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- 8 years at Frontier Precision
- Technical Specialist Scanning & Survey

Unlocking the Future with LiDAR Technology

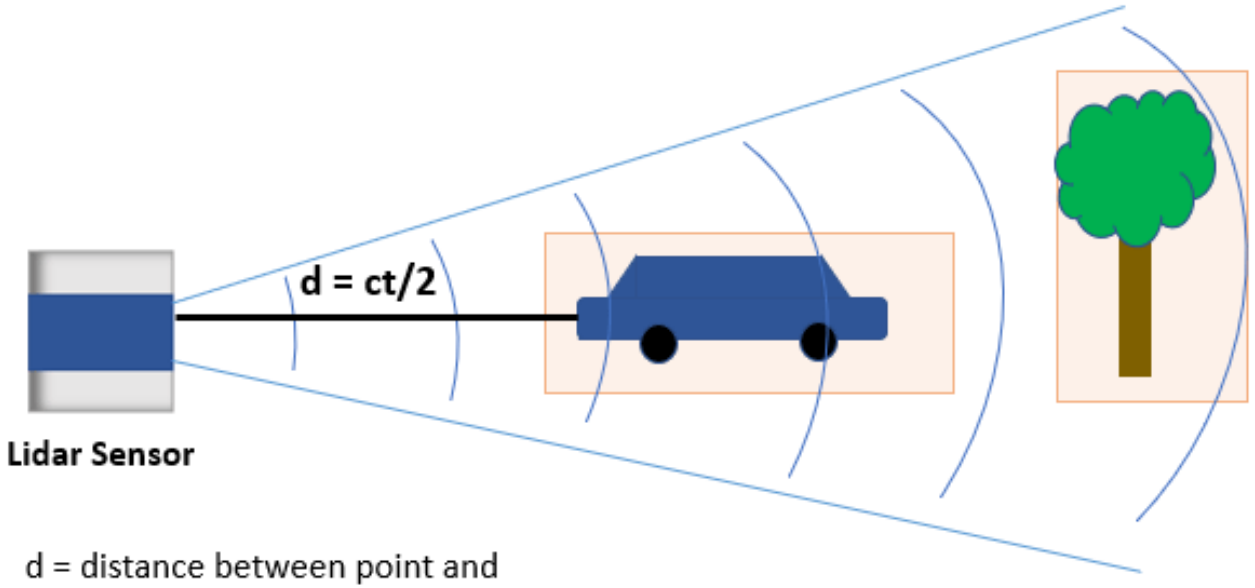
Agenda

- **What is LiDAR Technology?**
- **Brief History of LiDAR**
- **Types of LiDAR Systems**
- **LiDAR Applications**
- **Deliverables**
- **Q&A**

What is LiDAR (Light Detection and Ranging) Technology?

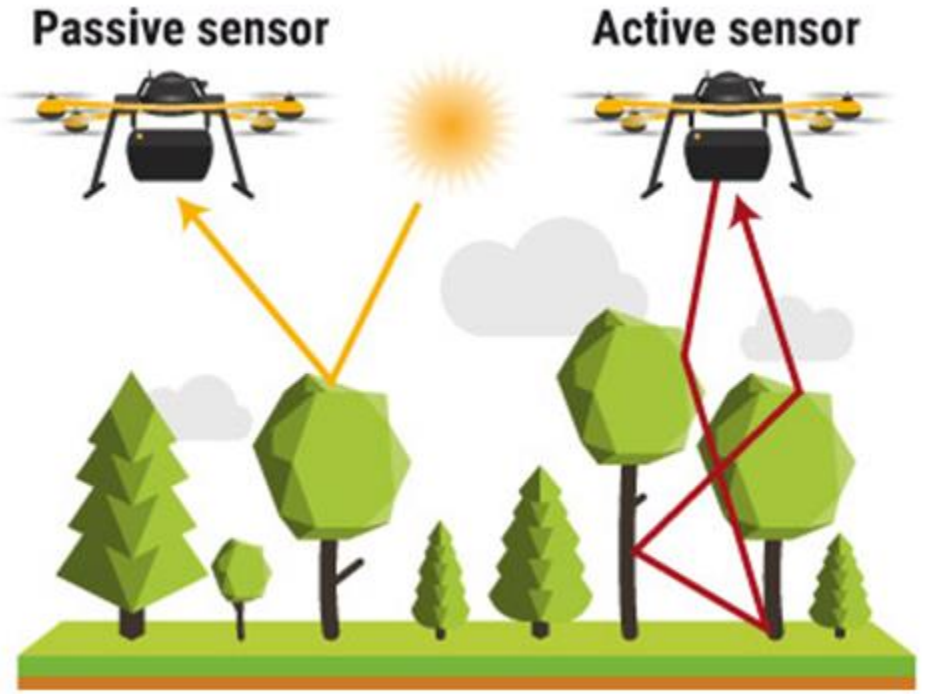
Put simply – when a laser is used to measure a distance to a surface or object.

Using a combination of lasers and advanced sensors, LiDAR systems can measure the surrounding environment in 3D with high accuracy, allowing us to make informed decisions.

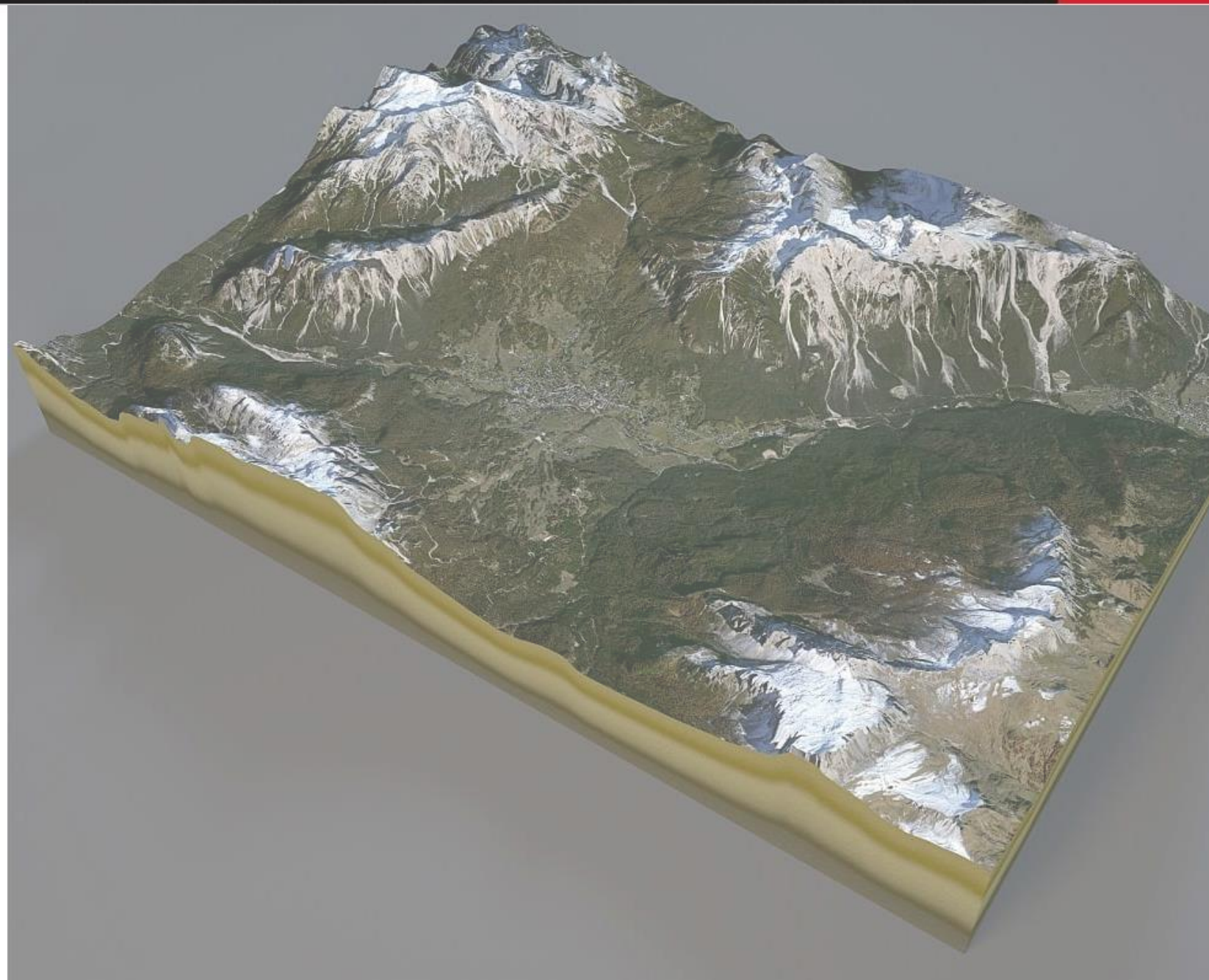


d = distance between point and the sensor
c = speed of light
t = time of flight

- LiDAR systems are **active sensors**
- Near-infrared or near-ultraviolet light
- Typically pulses between hundreds of thousands to millions of times per second
- Distance = Speed of Light * Time
- Computed coordinate is relative to the location and orientation of the LiDAR sensor
- Intensity of the reflected laser beam is measured, which can be used to determine the reflectivity or surface roughness of the target.



The concept of LiDAR dates to the early 20th century, when researchers first demonstrated the use of lasers for distance measurement. However, it wasn't until the 1960s that LiDAR technology began to be developed for practical applications.



Key Milestones in the History of LiDAR

- 1930s: Light pulses used to measure heights of clouds
- 1960s – 1970s: LiDAR R&D for Aerospace & Defense applications
- 1980s – 1990s: LiDAR used for scientific studies such as atmospheric gases, geological features, vegetation canopy heights, topographic mapping, and natural hazard studies. Integration with other sensors.
- 2000s: LiDAR technology becomes affordable for common uses in surveying, construction and engineering.
- 2010s: LiDAR sensors in consumer electronics, and a rise in use with sUAS (drones)
- Present: LiDAR for autonomous vehicle navigation, IoT, and other industrial uses

LiDAR Systems for Mapping and Surveying

Terrestrial LiDAR

Station-Based LiDAR (tripod)
Highest-resolution
Accuracies of up to a few millimeters
Registration process
Georeferencing process

Terrestrial (Stationary) LiDAR

$15k – $125k

Benefits

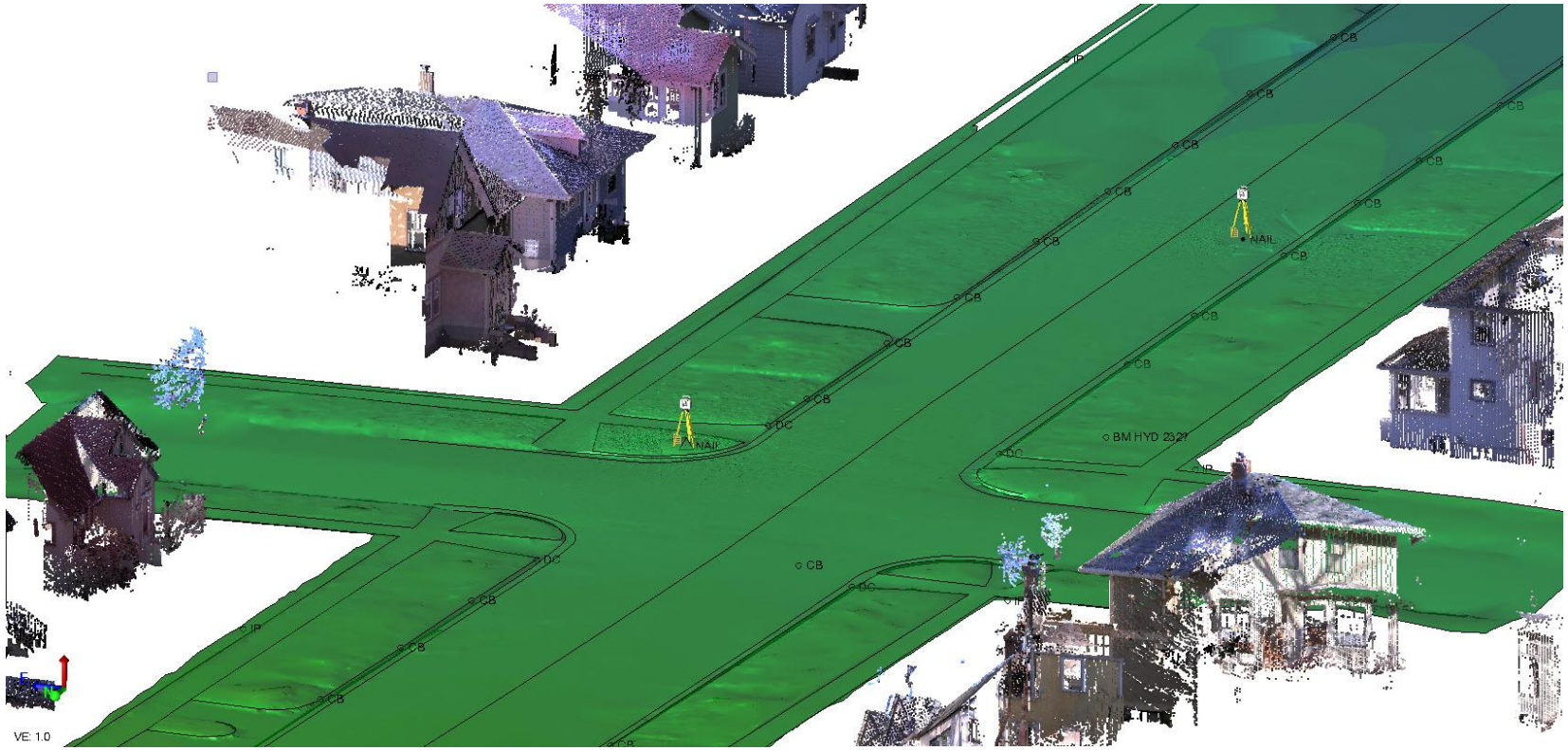
- Highest quality 3D data
- Up to 2 million pps
- Minimal point cloud noise
- Highly accurate – within millimeters
- 360 scan in less than 1 minute
- High resolution imagery
- Range up to 1000m!
- Survey workflows for some

