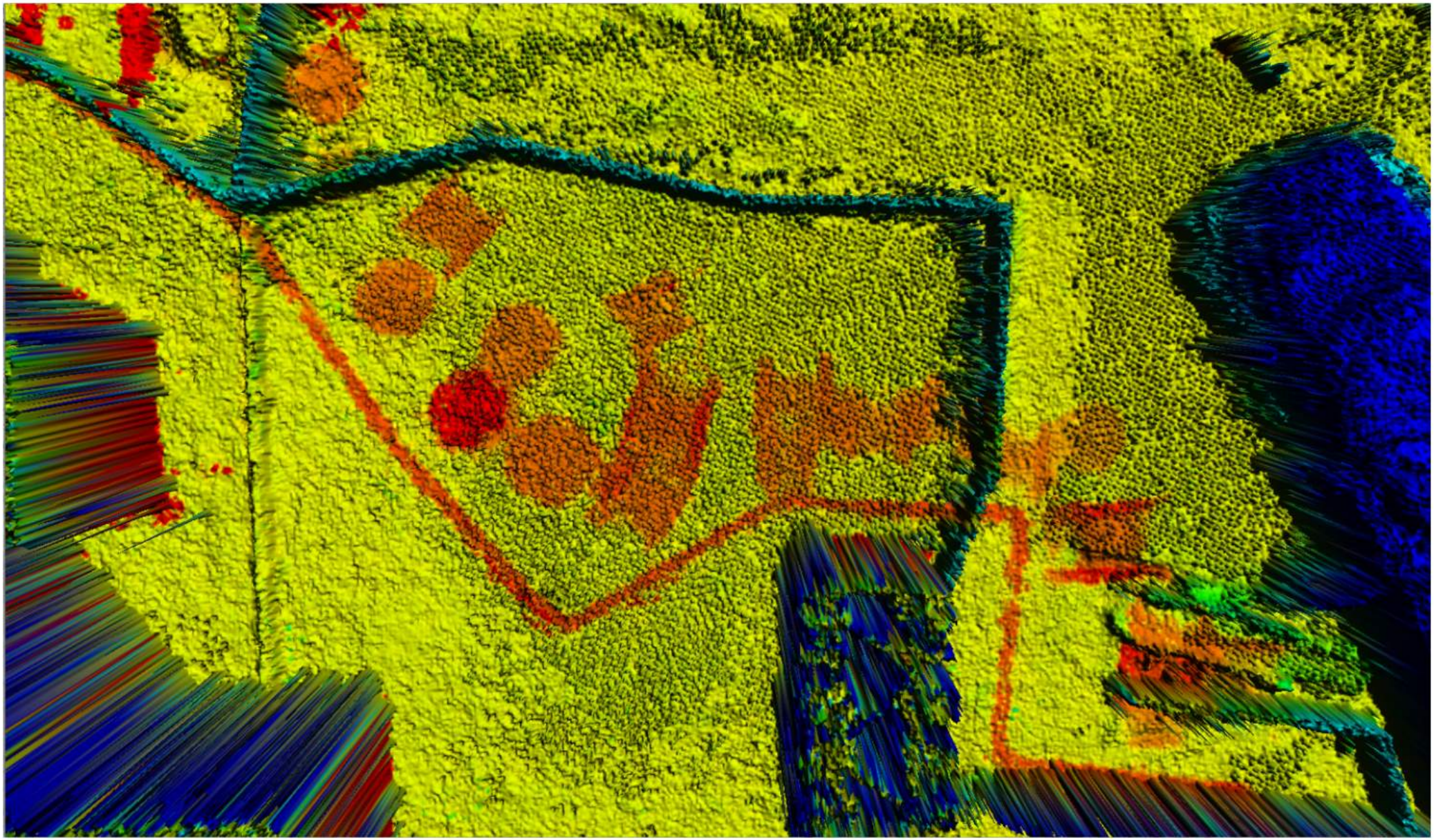
Change Detection

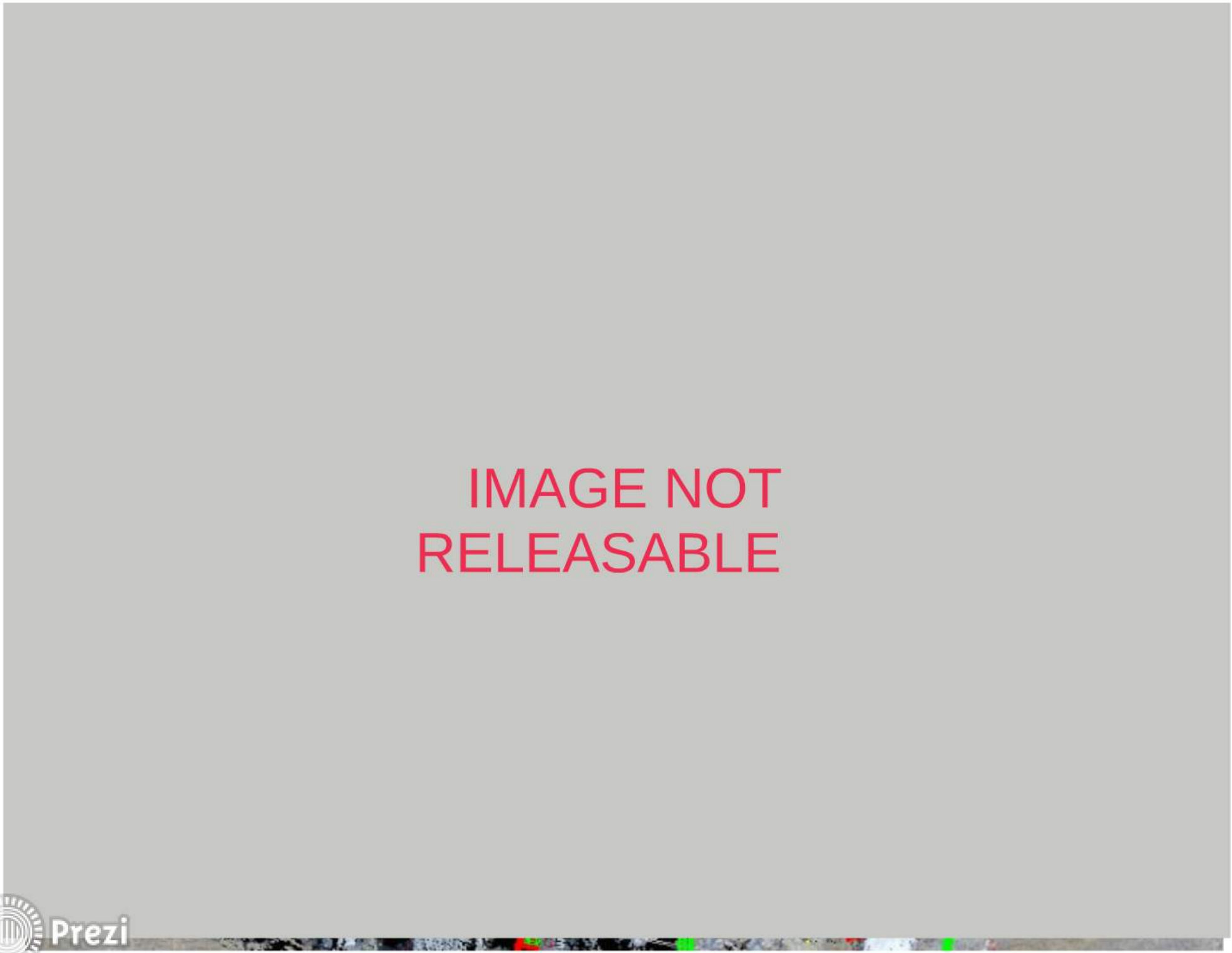
- Limitations in 2D imagery
  - Frame-based
  - Difficult to compare to other datasets
- Focus on 3D point cloud
  - "Spatial geometry" for comparison
  - Comparison to other point clouds
  - Comparison to 3D models
- ACCURACY DETERMINATION
  - What's noise?
  - What's actual change?
  - Accuracy statement:
    - x/y: ~0.25 ft
    - z: ~0.25 ft


