3D Laser Mapping:
The power to discover

Jim van Rens
President
Riegl USA
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Introduction

- Laser mapping is an important and indispensable metrology tool in the area of surveying and engineering
- In these areas and others, Laser mapping compliments measurement technologies such as GPS and total stations and close-range photogrammetry
- We will review the technology, a leading system, field operations and typical results from the system

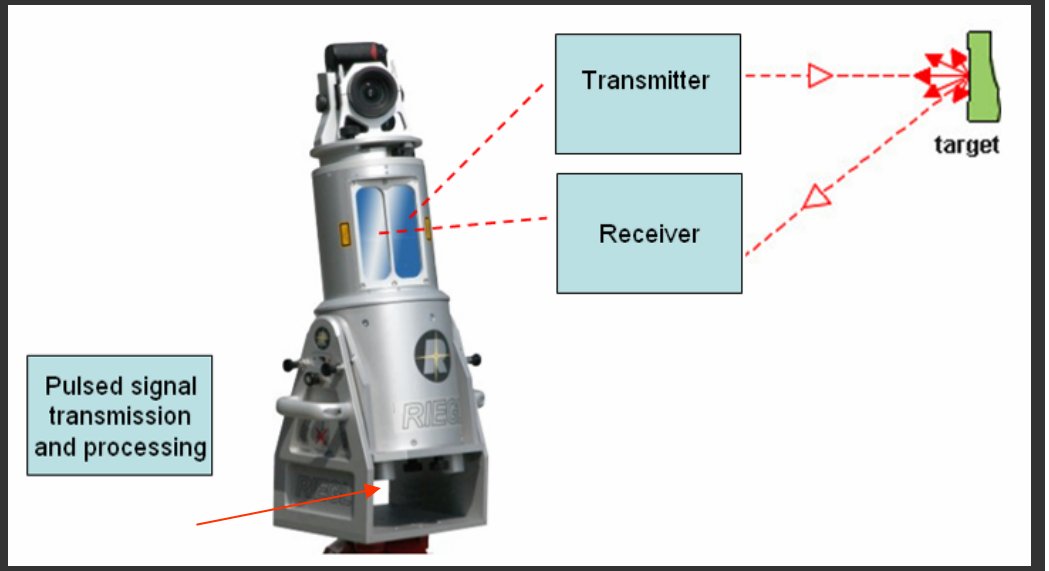
LIDAR

The key technology is commonly referred to as “**Lidar**”.

Lidar (Light detection and ranging) is a type of laser radar technology determining distance to an object by measuring the time between the emission of a light pulse and return from an object surface

This type of Lidar is called

“pulsed Lidar“



Key Features of a Pulsed Laser Sensor

rinciple:

Time-of-flight method this measures the time taken for a light pulse to travel to the target and back

- TOF devices capture data at a rate between hundreds and thousands of points per second
- Useful data can be provided from 1m up to 3000m

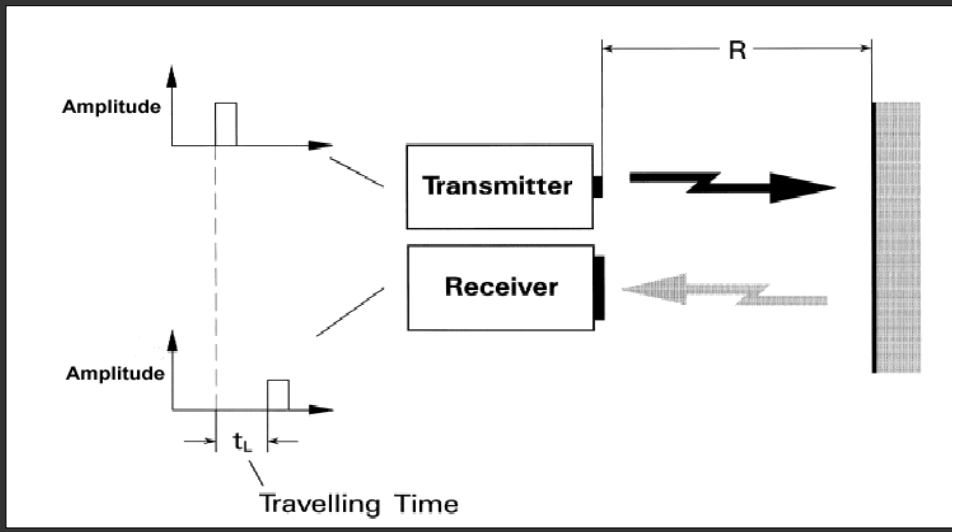
Near-infrared wavelength

Class 1 eye safe in Riegl instruments

300 KHz pps laser source in VQ series scanners

Pulsed laser transmitter

Sensitive narrow-band optical receiver



dvantages:

High Reliability

High interference immunity

Quick Data Acquisition

Highly collimated measuring beam

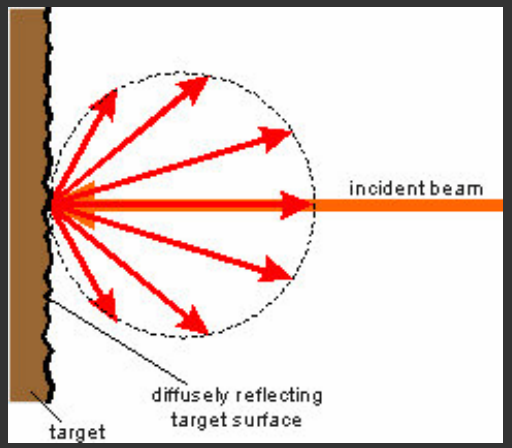
Excellent cost / performance ratio

Compact Size

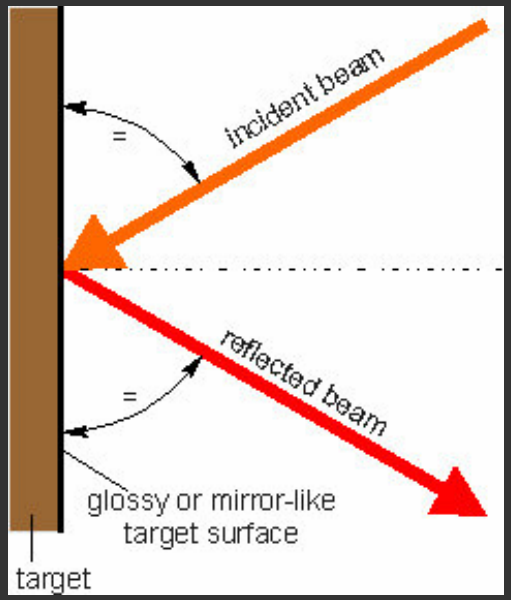
Long range

Reflectivity

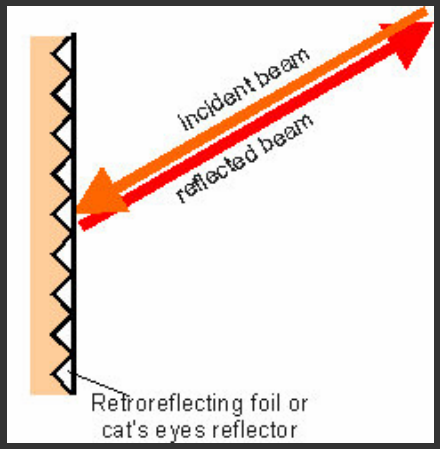
Diffuse Reflection
Most Objects



Mirror-like Reflection
Water



Retro Reflector
3m Reflective Paper



Reflectivity

- The amount of light that is returned from a target's surface is characterized by the reflection coefficient ρ.
- For a diffusive reflecting target, the maximum value of ρ is 100 %.
- A list of diffusive materials at 900nm wavelength

Glossy, mirror-like or retro-reflecting surfaces / material:	
MATERIAL	REFLECTIVITY
Reflecting foil 3M2000X3	1250%
Opaque white plastic	110%
Opaque black plastic	17%
Clear plastic	50%

Diffusely reflecting surfaces / materials:	
MATERIAL	REFLECTIVITY
White paper	up to 100%
Dimension lumber (pine, clean, dry)	94%
Snow	80-90%
White masonry	85%
Limestone, clay	up to 75%
Carbonate sand (dry)	57%
Carbonate sand (wet)	41%
Beach sands, dessert typ.	50%
Rough wood pallet (clean)	25%
Concrete, smooth	24%
Asphalt with pebbles	17%
Lava	8%
Black neoprene	5%
Black rubber tire wall	2%

Pulse Detection

AST TARGET

RIEGL 3D laser scanners have the ability to ollect last targets using Last Target echnology.