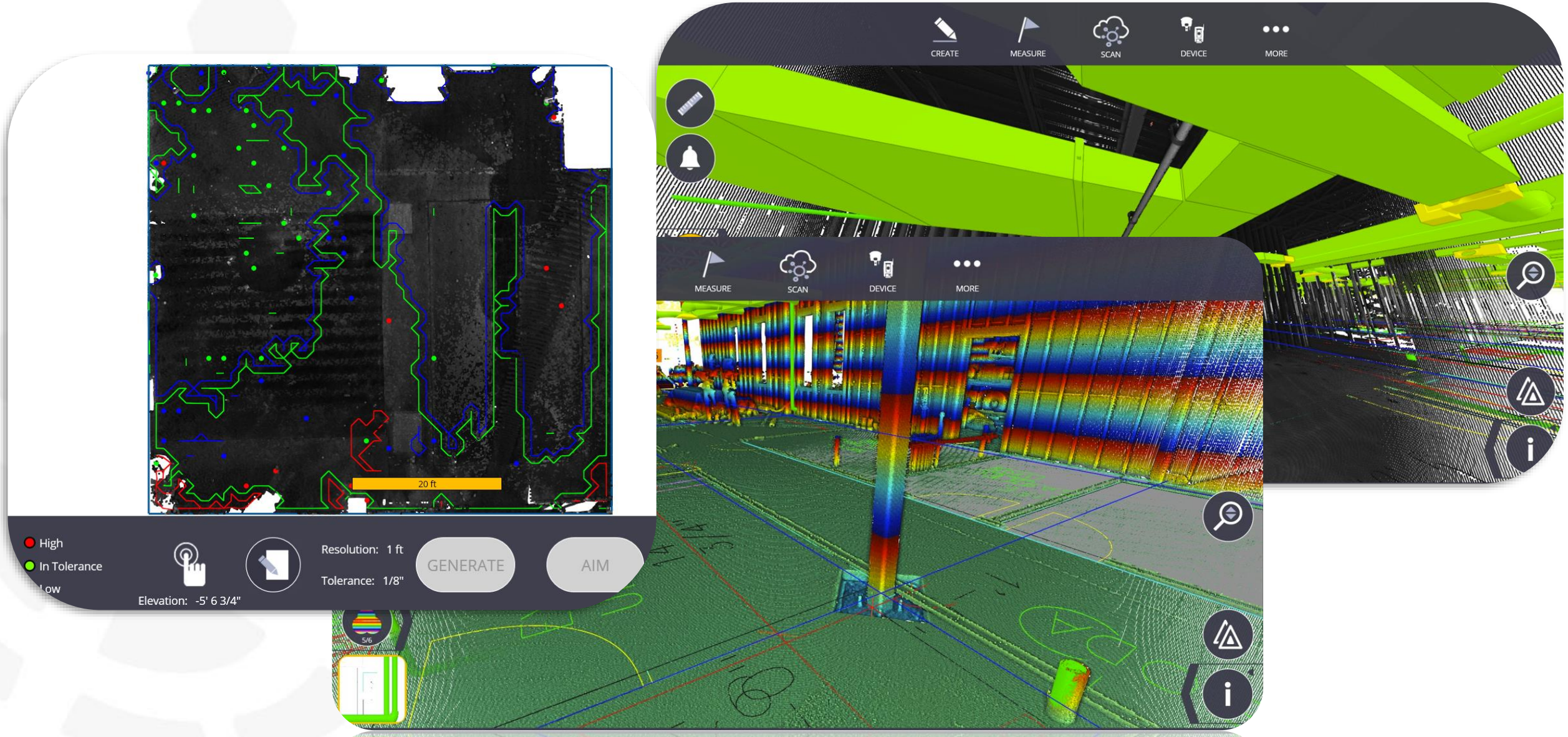
Applications

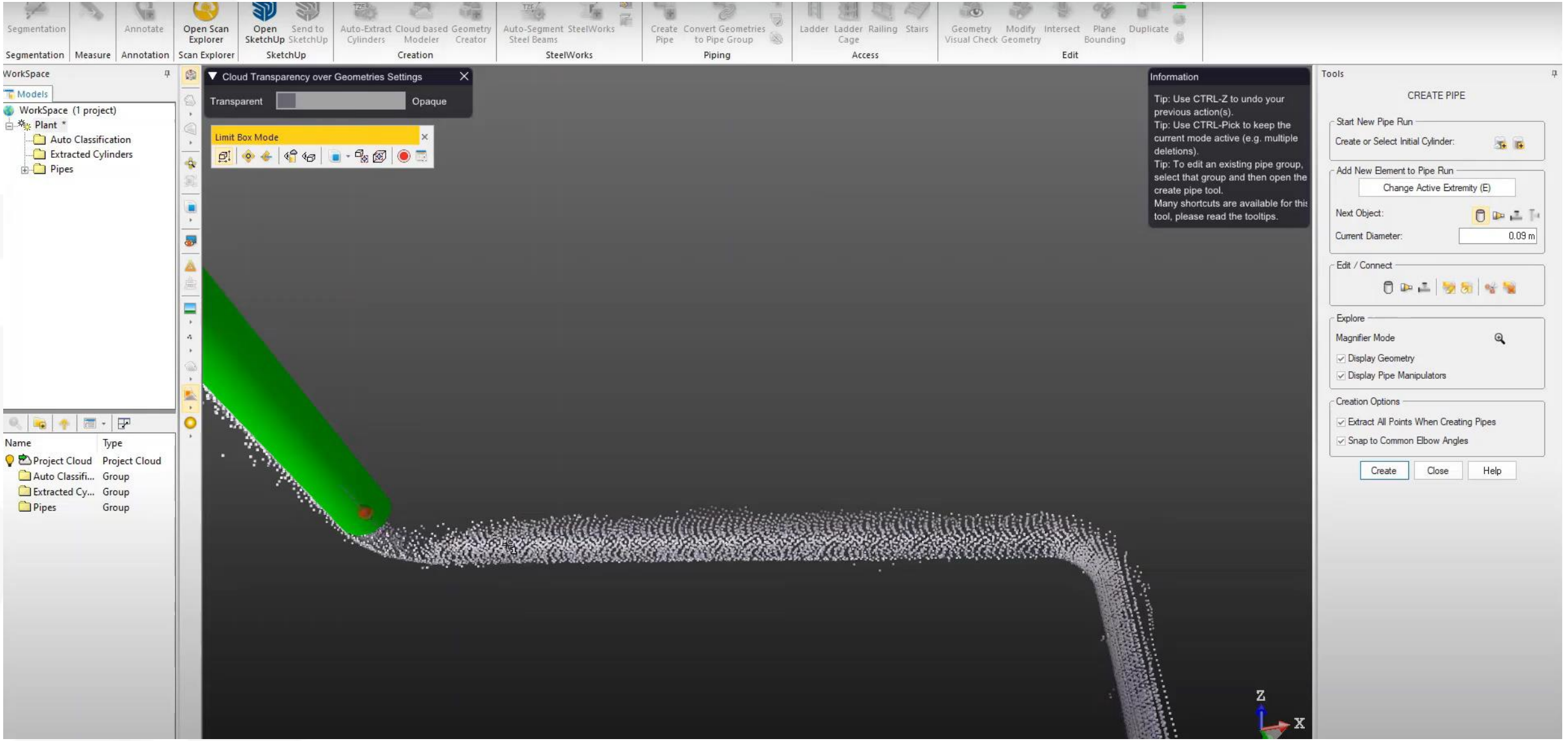
- Plant & industrial measurement
- Mining and quarries
- Infrastructure & Building as-builts
- Volumetric surveys
- Roadway corridor surveys
- Deformation monitoring
- Topographical & ALTA surveys
- Powerline and Utility surveys

Terrestrial LiDAR Workflow

- Preplanning of station locations
- GCP Targets
- Scan
- Post Process/Register/Data conversion
- QA/QC
- CAD Feature Extraction & Modelling

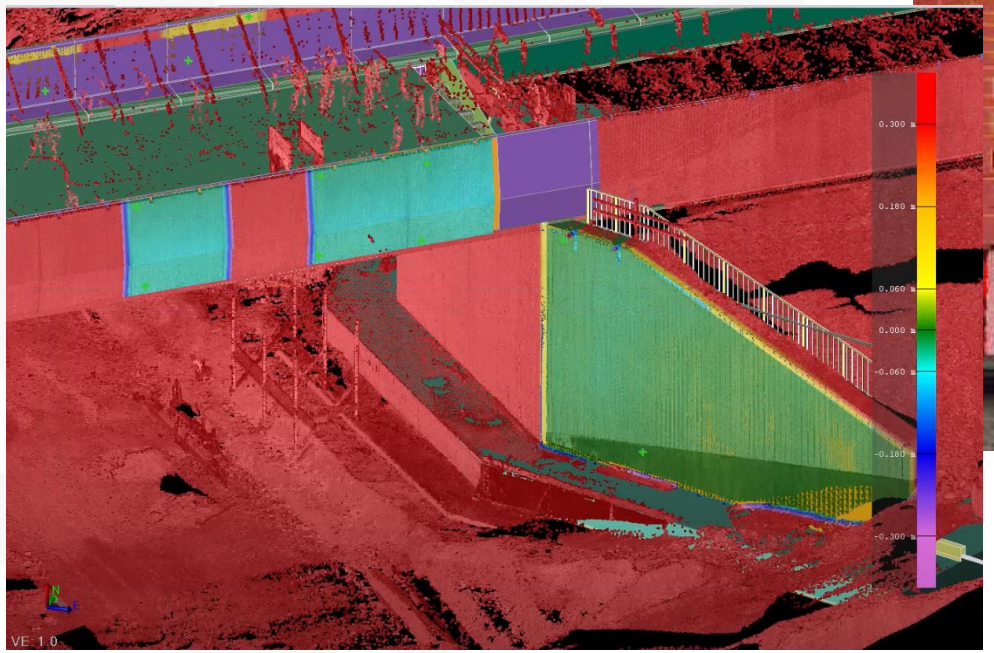


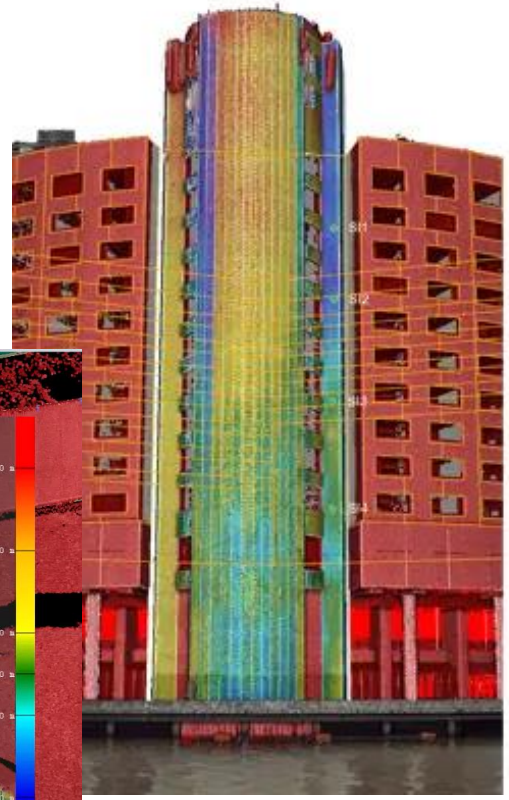

CREATE
MEASURE
SCAN
DEVICE
MORE
MEASURE
SCAN
DEVICE
MORE
20 ft
High
In Tolerance
Low
Elevation: -5' 6 3/4"
Resolution: 1 ft
Tolerance: 1/8"
GENERATE
AIM
5/6

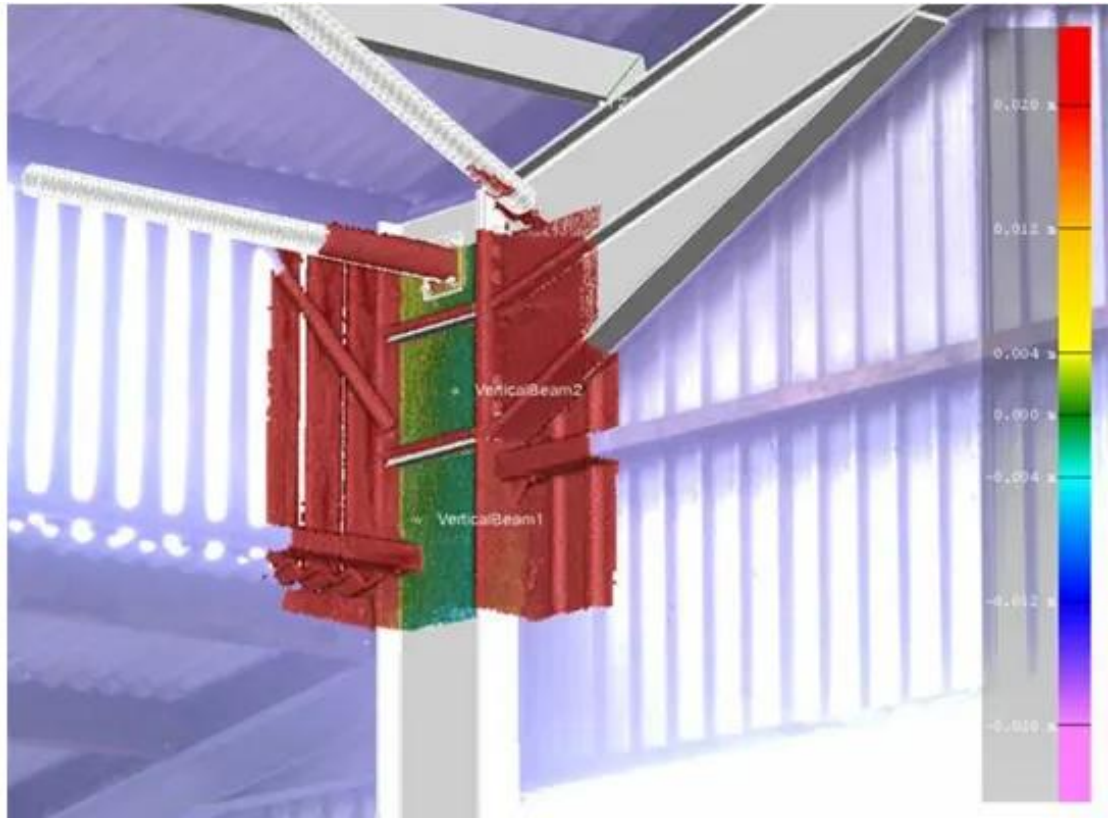

Segmentation
Measure
Annotate
Open Scan Explorer
Open SketchUp
Send to SketchUp
Auto-Extract Cylinders
Cloud based Modeler
Geometry Creator
Auto-Segment Steel Beams
SteelWorks
Create Pipe
Convert Geometries to Pipe Group
Ladder
Ladder Cage
Railing
Stairs
Geometry Visual Check
Modify Geometry
Intersect
Plane Bounding
Duplicate
Segmentation
Measure
Annotation
Scan Explorer
SketchUp
Creation
SteelWorks
Piping
Access
Edit
WorkSpace
Models
WorkSpace (1 project)
Plant *
Auto Classification
Extracted Cylinders
Pipes
Name
Type
Project Cloud
Project Cloud
Auto Classifi...
Group
Extracted Cy...
Group
Pipes
Group
Cloud Transparency over Geometries Settings
Transparent
Opaque
Limit Box Mode
Information
Tip: Use CTRL-Z to undo your previous action(s).
Tip: Use CTRL-Pick to keep the current mode active (e.g. multiple deletions).
Tip: To edit an existing pipe group, select that group and then open the create pipe tool.
Many shortcuts are available for this tool, please read the tooltips.
Tools
CREATE PIPE
Start New Pipe Run
Create or Select Initial Cylinder:
Add New Element to Pipe Run
Change Active Extremity (E)
Next Object:
Current Diameter:
0.09 m
Edit / Connect
Explore
Magnifier Mode
Display Geometry
Display Pipe Manipulators
Creation Options
Extract All Points When Creating Pipes
Snap to Common Elbow Angles
Create
Close
Help
Z
X

Scan Inspections

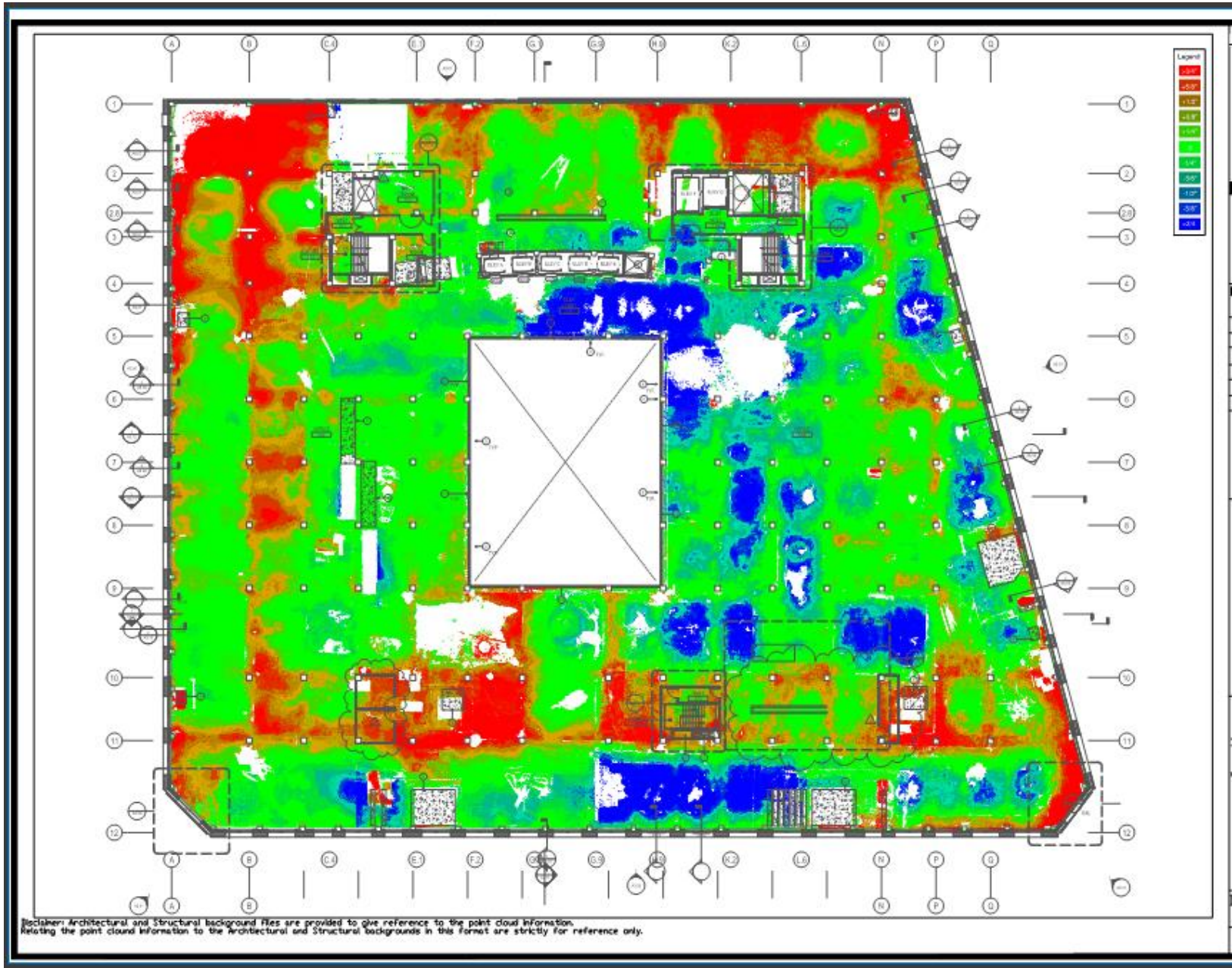
- Scan to Scan
- Scan to BIM
- Scan to Surface