Prezi







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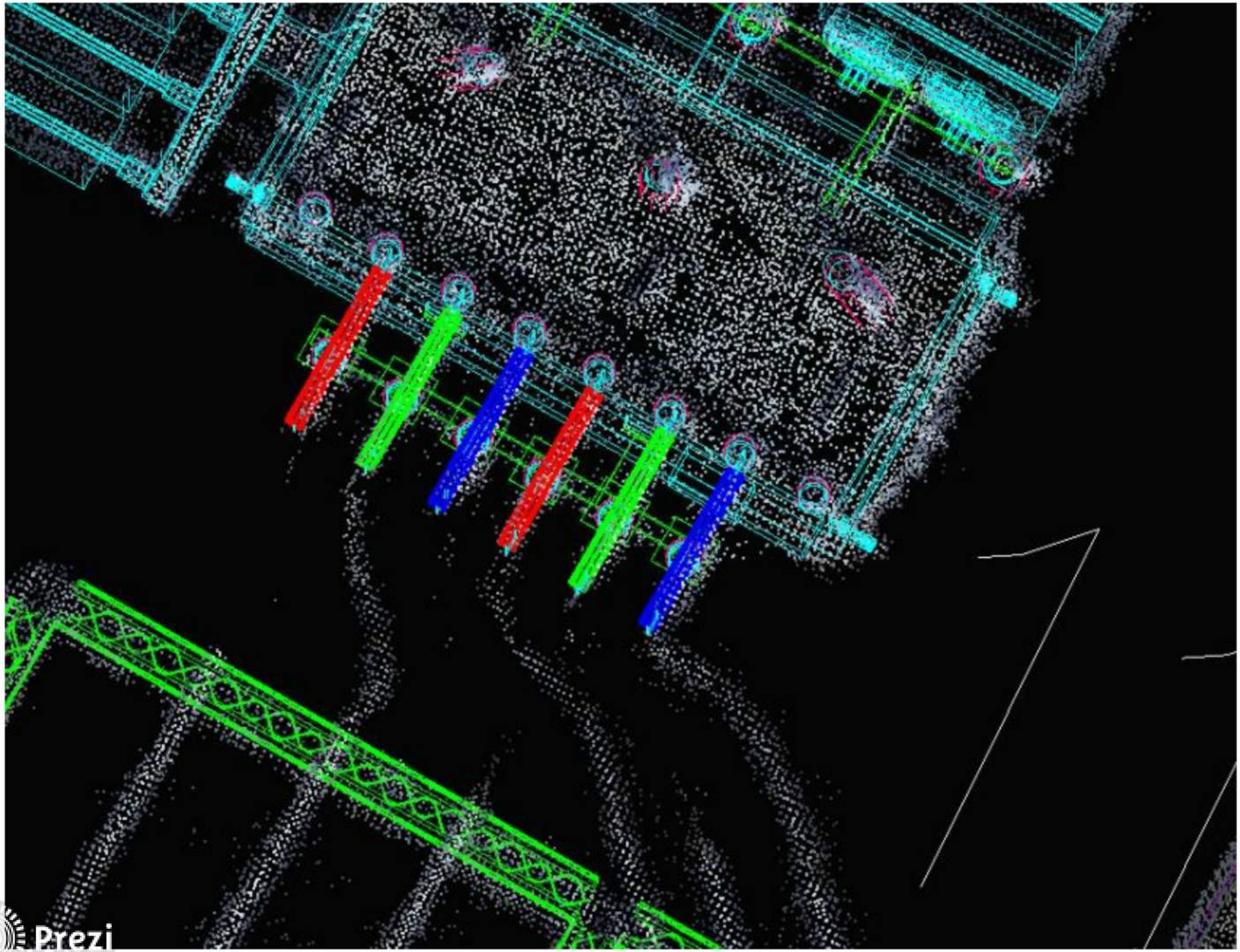
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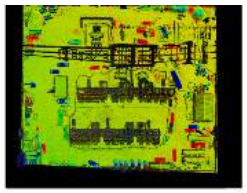
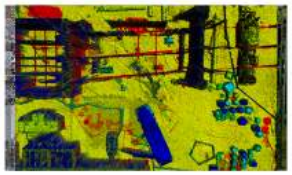




Next Steps

- ***Refinement of change detection***
- ***Automation of detection***
  - ***Between point clouds***
  - ***Against models***
- ***Object identification***
- ***Comparison to model/parts***

Why?

- Compare to 4D schedule
- Check alignment, orientation, clearances, prefab measurements
- Effective way to understand change remotely
- Visual "gut check" - cannot be faked and unlikely to be misunderstood

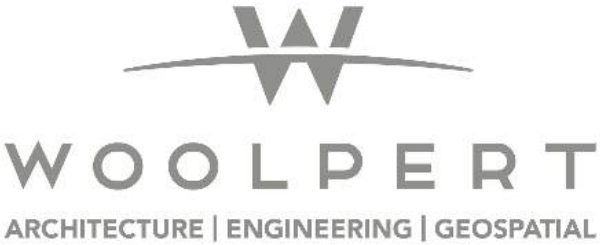
Lessons Learned

- Risk mitigation is crucial
  - Safety
  - Liability
- Repetitive acquisition can be challenging
  - "noise" on the project site
  - Light conditions
- Creation of imagery is easy
- Creation of ACCURATE imagery is more challenging
- Creation of ACCURATE 3D data is even more challenging
- BUT.. accuracy or an understanding of limitations is needed to ensure successful change detection
- How to best fit UAS data into workflows?

Questions?

Thanks!

- Aaron Lawrence
- Andria Shaman
- Ethan Schreuder



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