Last Target setting enables laser range easurements under conditions of bad visibility, oise and obstructing narrow objects.

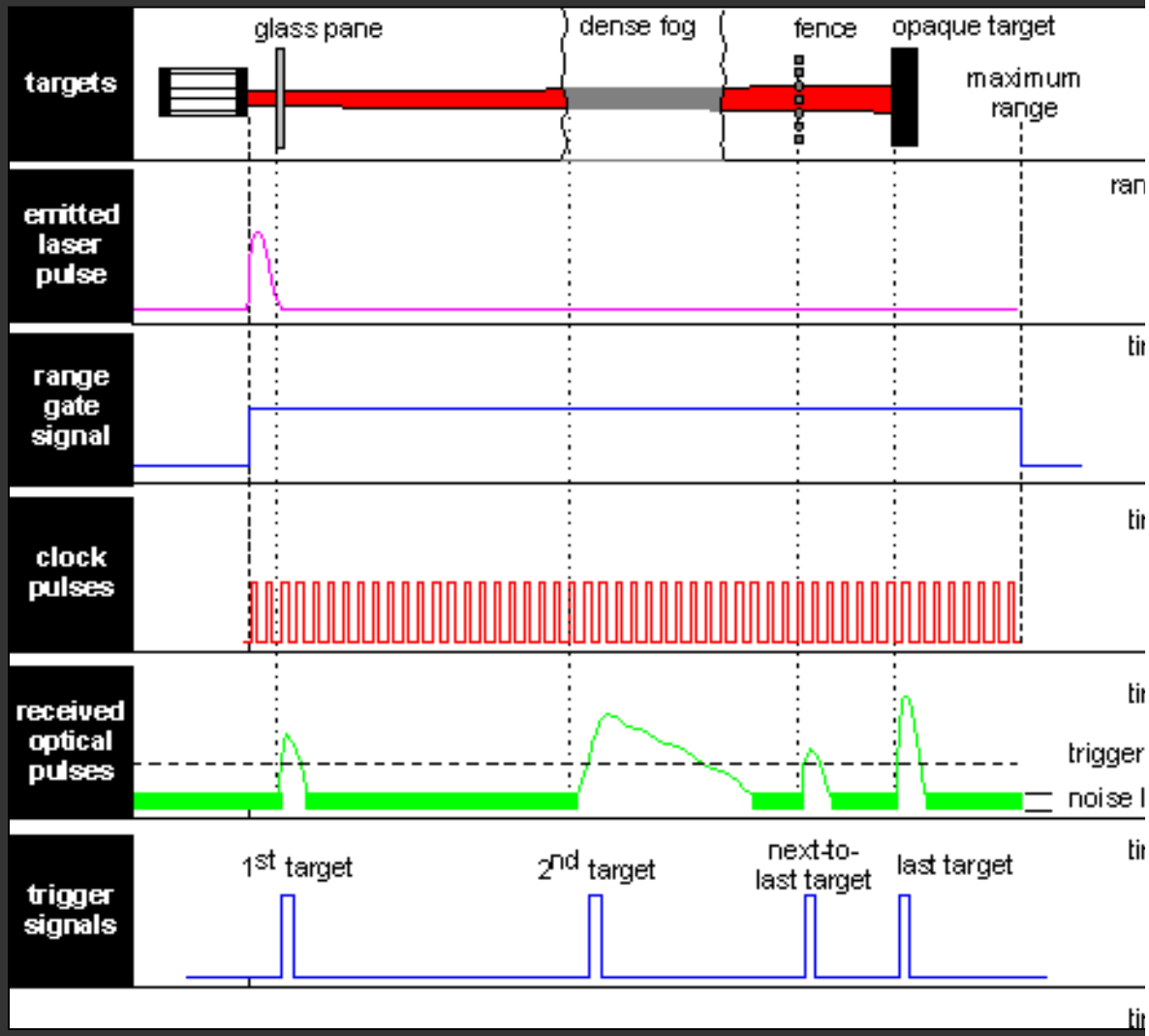
In the graphic representation, the last target ould be the opaque target detected after the easuring beam partially hit other targets in its ath.