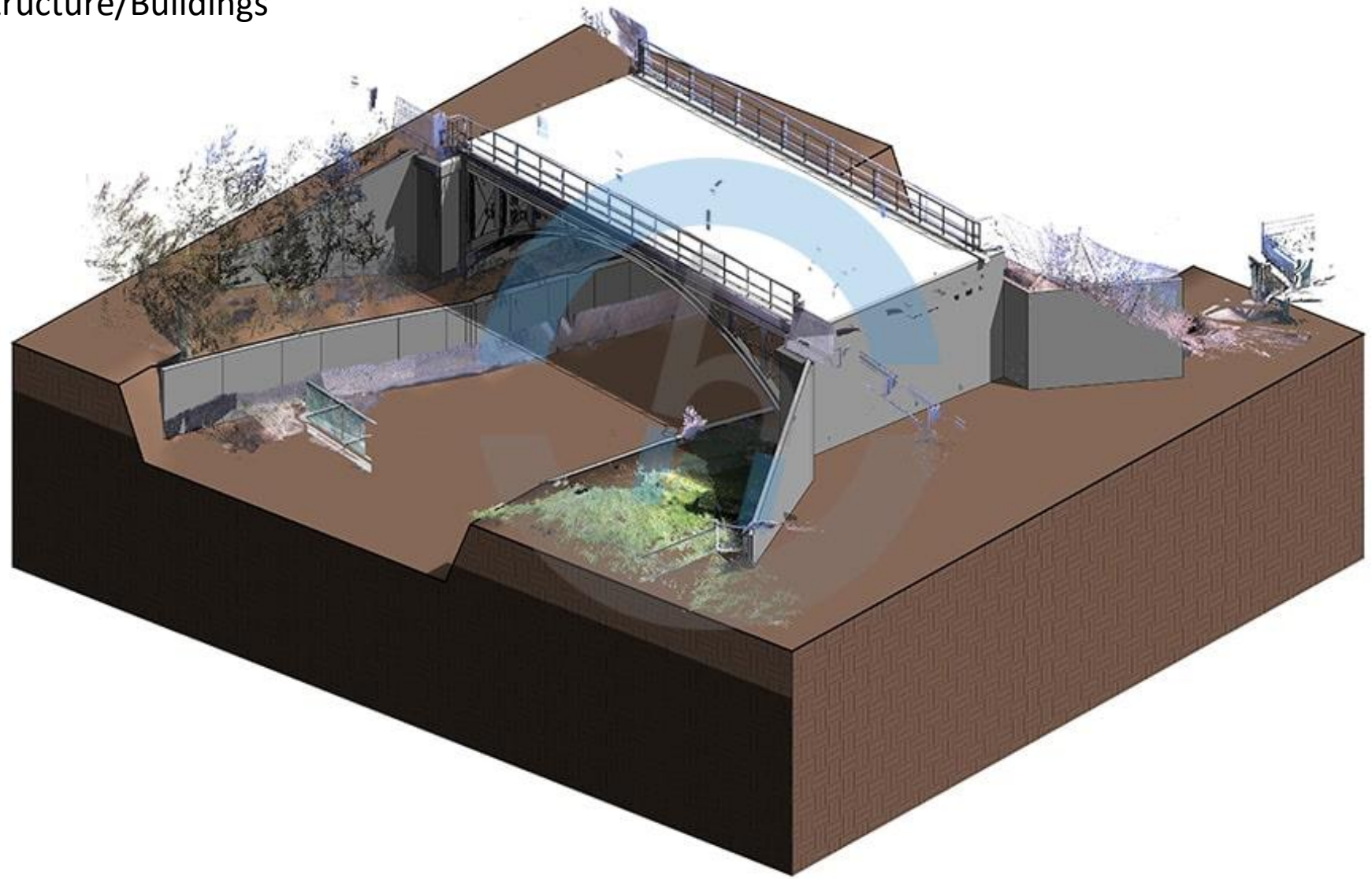




Floor Flatness and Floor Levelness



Modeling Infrastructure/Buildings



Mobile LiDAR

Mounted to moving ground-based vehicle

GNSS + IMU positioning

Accuracies range from a few centimeters to millimeters

Targets for position adjustment

Usually equipped with cameras

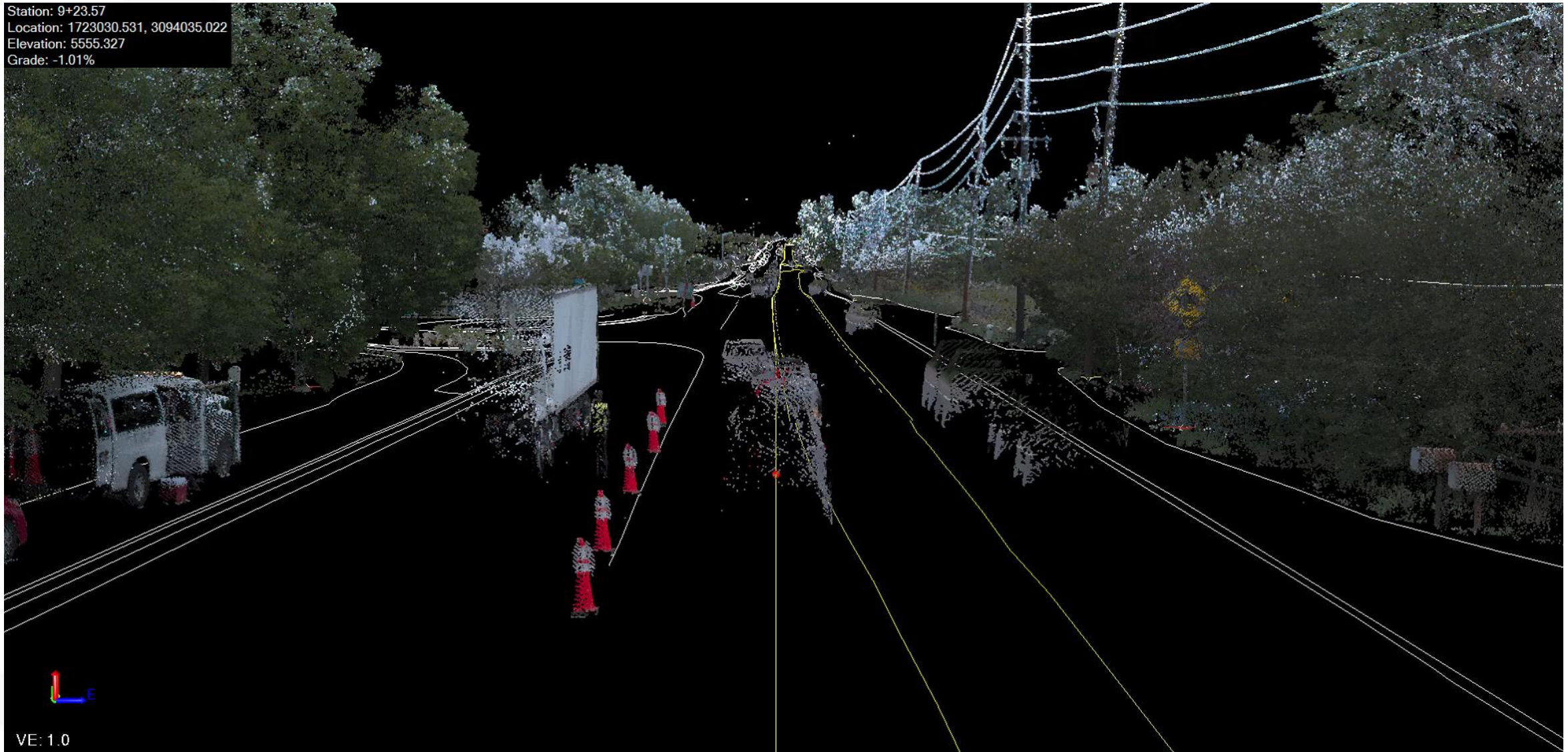
Mobile Lidar & Imaging

$100k - $1M+

Benefits

- Safest option for corridor surveys
- Up to 2 million pps
- Survey accuracy
- High resolution imagery
- Drive highway speeds
- No special DOT clearances or road closures
- No “forgotten” features

Mobile Lidar & Imaging



Mobile Mapping Applications

DOT's & Highway

- Street assets and road surfaces
- Guard Rails
- Slope Monitoring
- Oversize Load and Vegetation Clearances
- Pre vs. Post Construction
- Preliminary Topographic Surveys
- As-Built Surveys
- Bridges
- Sight Line Analysis
- Tunnelling
- Milling & Paving

Utilities, Mining & Energy

- Asset extraction and inspection
- Haul Road planning & quantities
- Volumes

Cities and Municipalities

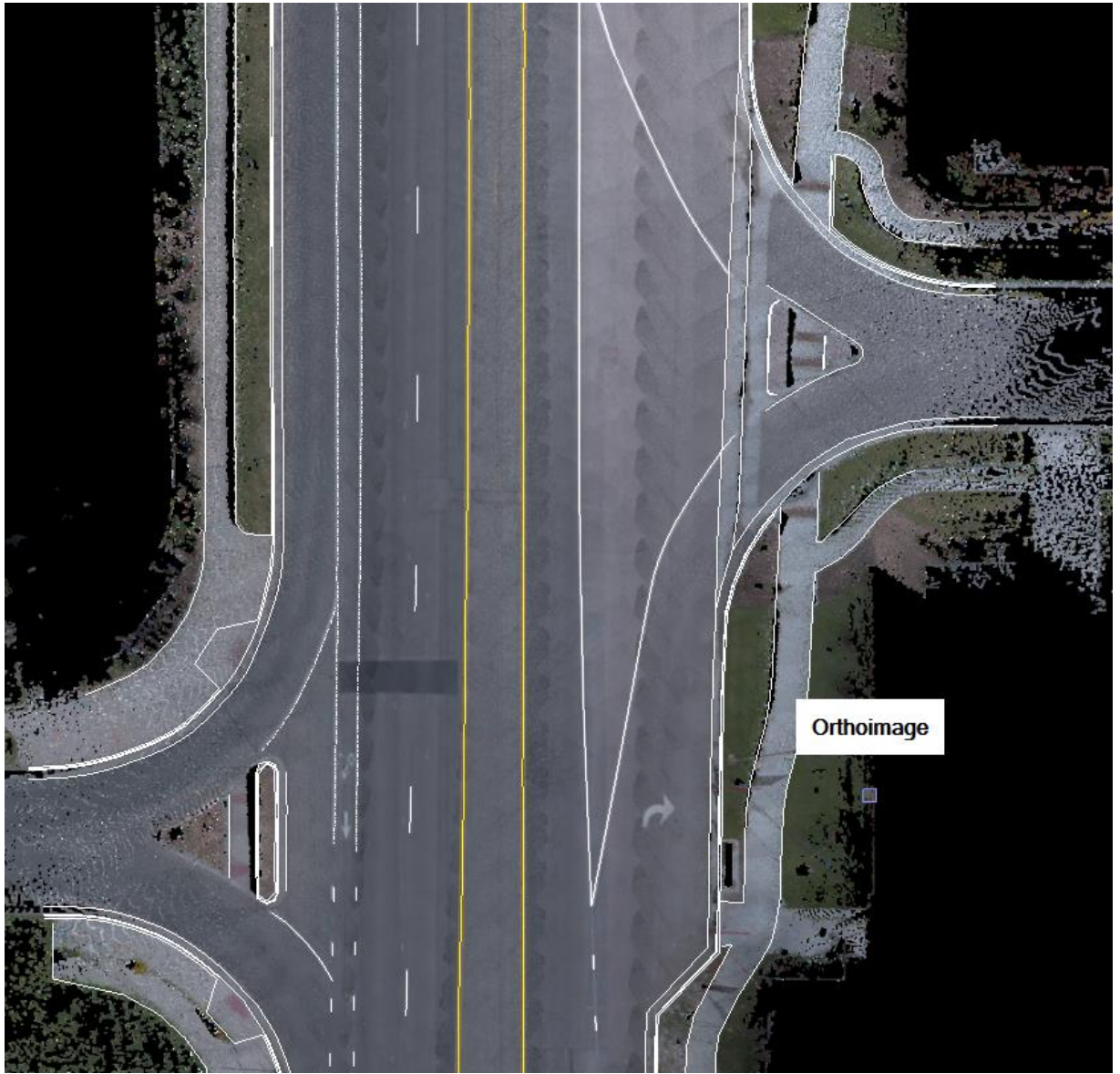
- Asset Extraction and Modelling
- Vegetation inventory
- Digital Twin
- Pavement Condition Analysis
- Surface Generation (storm/sewer)
- Updated private 'streetview'

Rail Corridors

- Track Alignment & Profile
- Asset Inventory
- Collision Avoidance
- Final As-Built

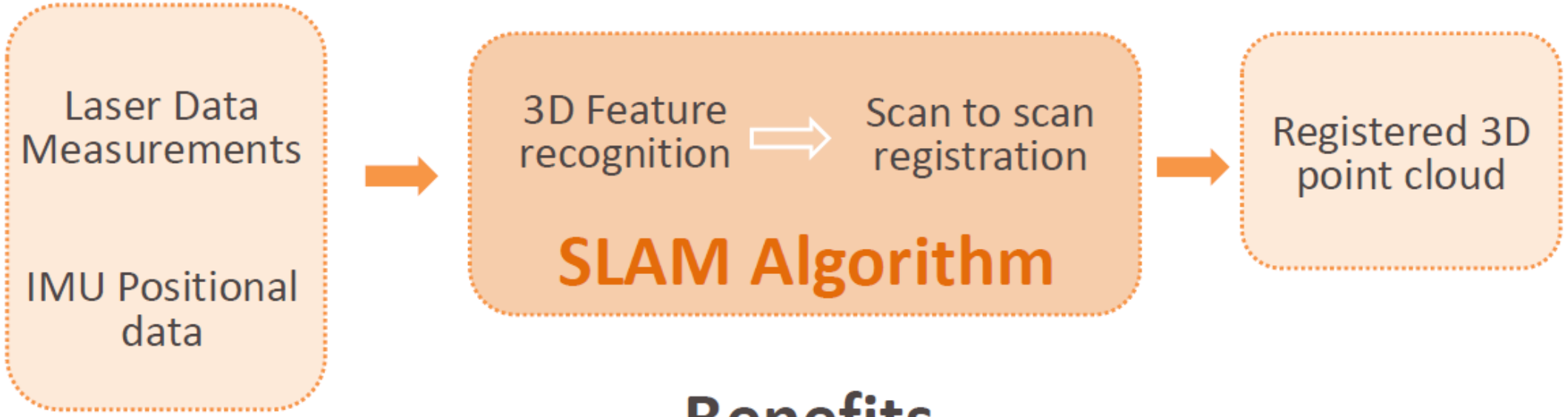
Mobile LiDAR Workflow

- Preplanning of driving route
- Targets
- Drive
- Post processing
- QA/QC
- CAD Feature Extraction & Modelling



SLAM Technology

Simultaneous Localisation And Mapping (SLAM)



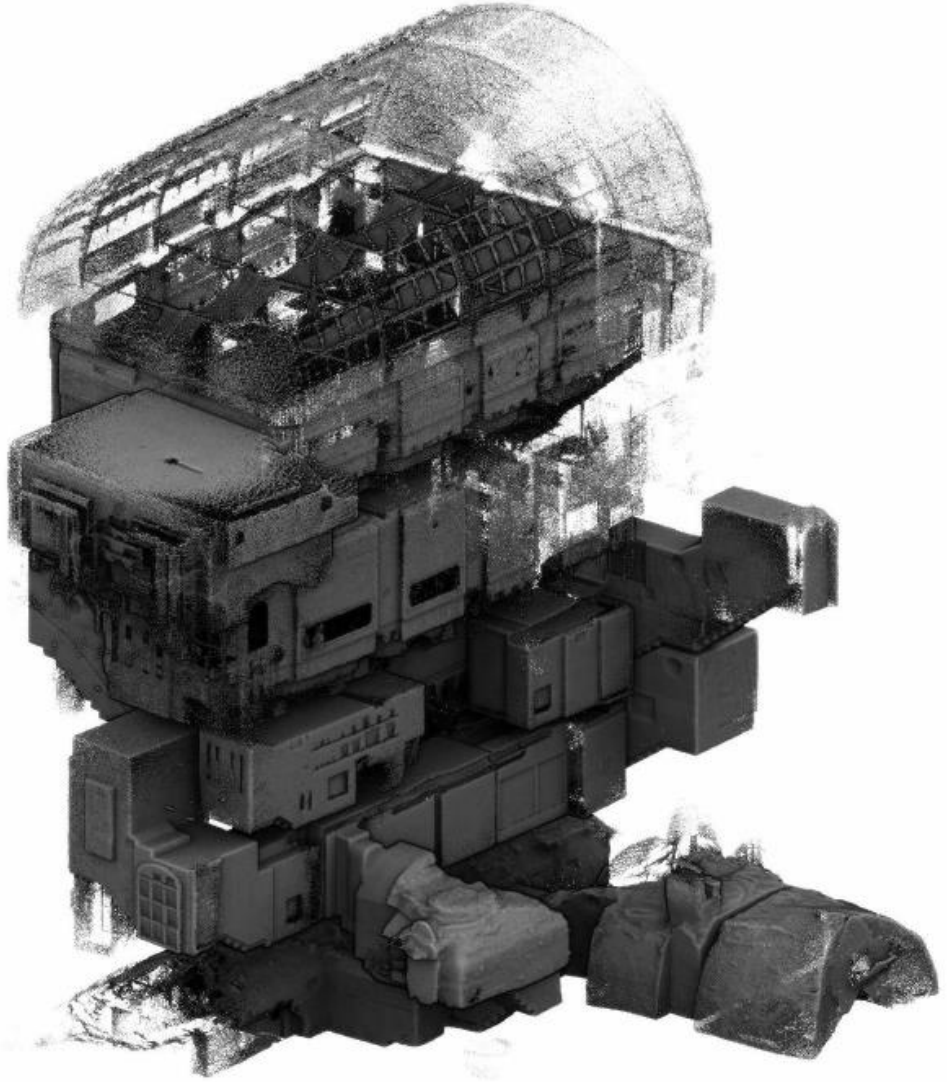
Benefits

- No need to remain static while scanning
- No need for GPS

Mobile Scanning + SLAM Technology

Applications

- Complex & restricted access spaces
- Multi-level environments
- Tunnels & Mines
- Underground infrastructure (ex. manholes, sewers)
- Power Stations
- Bridge Inspections
- Forestry management
- Building & facility management
- Stockpile surveys

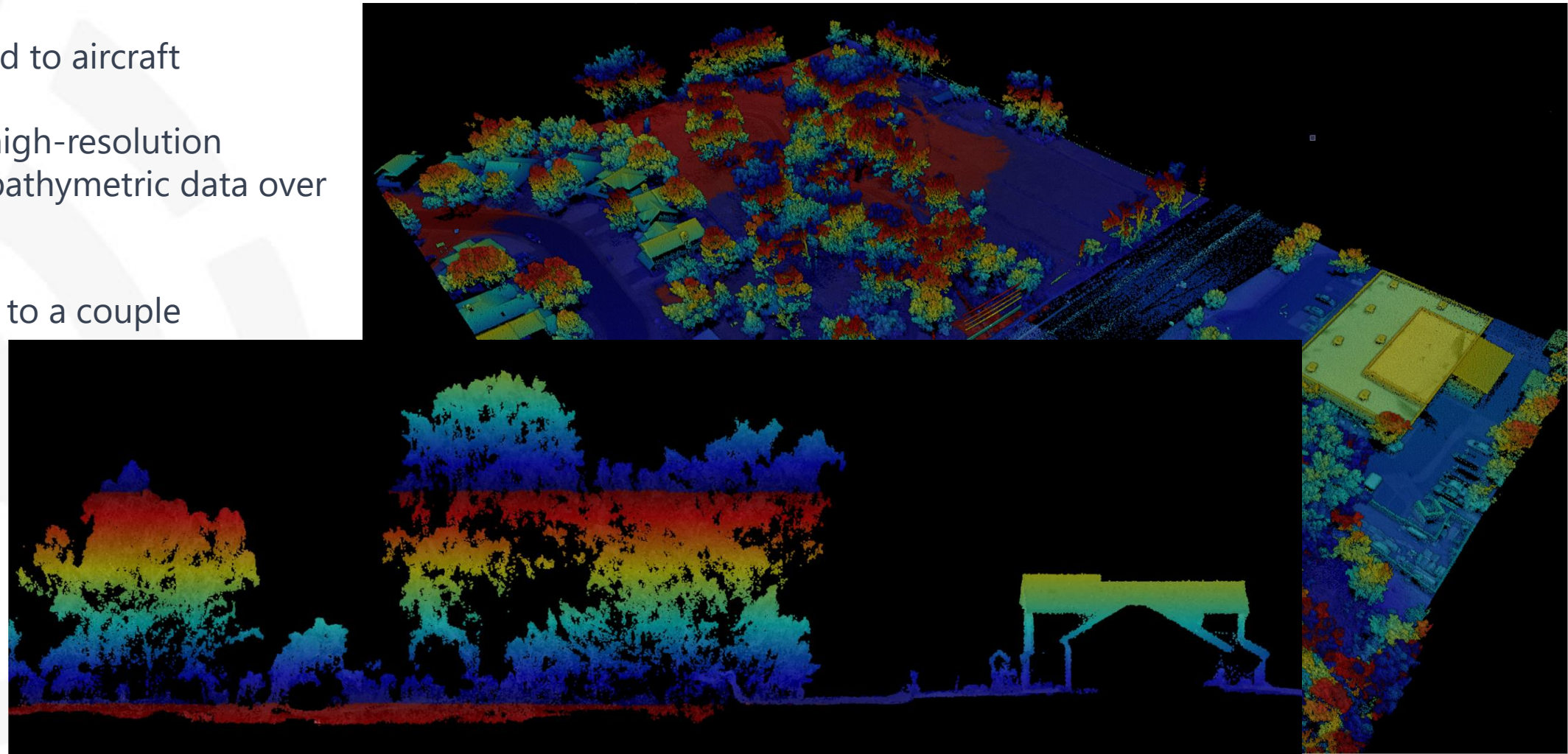


Aerial LiDAR

LiDAR is mounted to aircraft

Used to collect high-resolution topographic or bathymetric data over large areas

Accuracies of up to a couple centimeters



UAS Aerial LiDAR

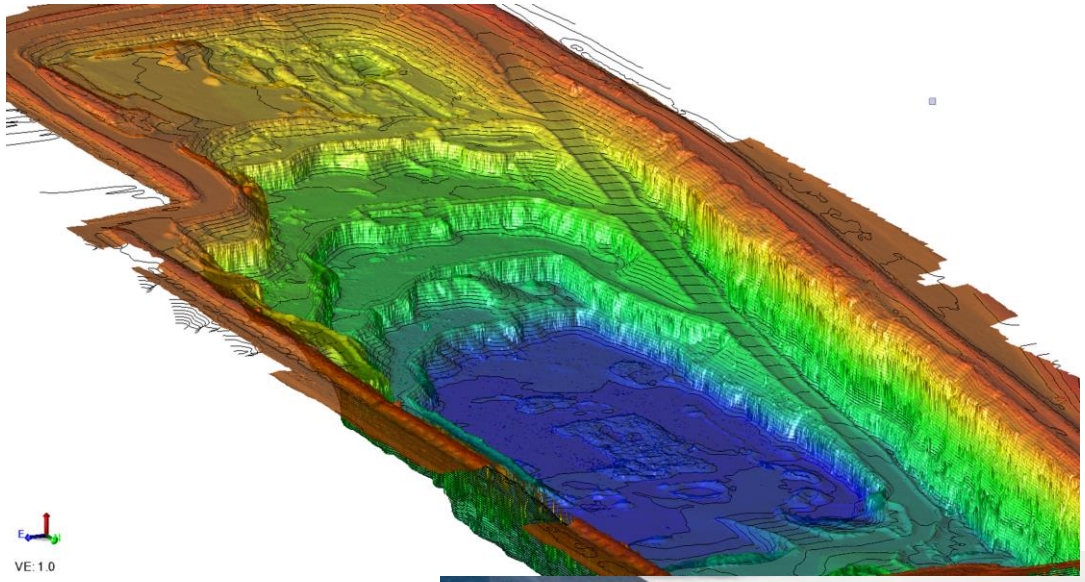
$30k - $250k

Benefits

- Speed of data capture
- Collect tops of features
- Penetrate vegetation for true ground elevations
- Capture dangerous or difficult terrain
- Collect data in poor lighting conditions