IRST TARGET

For other applications like power lines etection, biomass volume calculation and pplications using detailed scanning of narrow bjects, RIEGL 3D laser scanner also detect irst Target only.

In the graphical example the first target would e the fence before the opaque object.

Short-range suppression techniques allow to nore nearby target echoes detected as noise, e. the cloud of dust, rain or fog.



Point Clouds derived from Laser Mapping

Point Clouds are suitable medium for use on a wide variety of subjects including architecture, topography, forestry and engineering among other applications.

Point Clouds should not be seen as a replacement to existing techniques, on the contrary they supplement and improve tradional deliverables.

Multiple Target Capability

ping

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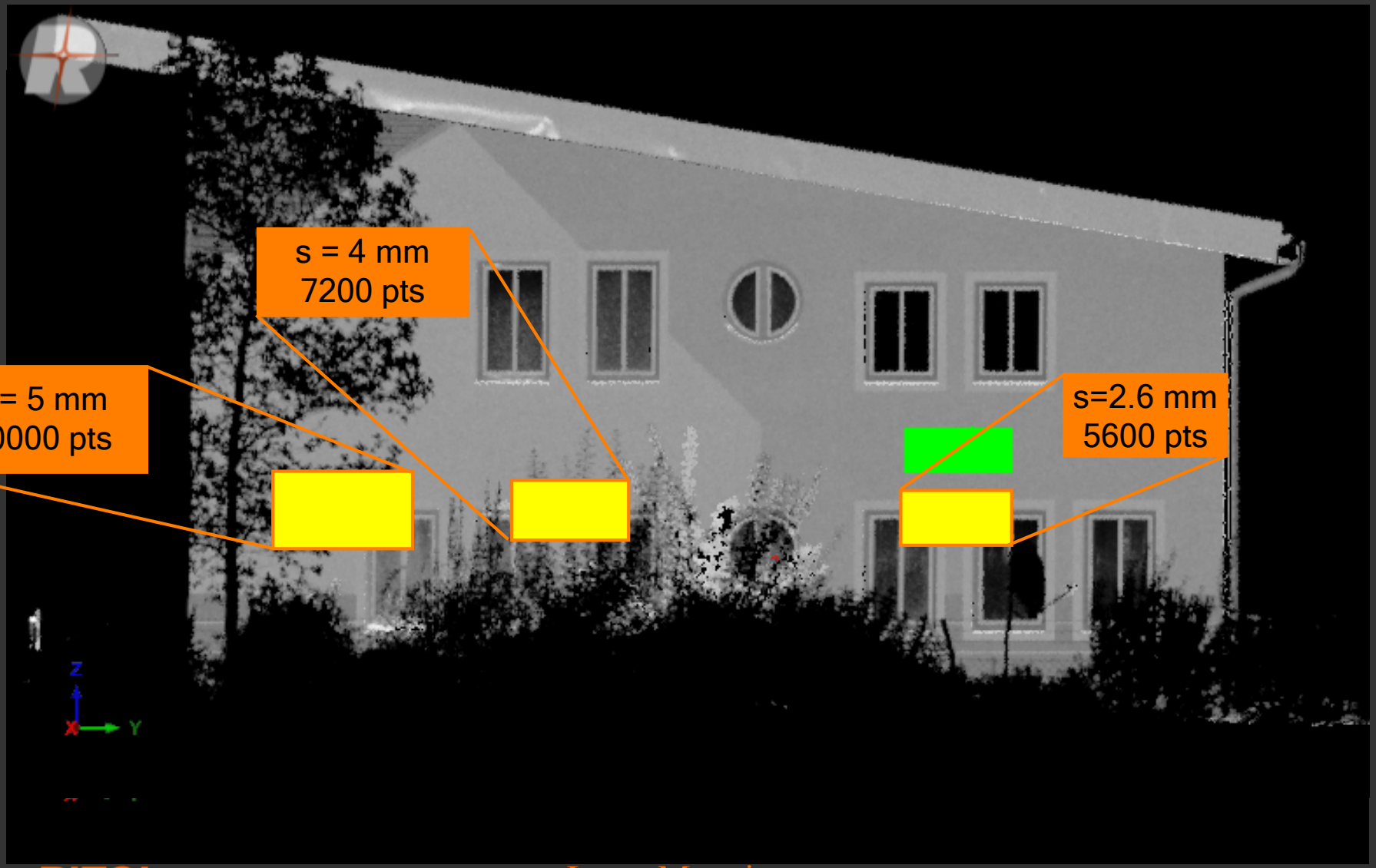
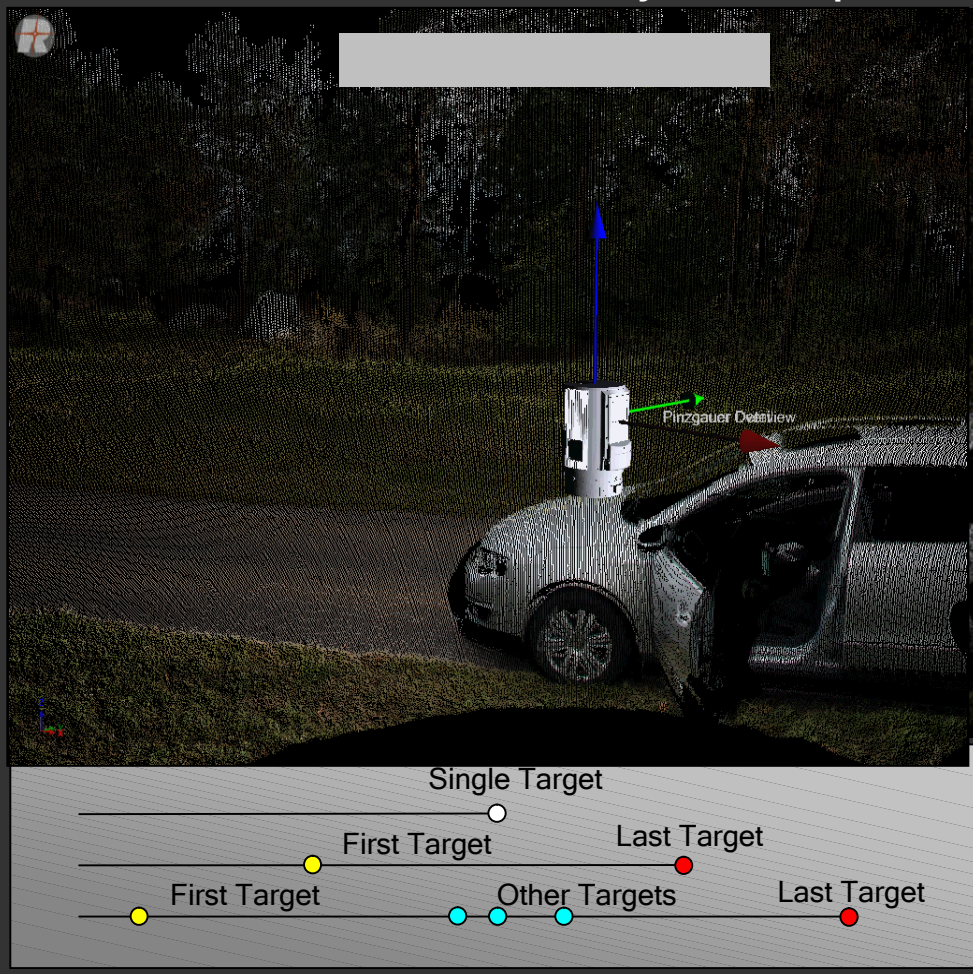
Precision and Accuracy