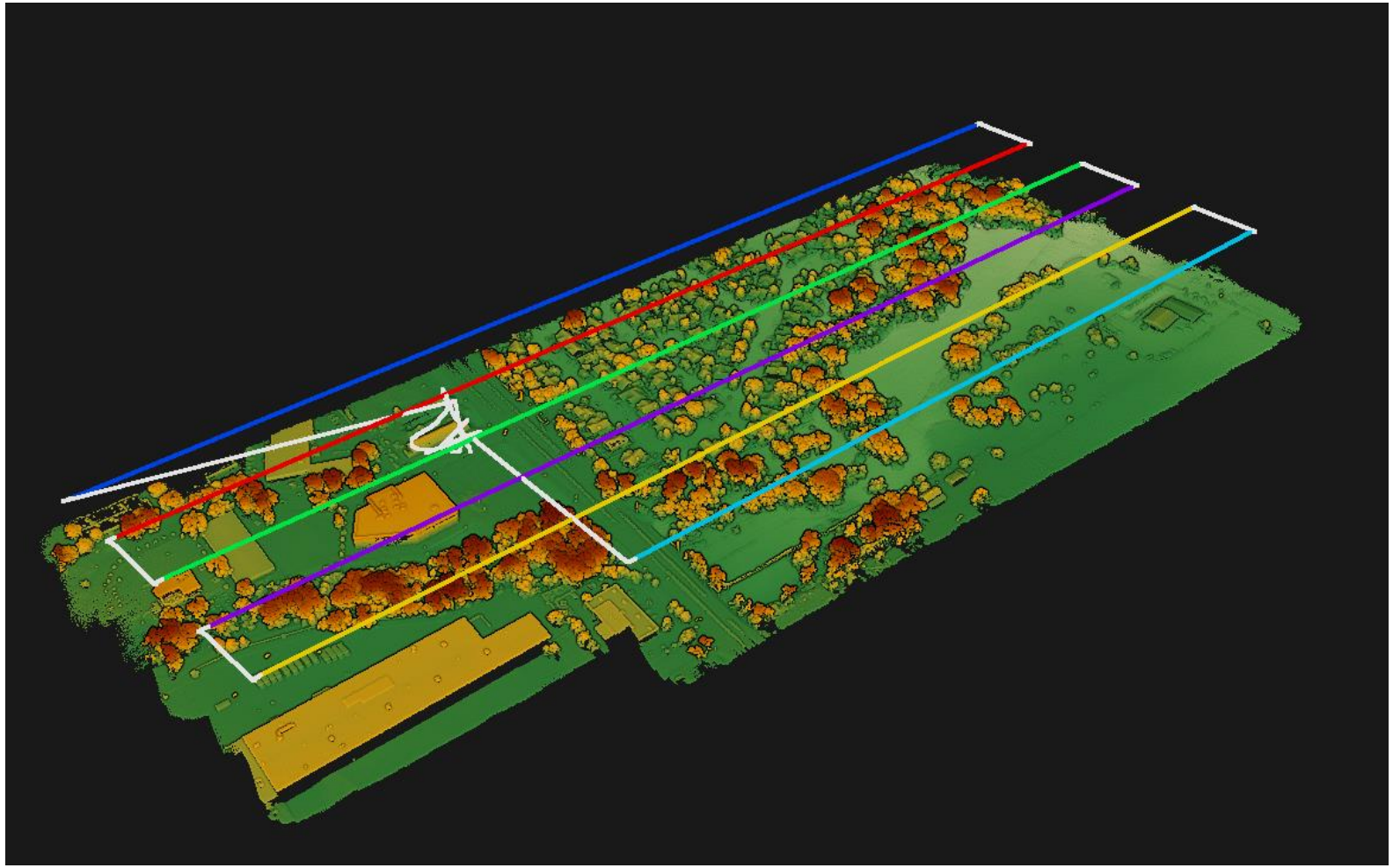
Applications

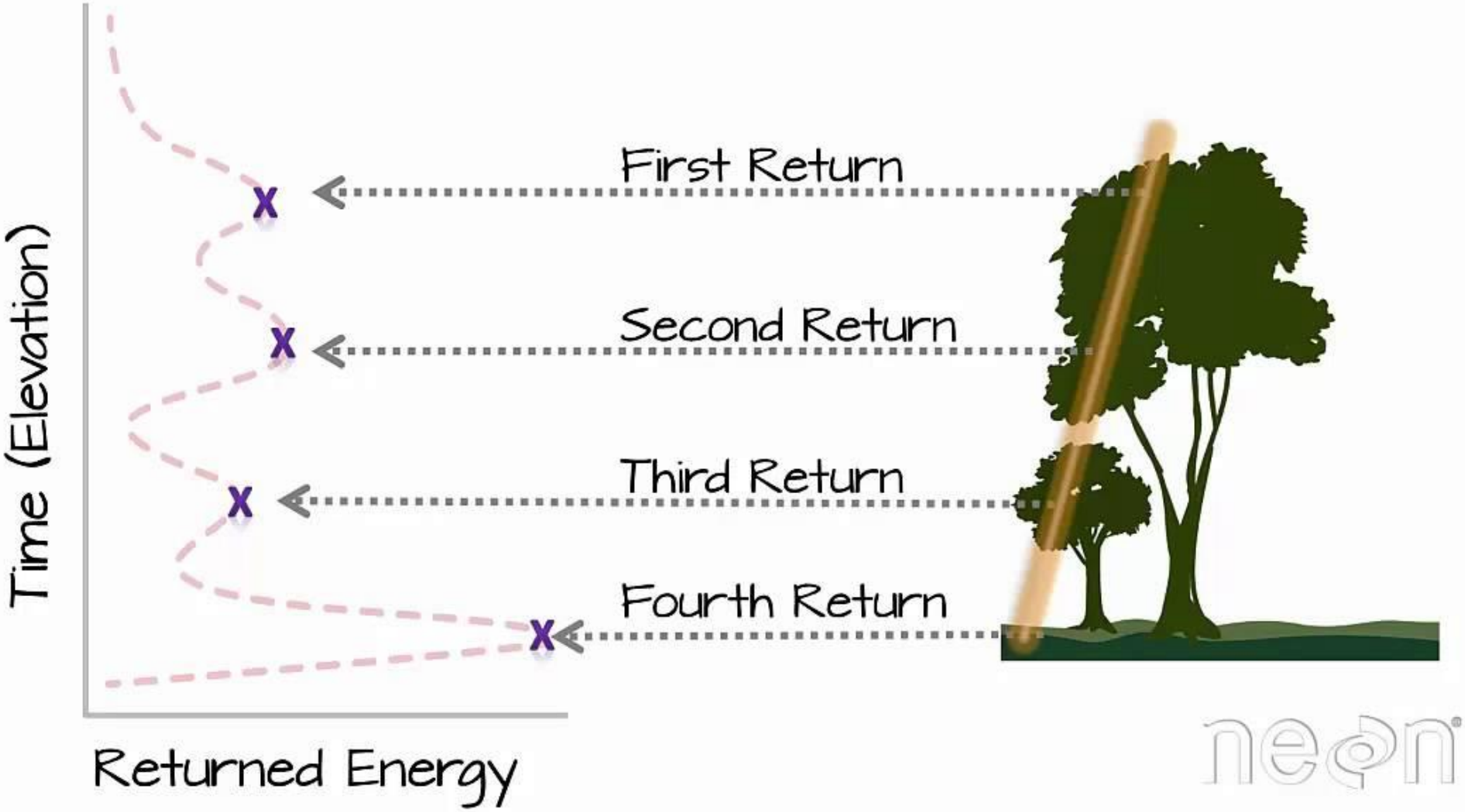
- Environmental changes
- Powerline & Utility surveys
- Pipeline surveys
- Construction site monitoring
- Mining (volume calculation)
- Road and Rail mapping
- Contour mapping



Aerial LiDAR Workflow

- Preplanning of flight routes
- GCP targets
- Part 107
- Flight Scan
- Post processing
- QA/QC
- CAD Feature Extraction & Modelling




First Return
Second Return
Third Return
Fourth Return
Time (Elevation)
Returned Energy
neon

Example Aerial Lidar Comparison

1000 acres

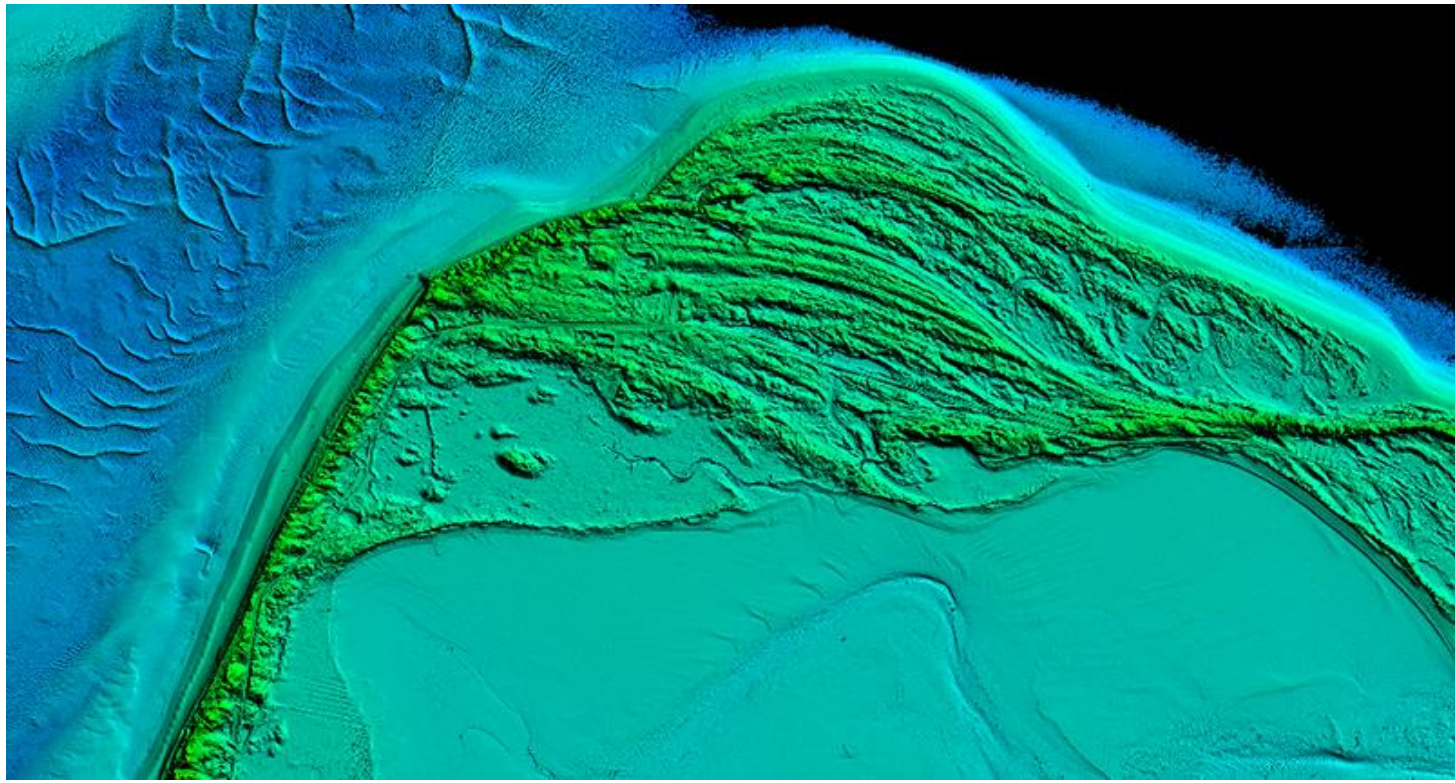
	Traditional Survey	Aerial Lidar
Field Time	10 days – 2 Crews	2 Days
Office Time	4 Days	2 Days
Total	14 Days	4 Days

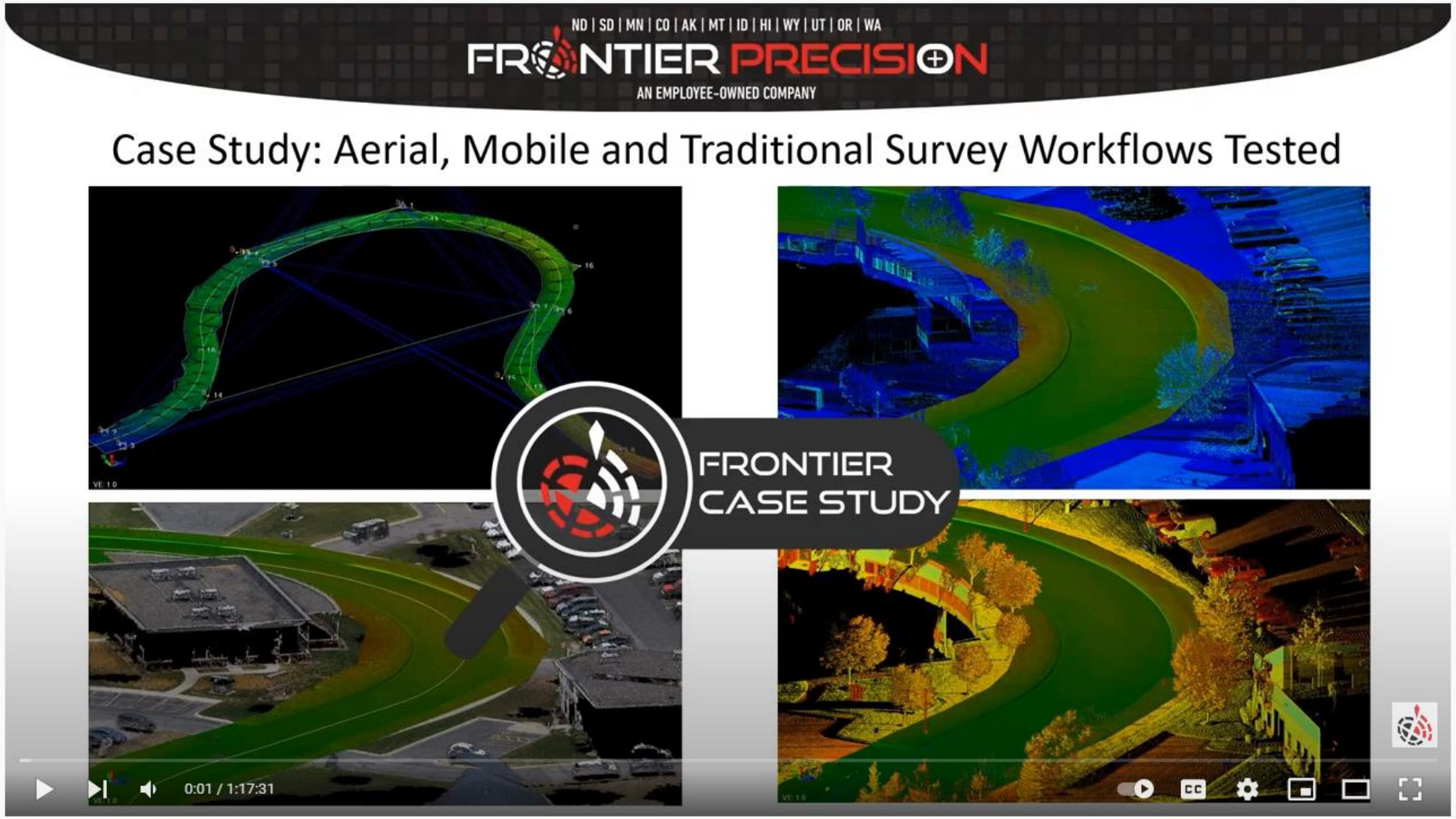
****71% Reduction in Time****

****Traditional Survey would have consisted of a mixture of continuous topo quads and boots on the ground where inaccessible - grid pattern would not be possible****

Bathymetric LiDAR

- Traditional Near-Infrared LiDAR gets absorbed by water, therefore no returns
- Blue-Green LiDAR used in Bathy systems
  - Can penetrate water
  - Signal weakens through water column





Case Study Aerial, Mobile and Traditional Survey Workflows Tested

472 views • Apr 8, 2020

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In this technology webinar we discuss the process and results of our case study that compares emerging technologies in survey data collection to the traditional methods that we are used to using. We compare GNSS, aerial photogrammetry, aerial LiDAR and mobile LiDAR to conventional

SHOW MORE

What do you need for a Data Processing Workstation?

Check your software minimum specs!