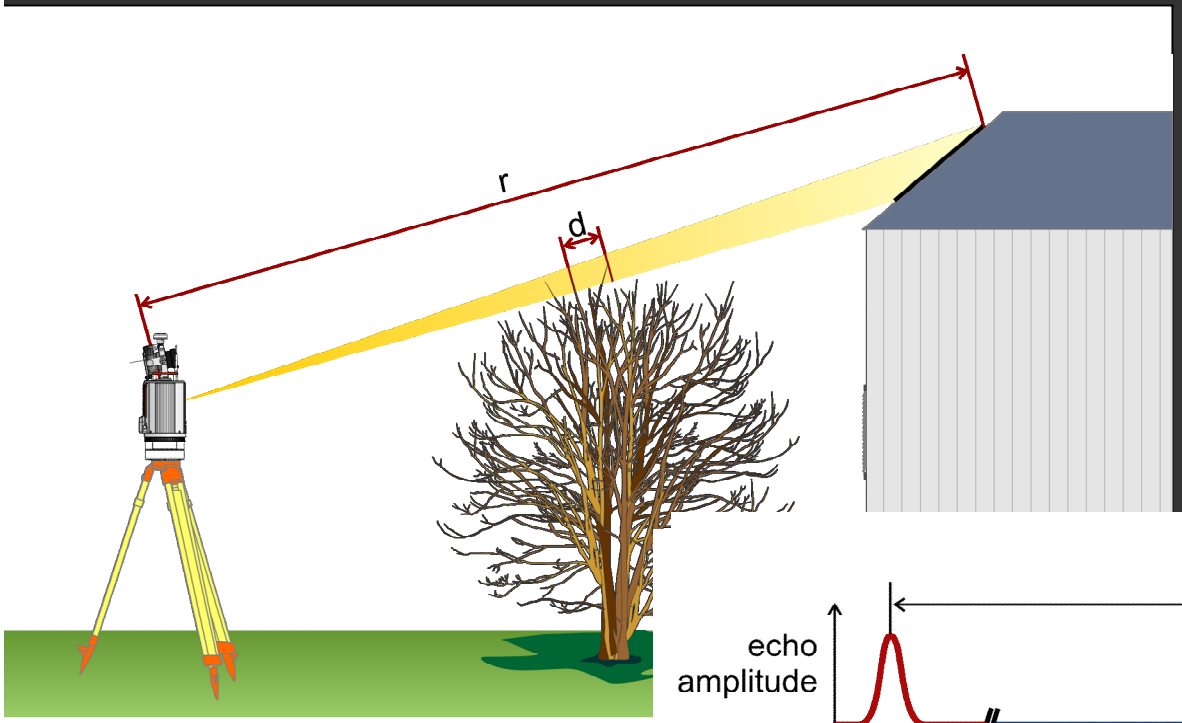
Waveform Analysis

Waveform analysis technology allows collection of multiple returns per signal.

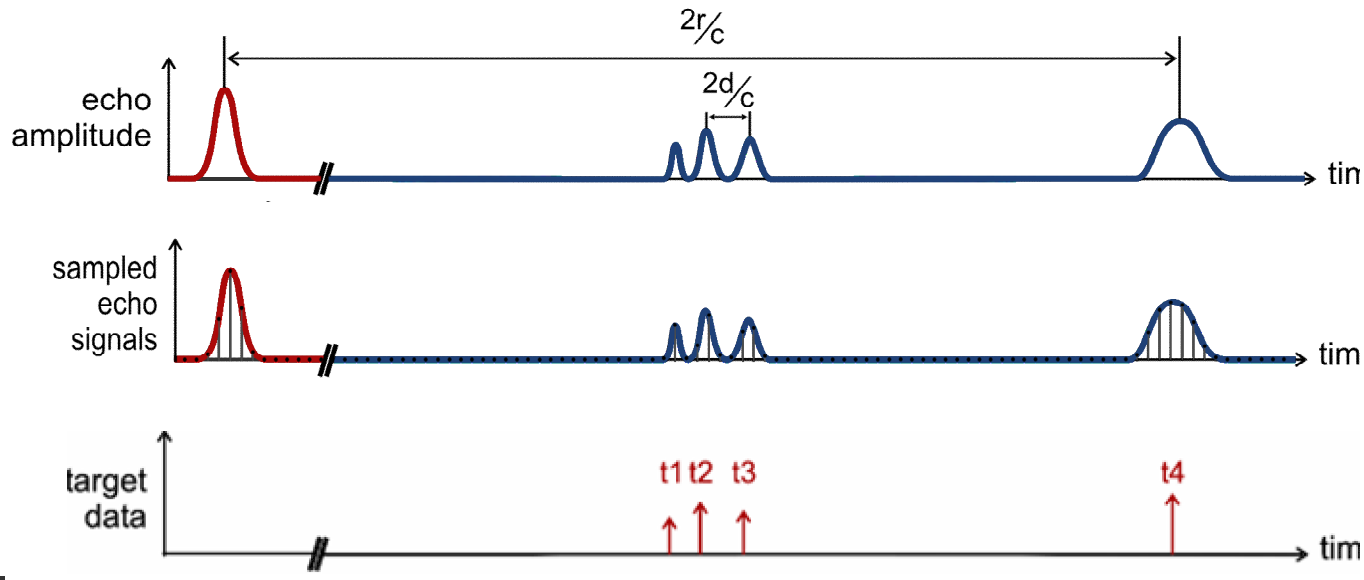
Double Click on Photo to Play Movie Clip



Echo Digitization



The digitization feature on RIEGL equipment enables the user to extract the mos comprehensive information from the echo signals



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ANSI Laser Safety Classifications

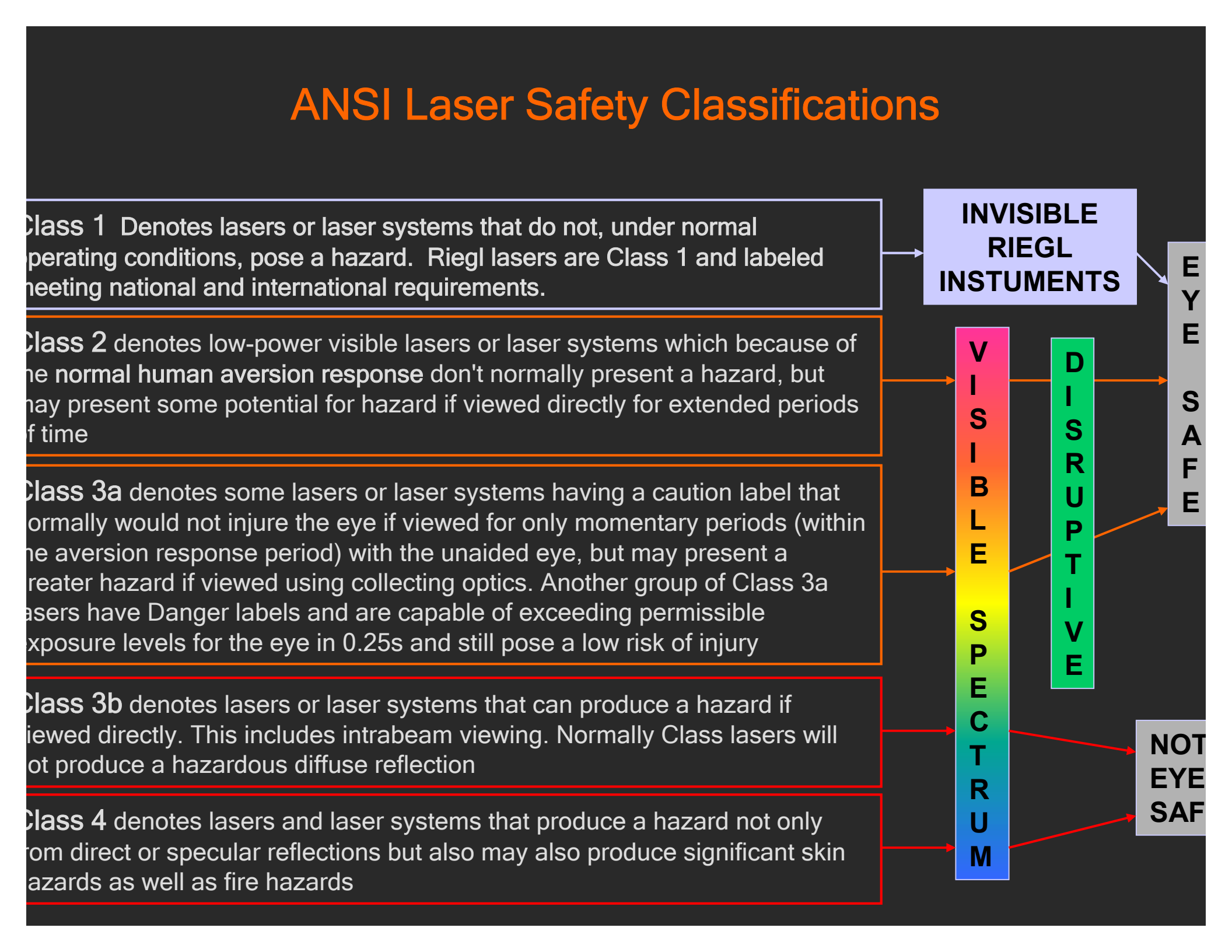
Class 1 Denotes lasers or laser systems that do not, under normal operating conditions, pose a hazard. Riegl lasers are Class 1 and labeled meeting national and international requirements.