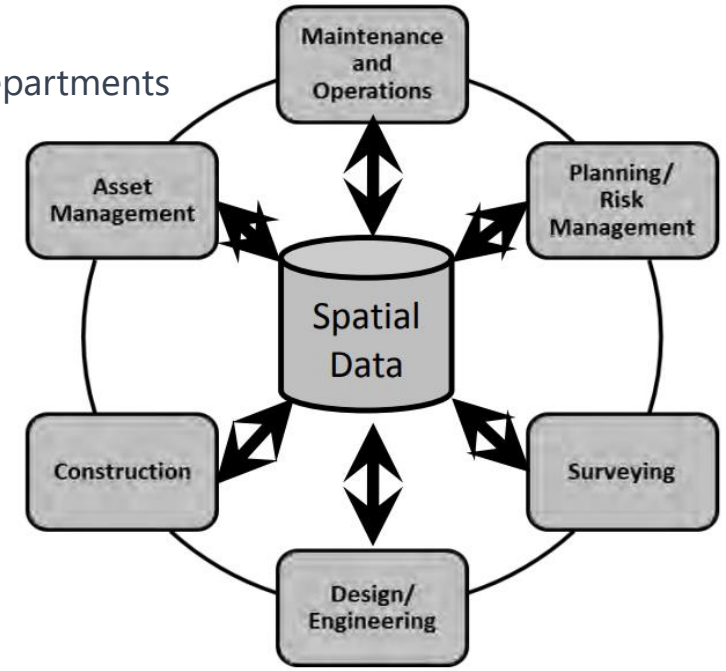
- CPU -> **Quad Core or better** (Hyperthreading = bonus)
    - Intel, AMD
- GPU -> Discrete graphics card! (8gb memory or higher)
    - NVIDIA, AMD
- RAM -> 32 GB or more
- Storage -> Solid State Drives (> 500gb)
    - NVMe
    - SATA

Advantages

- Ability to collect data in a variety of environments and conditions
  - GNSS disadvantaged areas
  - Indoors and outdoors
  - Day or Night
- Safe operations
- Detailed surfaces
- Fast/Efficient data collection
- Integration with other tools/sensors
- Capture beyond physical means
- Utilize same dataset for multiple disciplines/departments

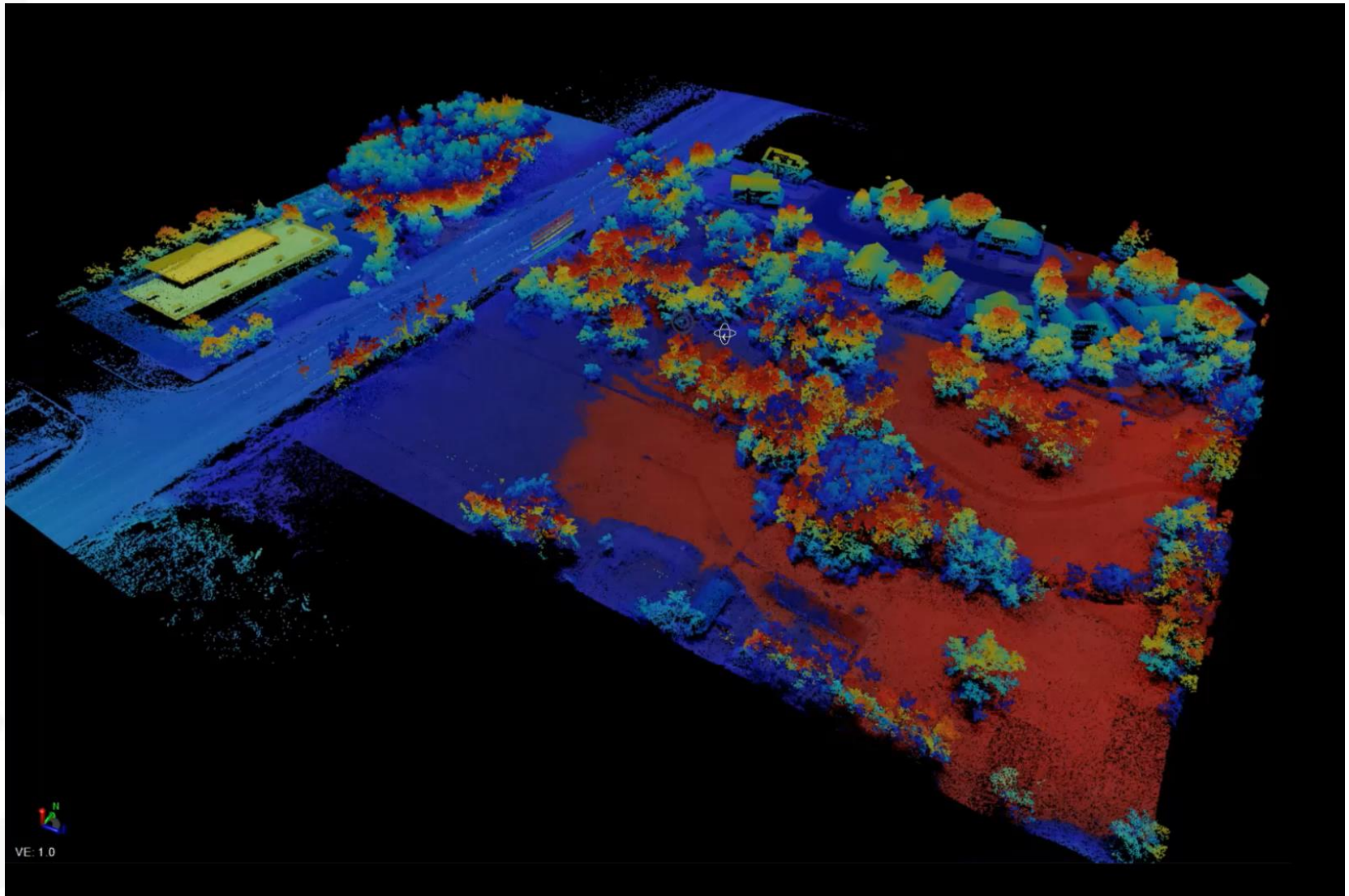
Limitations

- Weather permitting
- Limited penetration through certain materials (e.g., water, vegetation)
- Range
- Cost
- Complexity
- Non-realtime for now



Mobile, Aerial & Terrestrial LiDAR in ONE Project!

Here's how we did it…



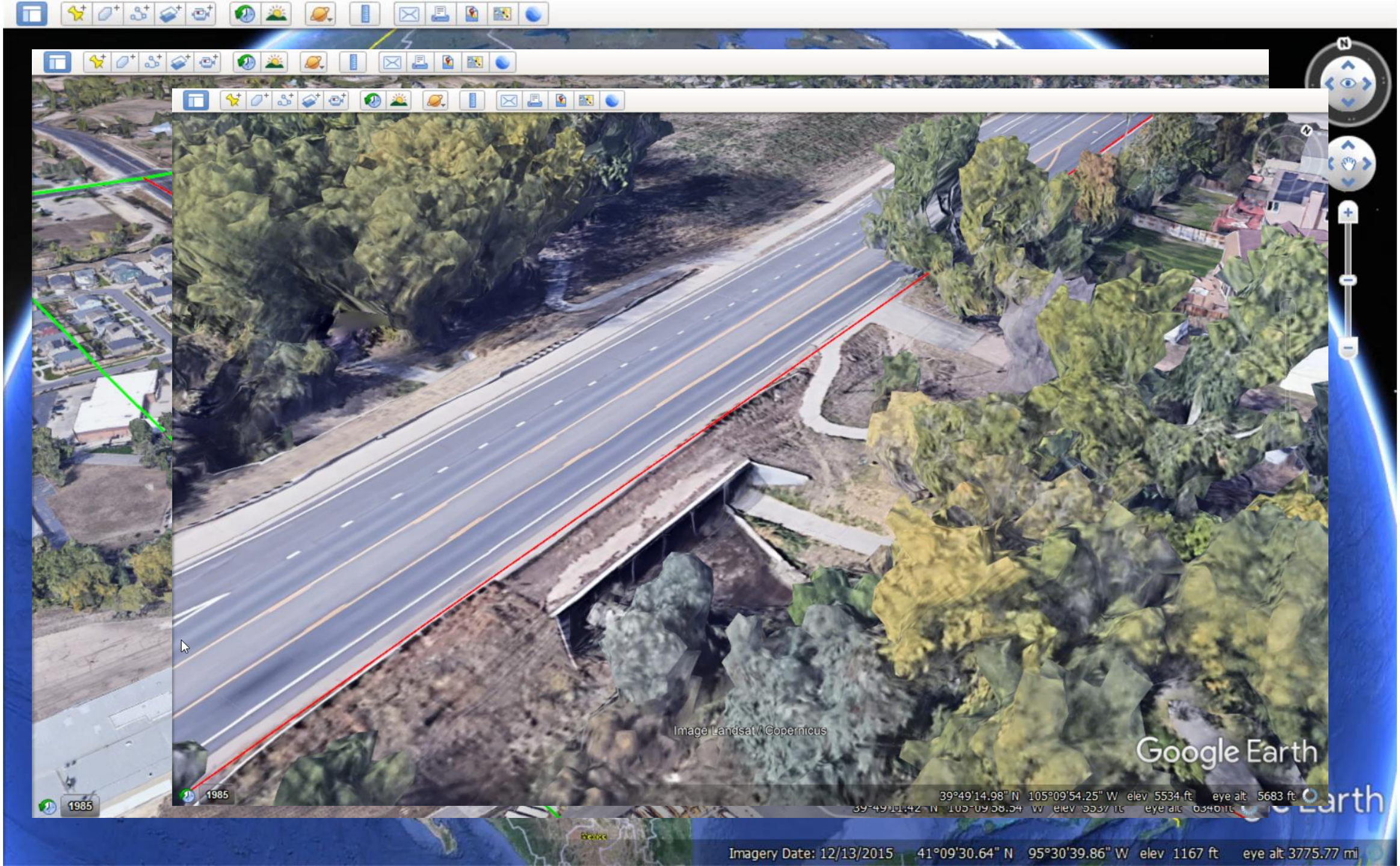
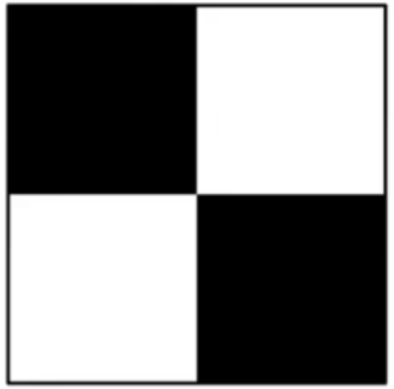


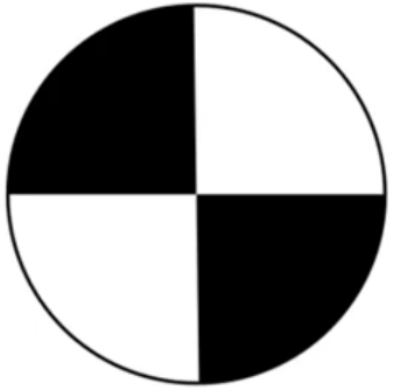
Image Landsat / Copernicus
Google Earth
1985
39°49'14.98" N 105°09'54.25" W elev 5534 ft eye alt 5683 ft
1985
Imagery Date: 12/13/2015 41°09'30.64" N 95°30'39.86" W elev 1167 ft eye alt 3775.77 mi

Mobile, Aerial & Terrestrial LiDAR in ONE Project!

1. Start with Ground Control (GCPs)

High contrast targets are well suited for recognition

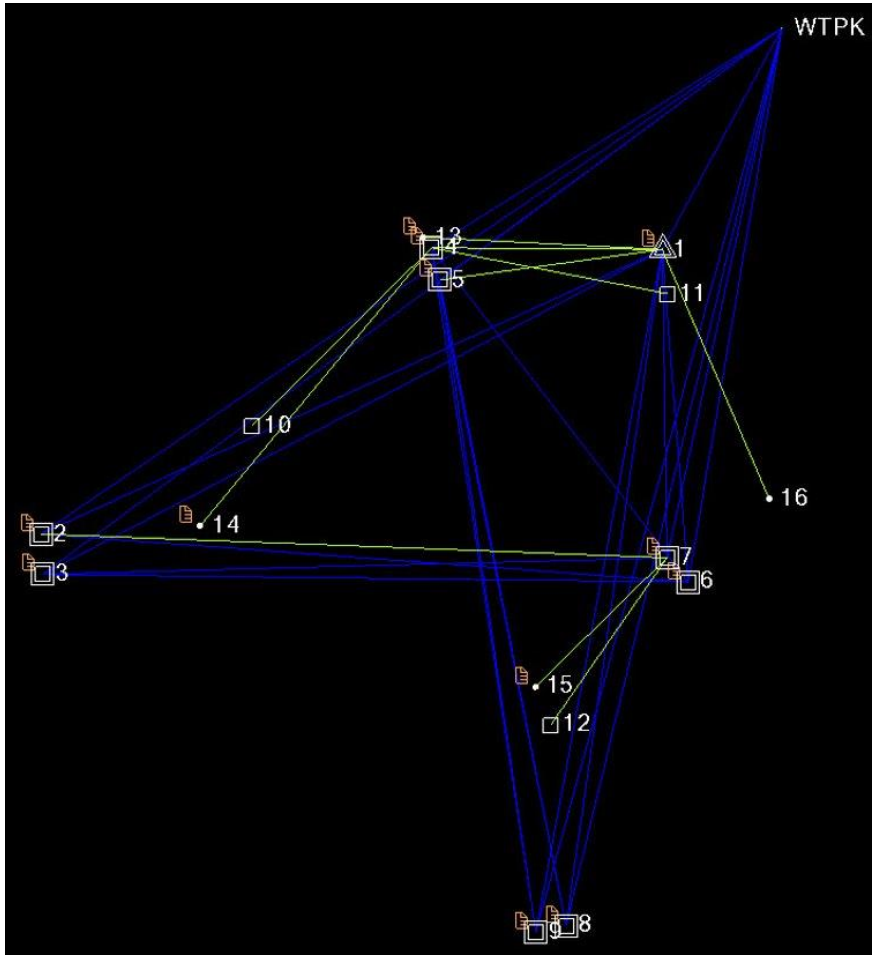




Mobile, Aerial & Terrestrial LiDAR in ONE Project!

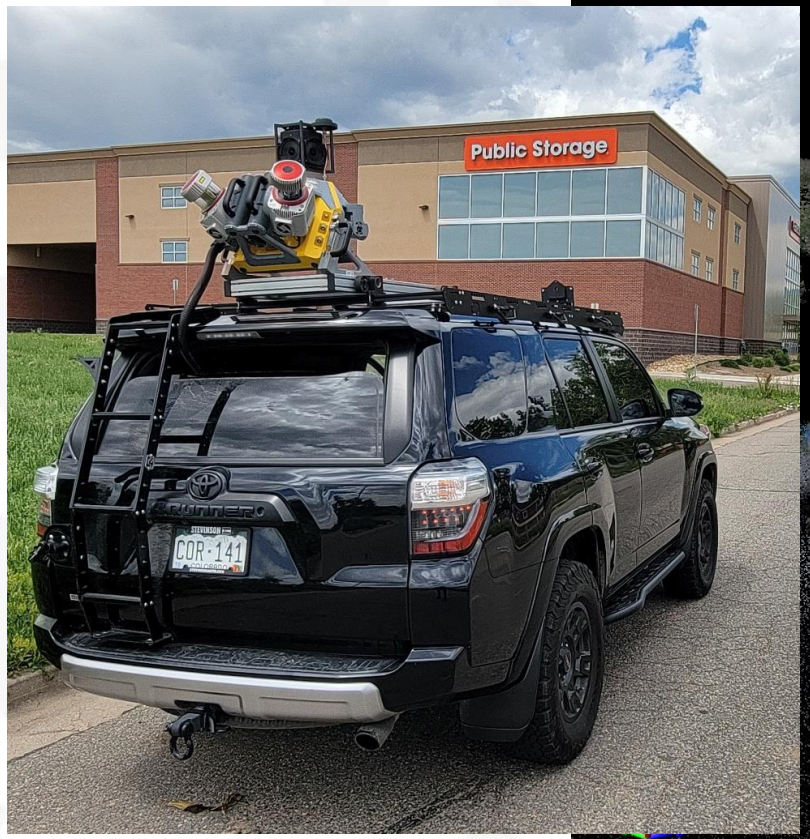
- RTK
- Static GNSS
- Total Station
- Trig Levelling
- Least Squares Network Adj.

- What is acceptable for your project?



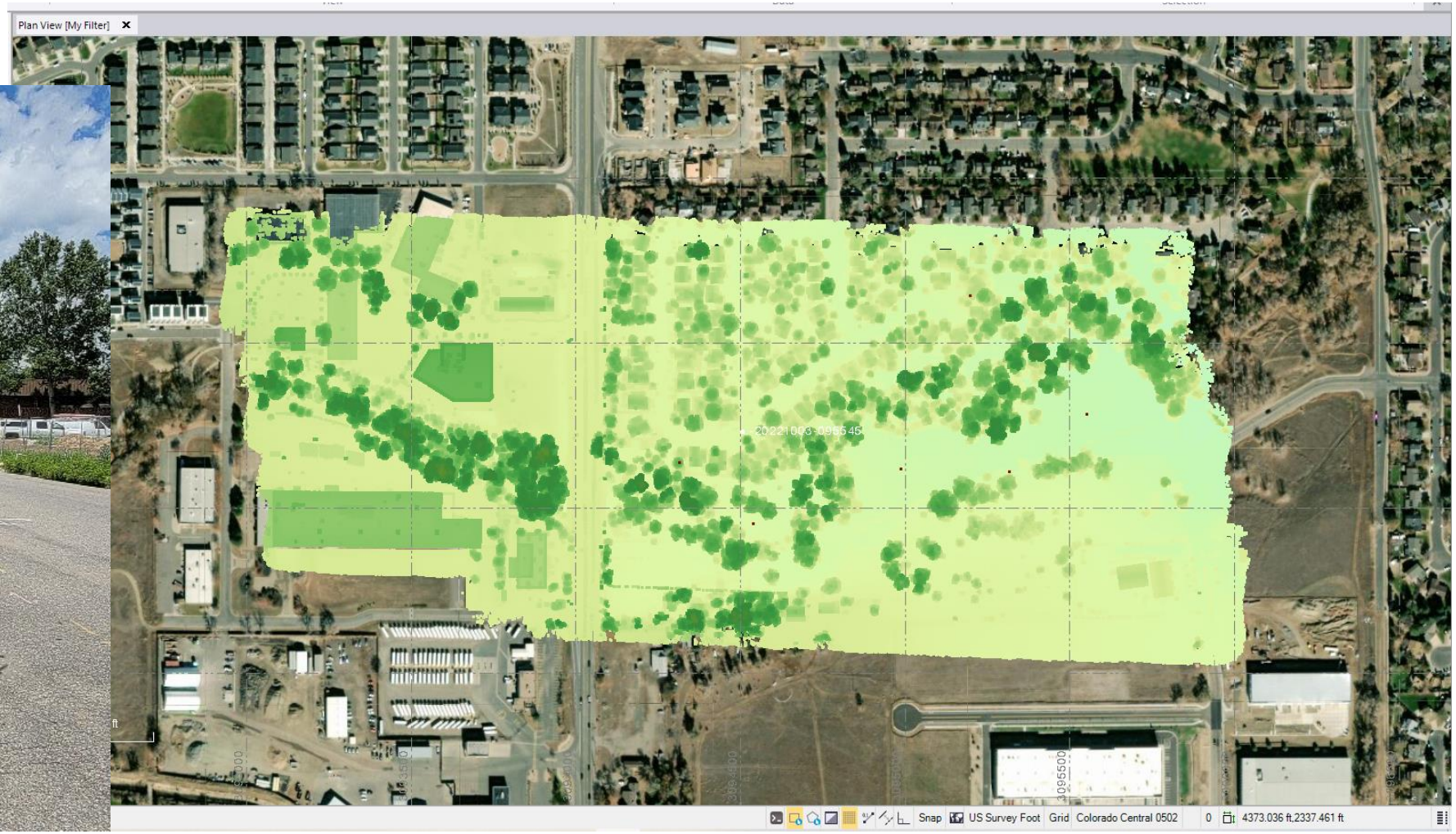
Mobile, Aerial & Terrestrial LiDAR in ONE Project!

2. Drive Mobile LiDAR



Mobile, Aerial & Terrestrial LiDAR in ONE Project!

3. Fly Aerial LiDAR

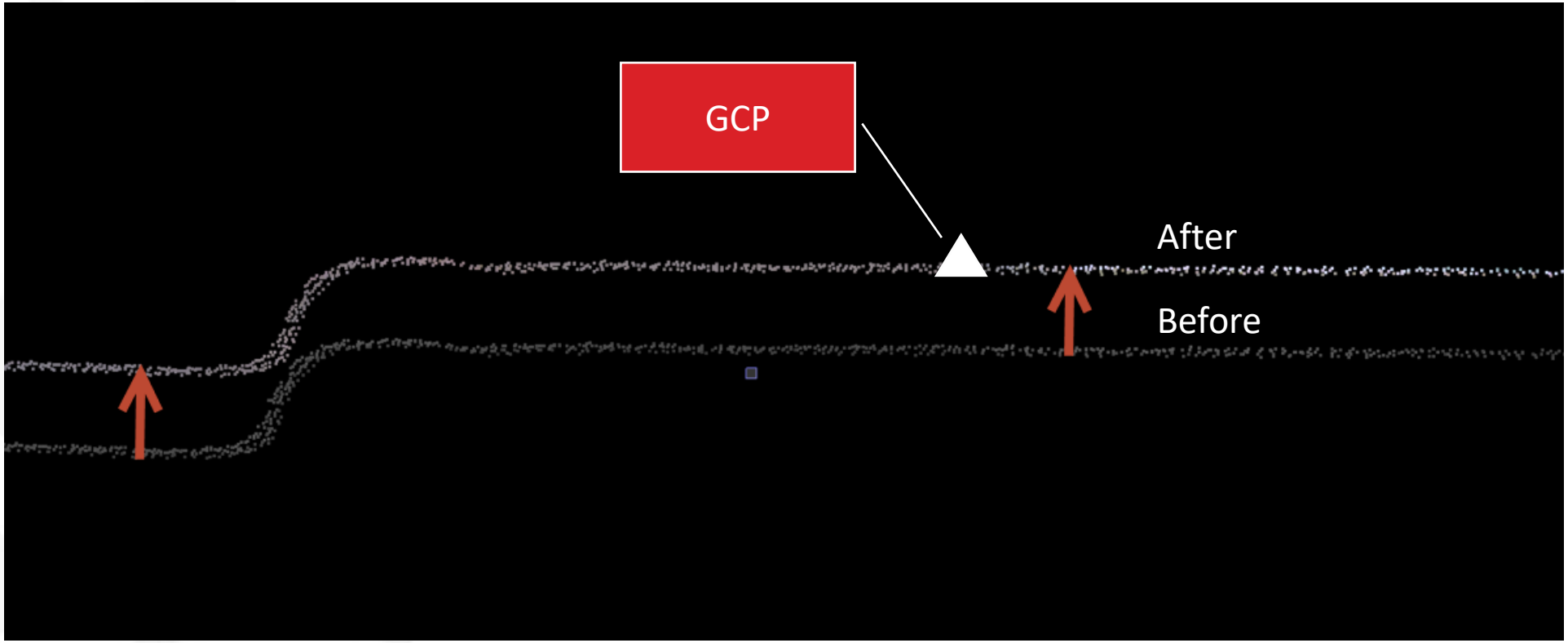


Mobile, Aerial & Terrestrial LiDAR in ONE Project!

4. Terrestrial Scanning

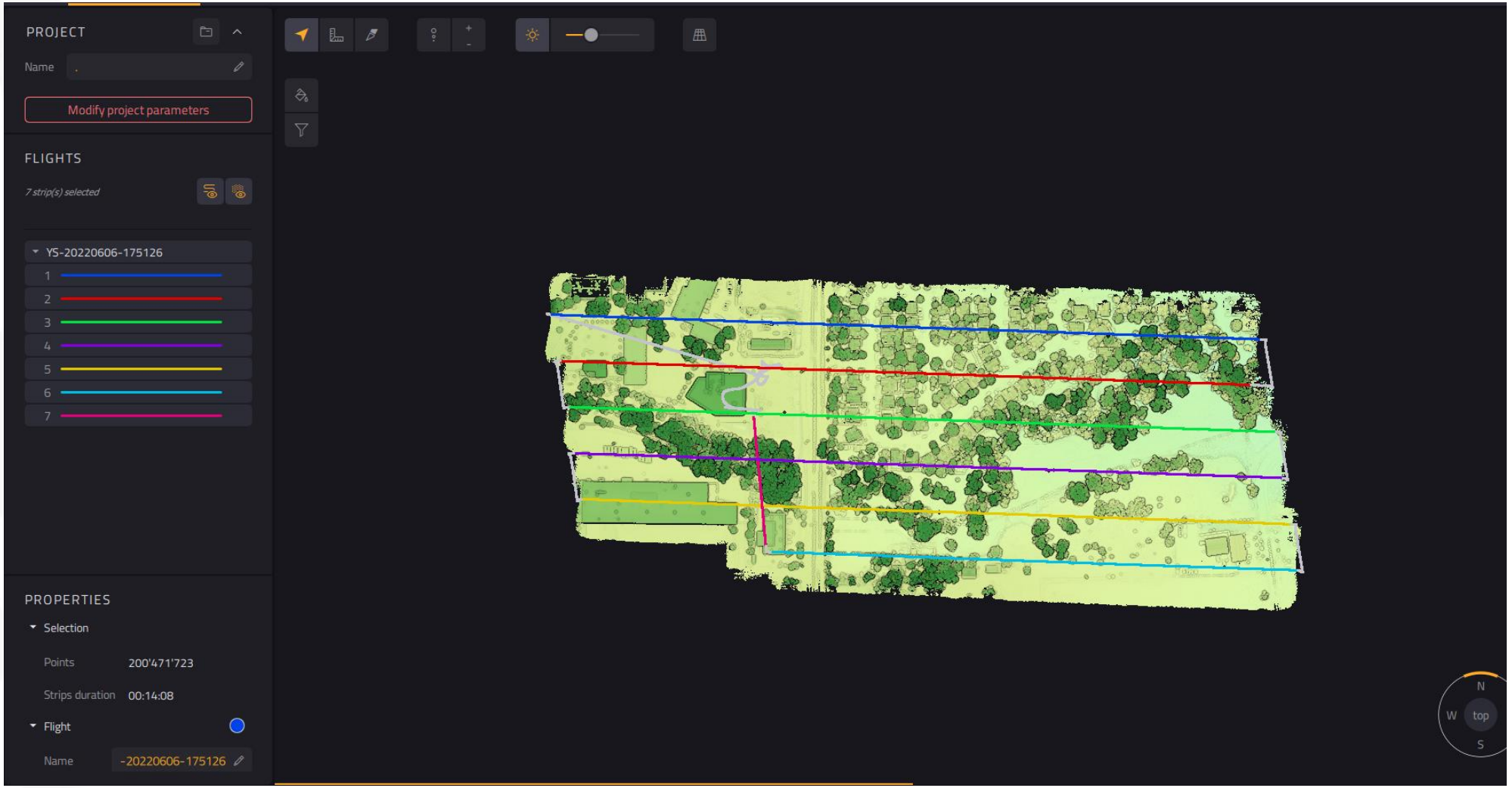
Mobile, Aerial & Terrestrial LiDAR in ONE Project!

5. Post Process Mobile LiDAR to GCP



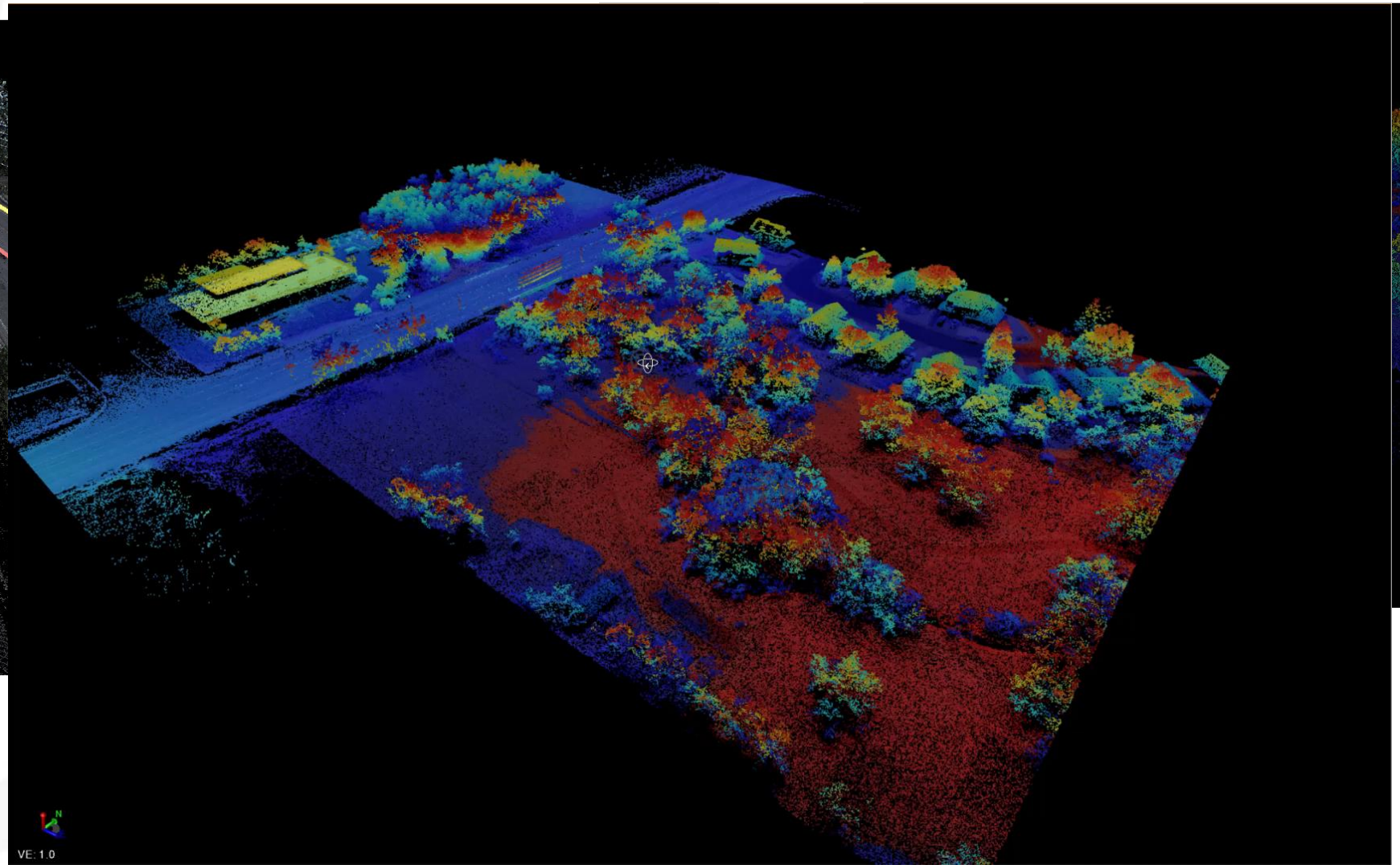
Mobile, Aerial & Terrestrial LiDAR in ONE Project!

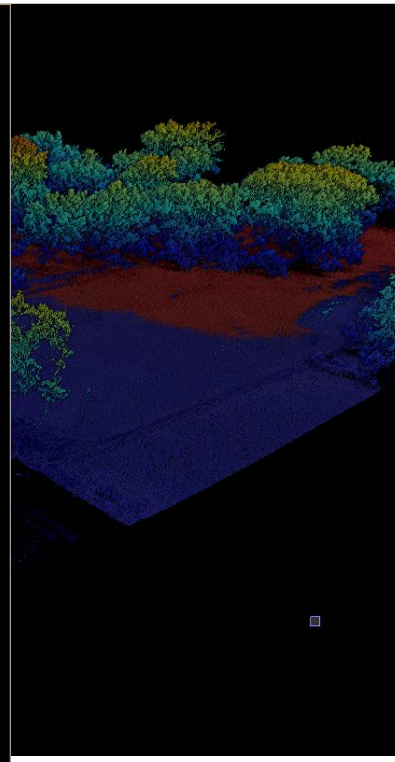
6. Post Process Aerial LiDAR w/ Strip adjustment



Mobile, Aerial & Terrestrial LiDAR in ONE Project!

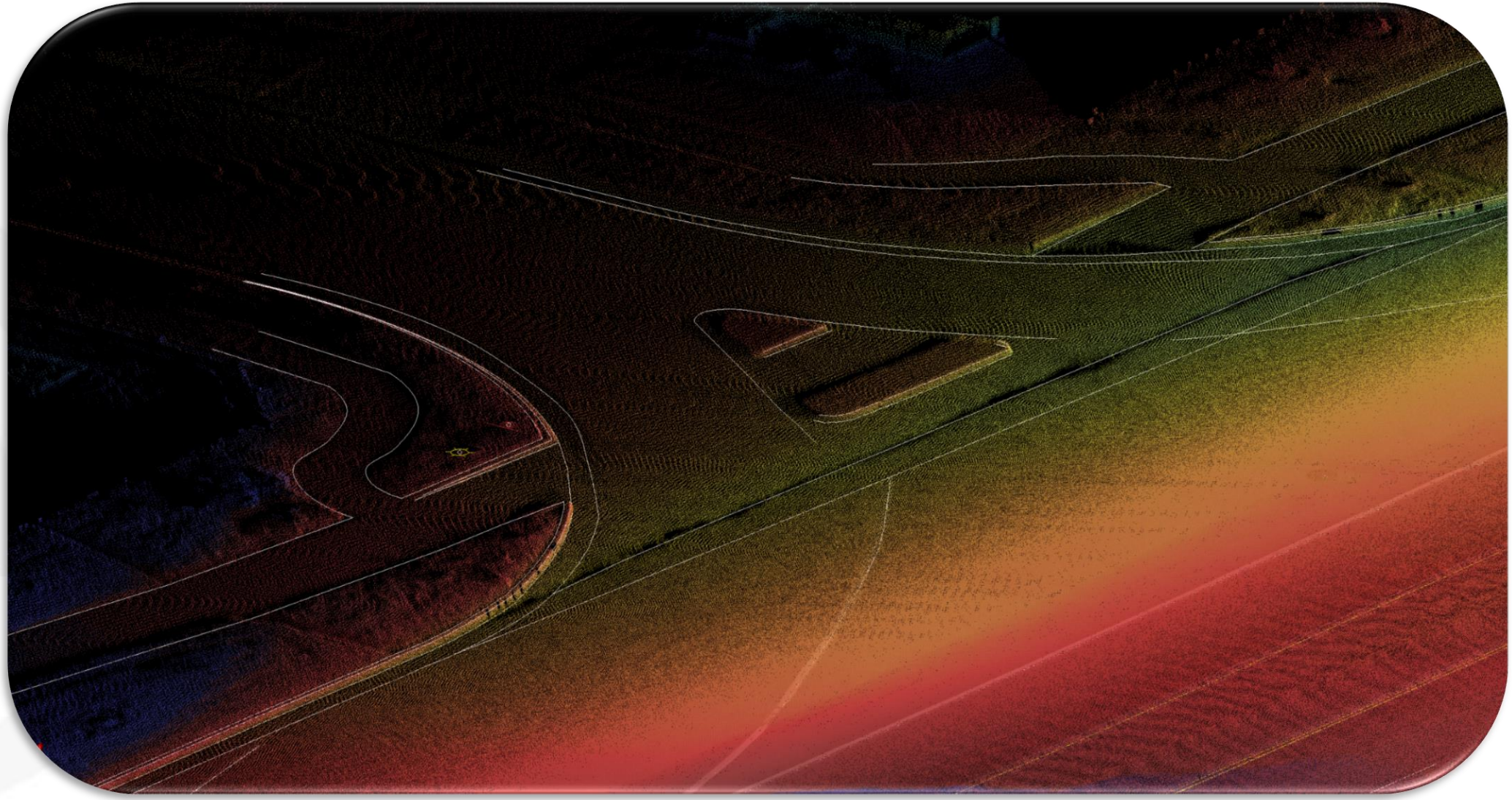
7. Combine All Data





Mobile, Aerial & Terrestrial LiDAR in ONE Project!

8. Create Linework



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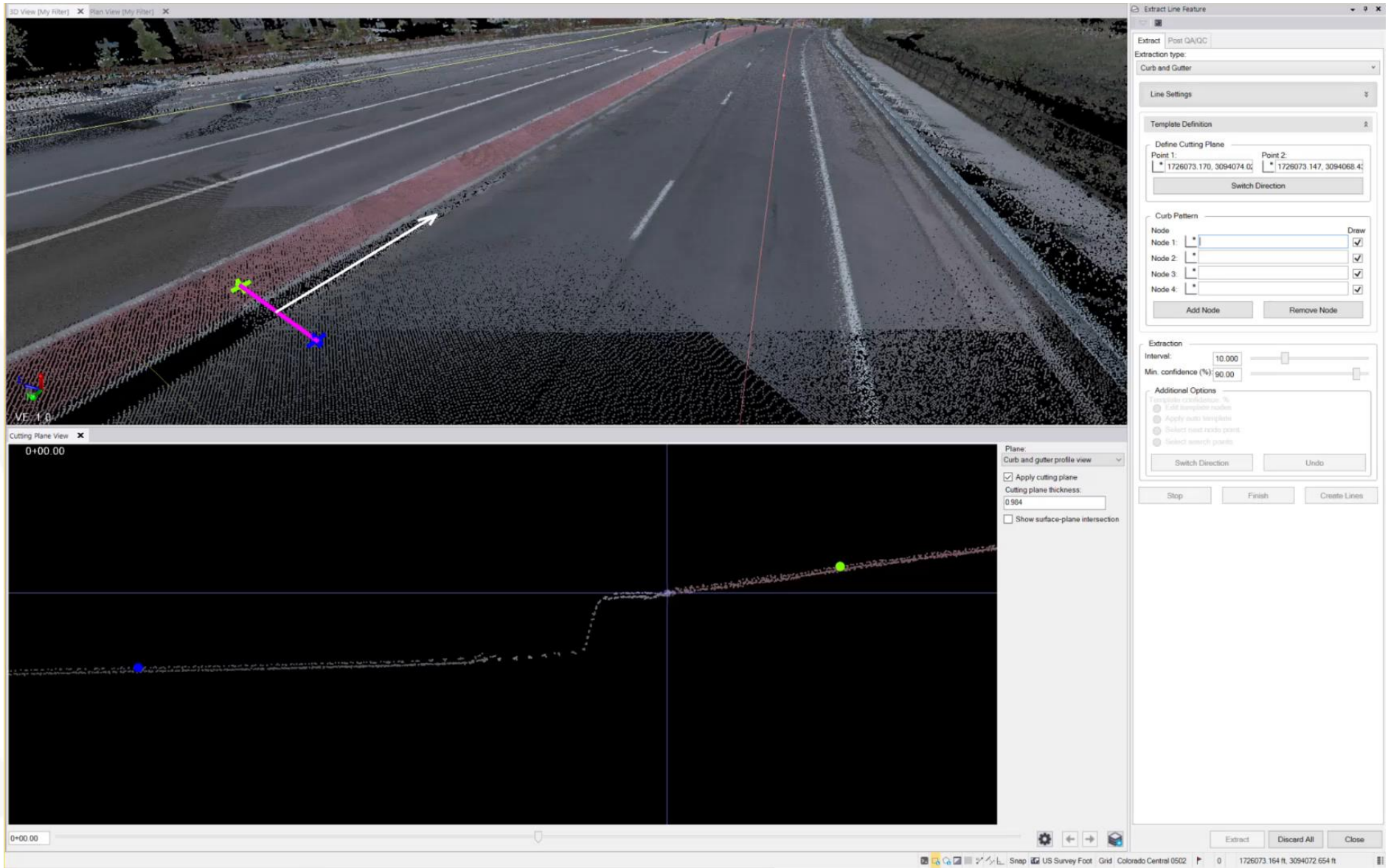

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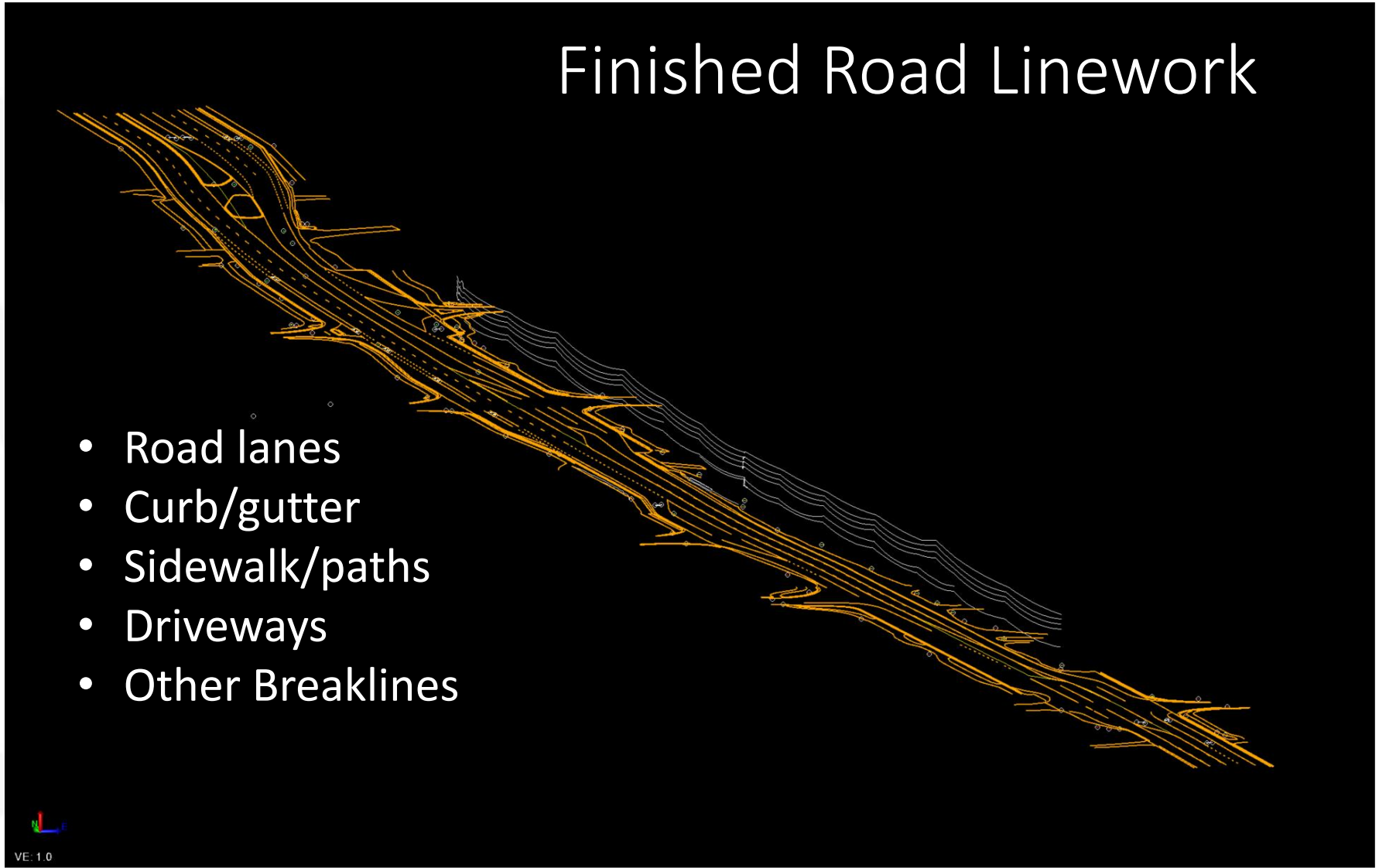

Mobile, Aerial & Terrestrial LiDAR in ONE Project!

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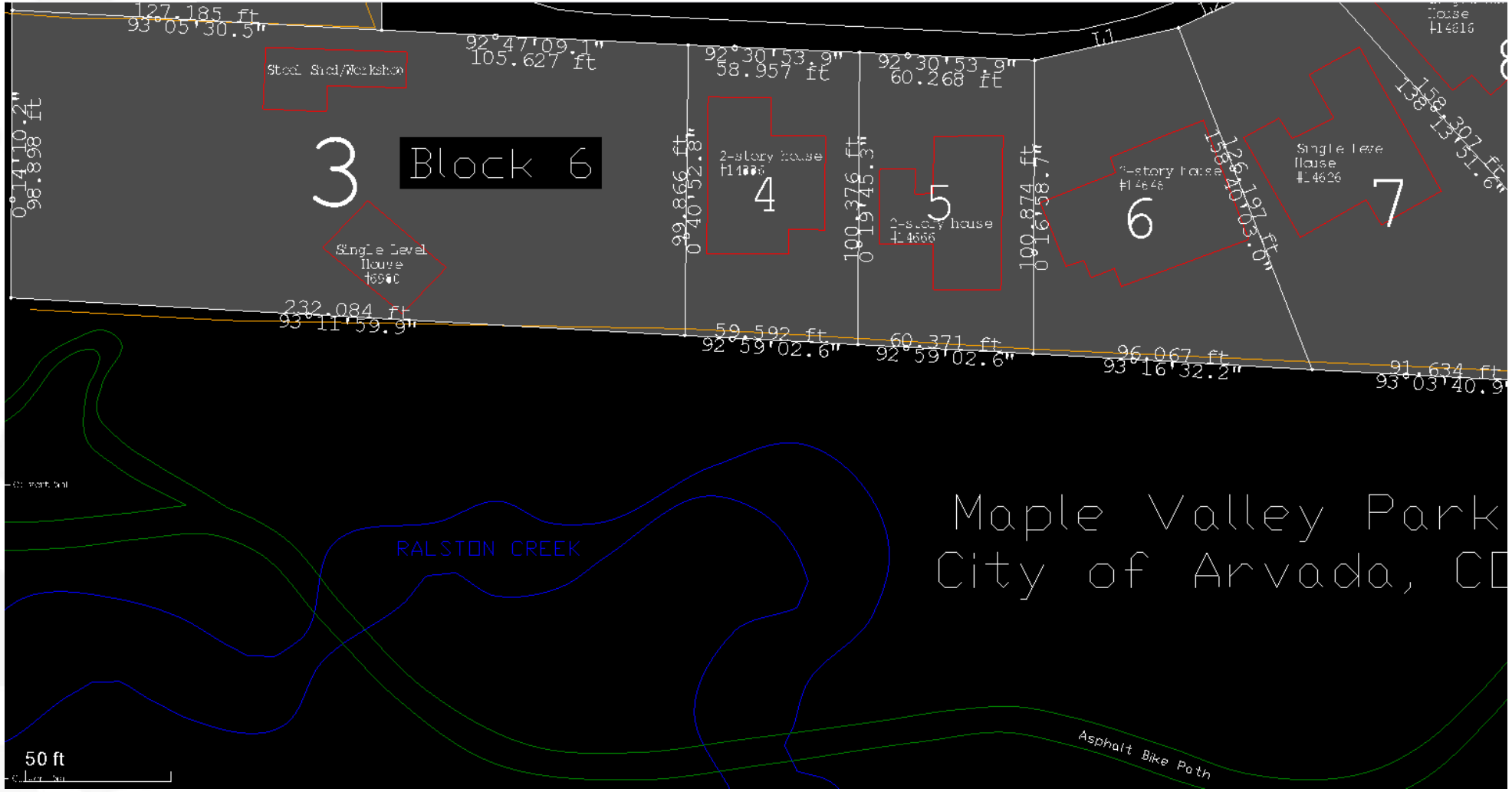
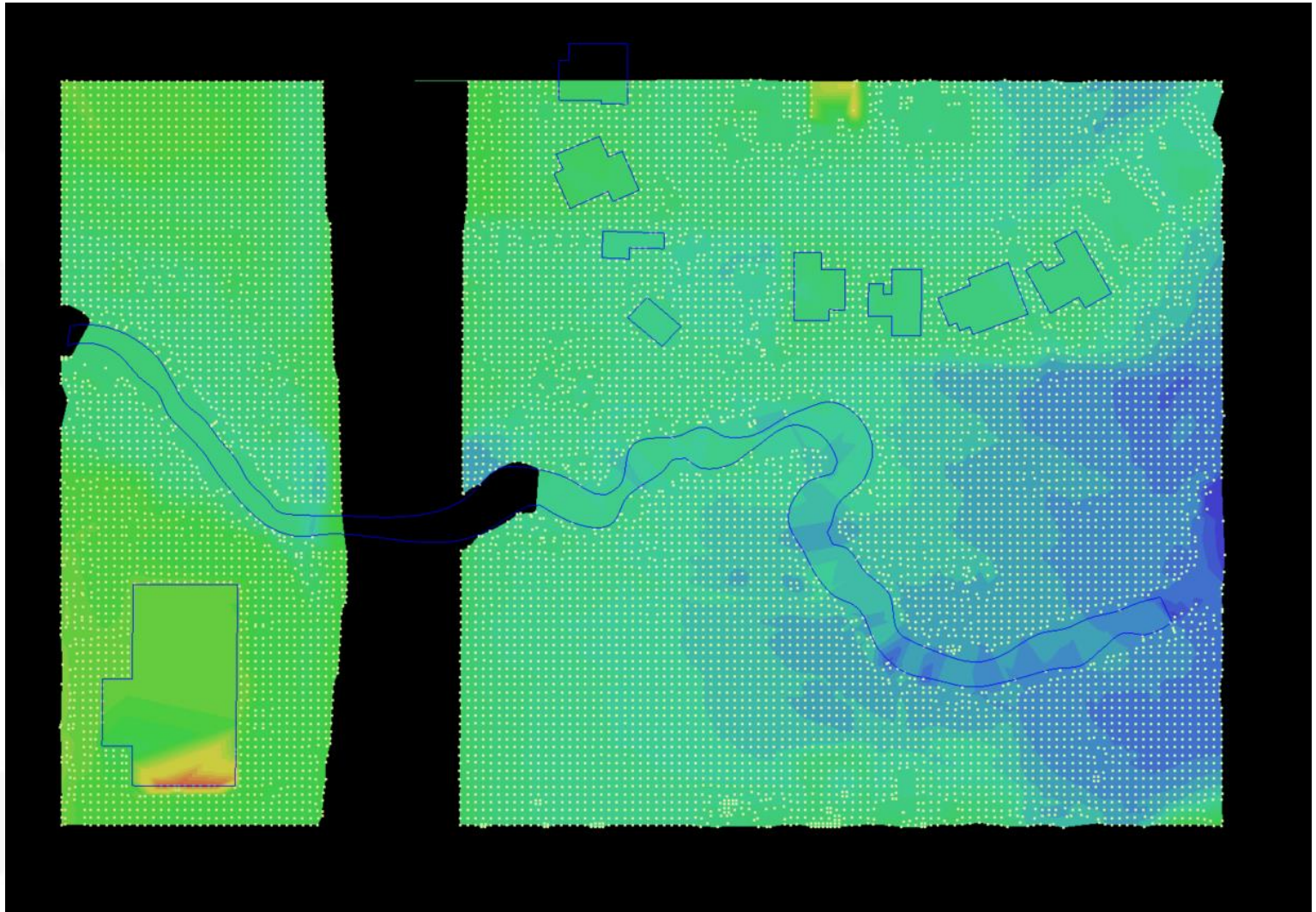


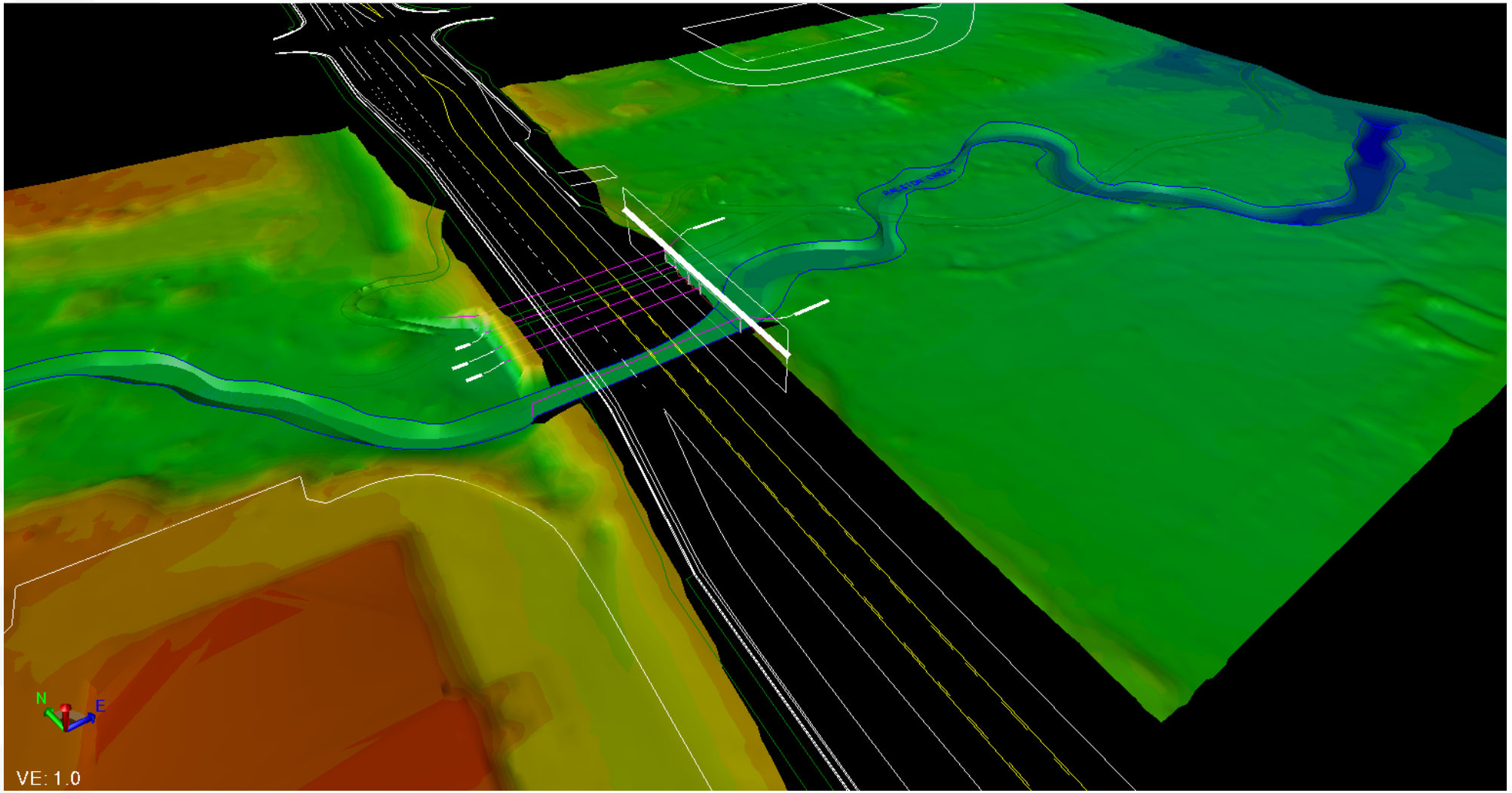
Mobile, Aerial & Terrestrial LiDAR in ONE Project!

9. Sample Ground & Create Surfaces



Mobile, Aerial & Terrestrial LiDAR in ONE Project!

9. Sample Ground & Create Surfaces



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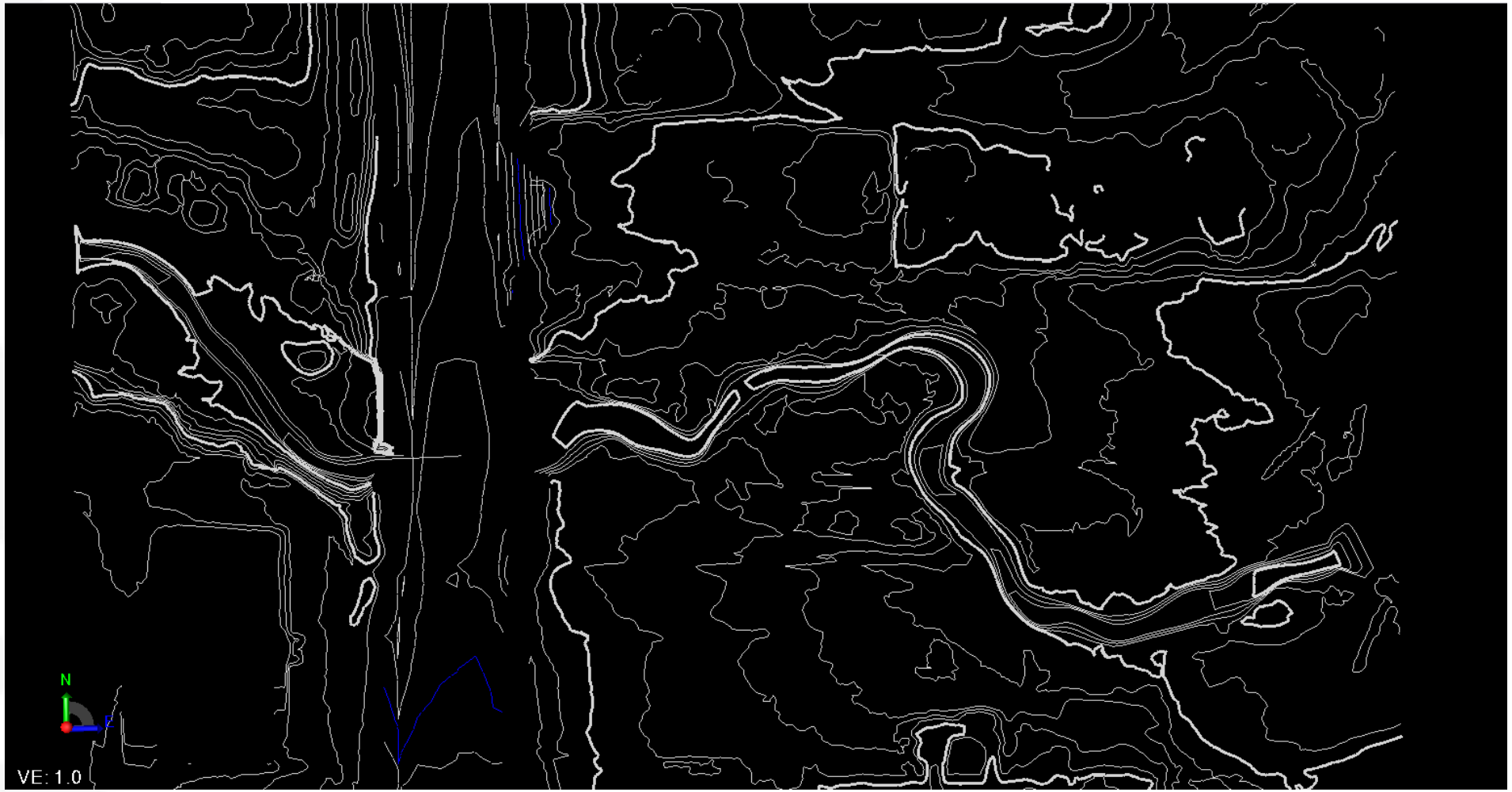
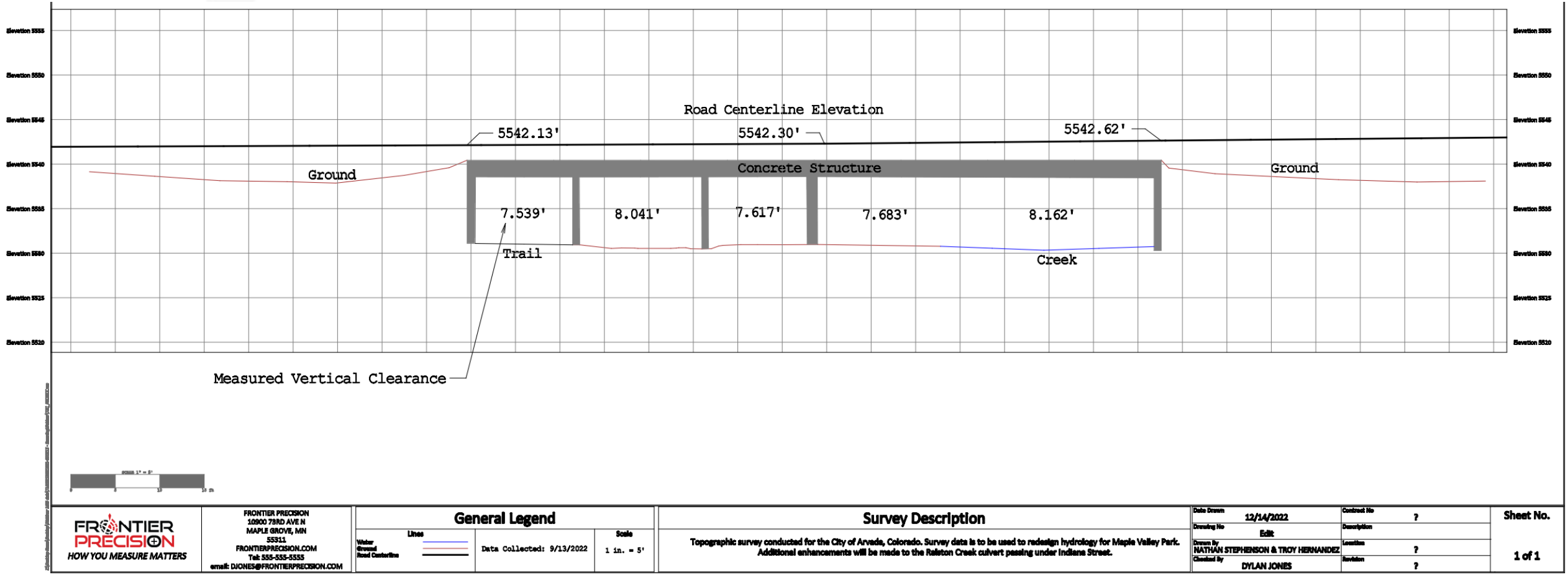
10. Create Contours



Mobile, Aerial & Terrestrial LiDAR in ONE Project!

11. Create Printable Deliverable



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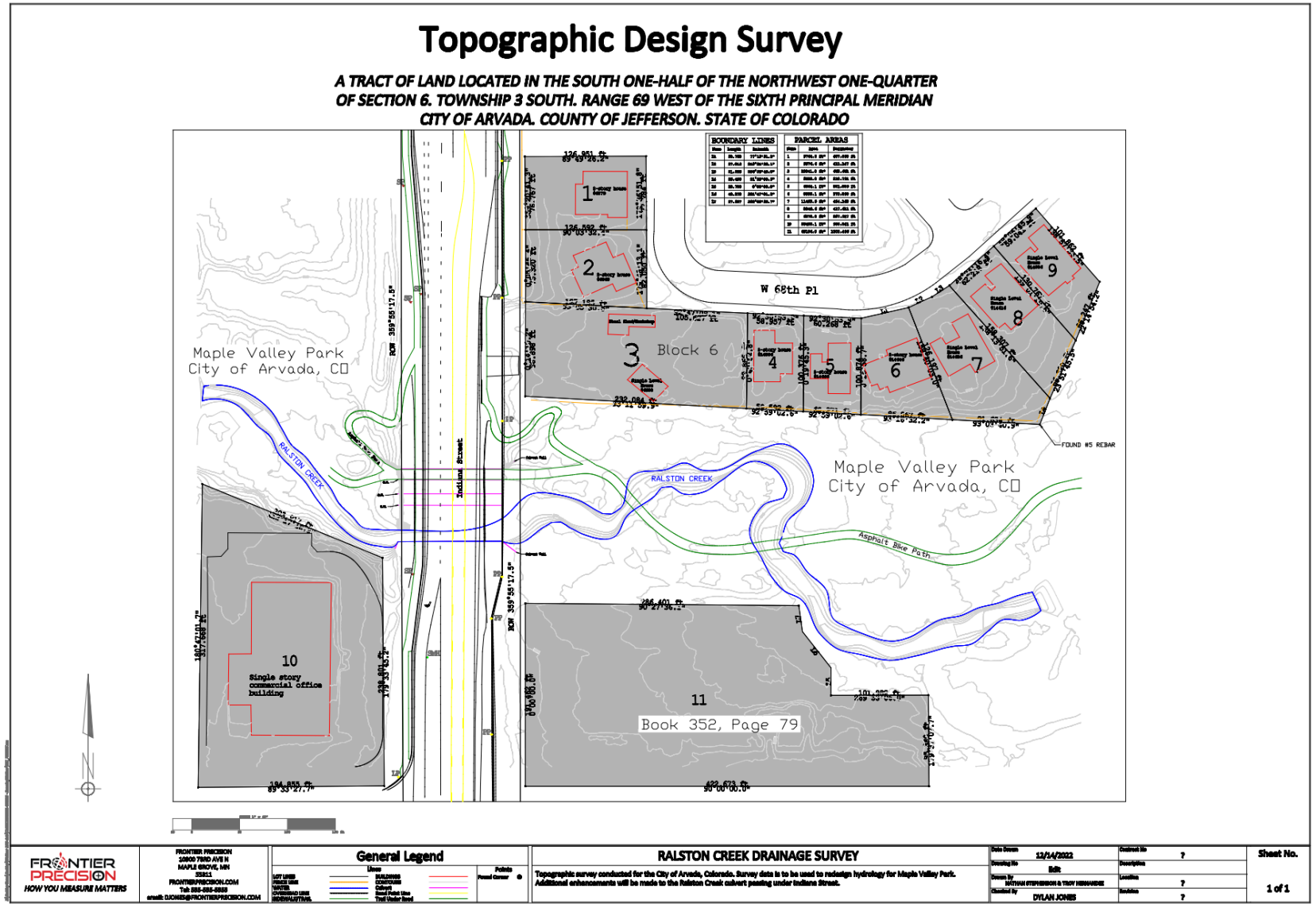


EVENT DETAILS

- **Date:** January 19, 2023 3:00 pm – 4:00 pm
- **Categories:** Technology Webinars
- **Tags:** 3D Laser Scanning, Aerial LiDAR, Laser Scanning, LiDAR, Mobile LIDAR, Mobile Scanning, Scanning, Technology Webinar, Terrestrial LiDAR, Webinar

Thursday | January 19, 2023 | 3:00 PM – 4:00 PM CST

This final session in our Conception to Completion Webinar Series will focus on a final deliverable incorporating all the LiDAR-based data discussed in the "Conception to Completion" series to this point (Mobile, Aerial, and Terrestrial). Additionally, we will focus on the survey interface and statistics involved. Our resultant product will be a traditional plat derived from non-traditional LiDAR data. As we wrap up this series focusing on the deliverables, this is the session you don't want to miss!

LiDAR Mapping Trends

Trend 1: New processing algorithms
Near-realtime processing of point clouds

Trend 2: Cloud-based processing
Centralization of data, collaboration, parallelization of tasks, storage

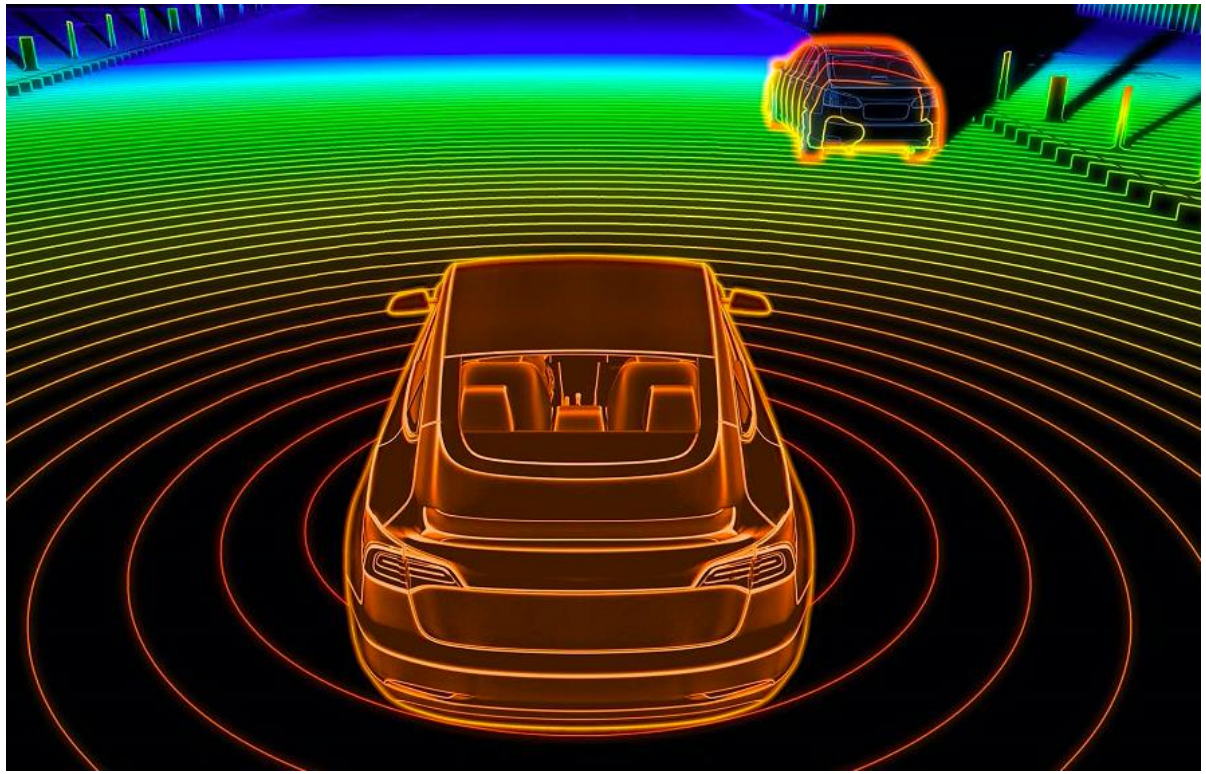
Trend 3: Feature extraction and data classification
Optimize extraction and classification efforts with AI-based tools

Trend 4: Mobile mapping and SLAM
Need for more data, faster!

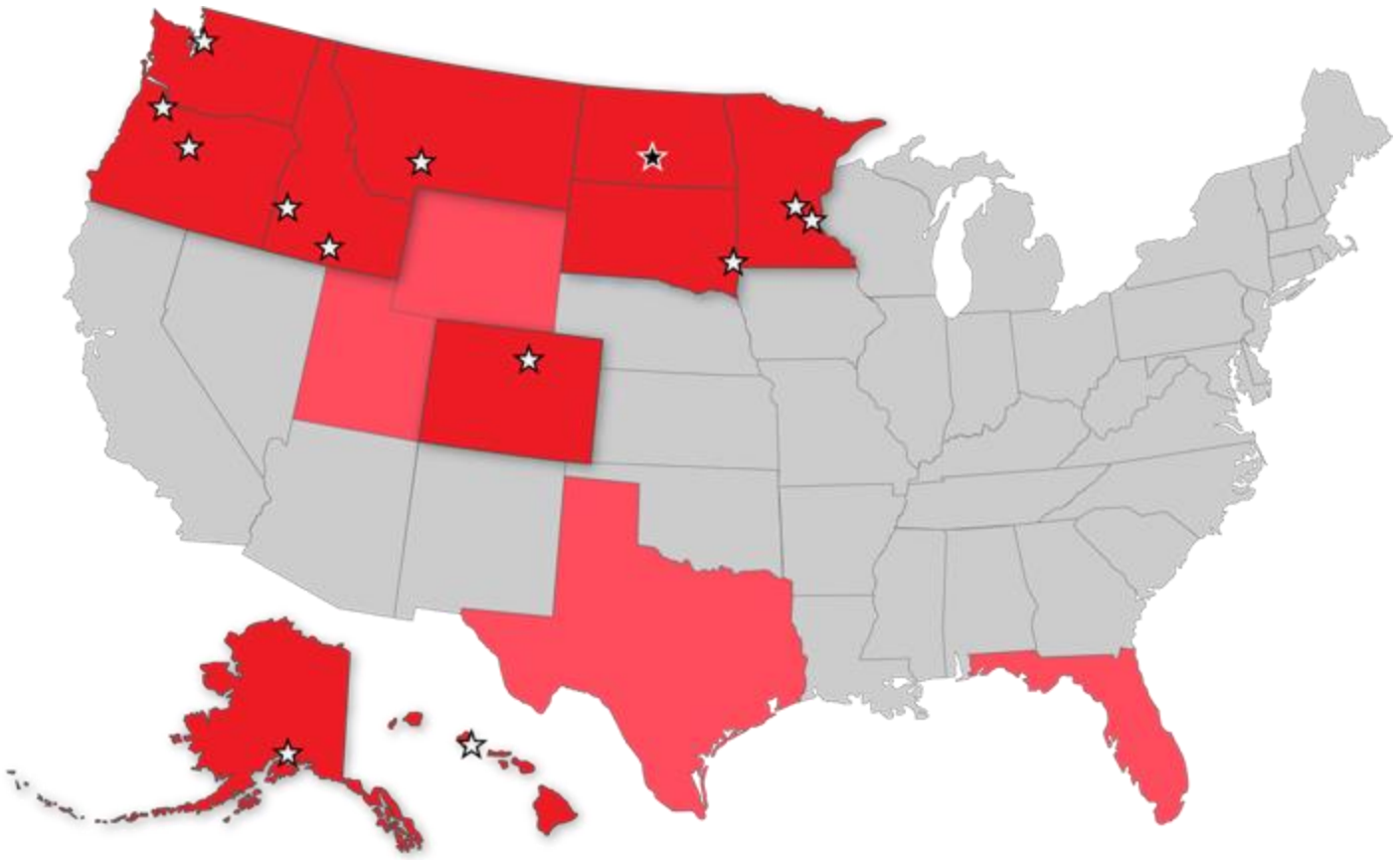
Trend 5: Hardware advancements
More data, sensor fusion, lighter, smaller, durable, more versatile equipment

Future Advancements of LiDAR

- Autonomous vehicles
- Consumer Electronics (phones & tablets)
- Virtual and Augmented Reality for immersive experiences
  - Education
  - Entertainment
  - Tourism
  - Business Collaboration
- Infrastructure inspection
- Environmental monitoring
  - Big Data analytics and machine learning (land use, permitting, deterioration)
- Digital Twins
  - Virtual model of a physical object or system
  - Test or simulate on the Digital Twin before implementing in physical world
  - Make smarter decisions
  - Need for up-to-date geospatial data



WHEREVER YOU ARE, **WE ARE**.



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We pride ourselves on offering exemplary customer service; and our industry professionals are here to help you find a solution to fit your needs.

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