Class 2 denotes low-power visible lasers or laser systems which because of the **normal human aversion response** don't normally present a hazard, but may present some potential for hazard if viewed directly for extended periods of time

Class 3a denotes some lasers or laser systems having a caution label that normally would not injure the eye if viewed for only momentary periods (within the aversion response period) with the unaided eye, but may present a greater hazard if viewed using collecting optics. Another group of Class 3a lasers have Danger labels and are capable of exceeding permissible exposure levels for the eye in 0.25s and still pose a low risk of injury

Class 3b denotes lasers or laser systems that can produce a hazard if viewed directly. This includes intrabeam viewing. Normally Class lasers will not produce a hazardous diffuse reflection

Class 4 denotes lasers and laser systems that produce a hazard not only from direct or specular reflections but also may also produce significant skin hazards as well as fire hazards



Hybrid Terrestrial Laser Mapping

Combination of

high performance digital Lidar scanner

and

high resolution (10+ megapixels)

calibrated digital camera

High Performance Digital Lidar Scanner

- Laser Pulse Repetition rate of 300,000 measurements per second
- Effective measurement rate of 125,000 measurements per second
- Maximum of 2,000,000 returns per second
- 1.5 meter to 500 meter range
- 0.3 mrad beam divergence
- 1.8 arc second angle measurement resolution
- 16 bit intensity channel with dB calibrated intensity
- Small form factor and 20 lb weight
- Multiple interface formats

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Laser Mapping

High Resolution Calibrated Digital Camera

- 10+ mega pixel format
- Full frame chip CMOS sensor
- Calibrated lens to remove distortions
- External mount to scanner
- Able to handle changing light conditions
- Controlled by data acquisition software
- Defined photogrammetric camera model
- Boresight methodology
- Upgrade path for system improvements
- Interchangeable lens

Integrated Camera and Scanner Data Acquisition Software

- Captures and organizes data such as scans, control targets, digital images, GPS data, survey control, tie points etc
- Command and control of scanner and camera
- Resident integration of transformation matrices to manage the coordinate systems of scanner, camera, survey control, GPS and project requirements.
- Advanced registration methods for scan positions, Lidar and imagery
- RGB assignation to vertices of the point cloud and related image mapping abilities
- Camera model integration
- Advanced analysis and QA/QC tools

Hybrid System Benefits

- Fast acquisition of scene geometry – high productivity
- Superior edge and detail information from imagery
- Transformation of pixel coordinates into beam parameters and the resultant intersection of the photogrammetric light ray with the Lidar geometry provides for superior feature extraction from imagery
- Feature extraction in CAD programs for faster throughput of 2D and 3D Deliverables
- Automatic generation of hybrid visuals
- Exact documentation of existing conditions and the ability for downstream users to access the imagery for improved communication of the project team.

Hybrid System Results

Digital Signal Processing of LIDAR

- Calibrated Amplitude (intensity) reading in dB
- Multiple target capability
- Echo Digitization
- High Spatial Frequency for imaging purposes

Hybrid System Results

Calibrated Images

- High resolution Textured Meshes
- Photorealistic 3D Construction
- Exact identification of details
- Position and distance measurements
- Real-time setting of any point of view
- Cad based feature extraction
- Integration into 2D deliverables for enhanced communication

VZ 400 Digital 3D Lidar Scanner Performance

- Range up to 500 m @ Laser Class 1
- Repeatability 5 mm
- Measurement rate up to 125.000 measurements/s
- Field of View up to 100° x 360°
- LAN/WLAN data interface, easily allowing wireless data transmission
- Operated by any standard PC or Notebook or cable less
- Fully portable, rugged & robust

Sensor Evolution

LMS Z-Series

- wide field of view
- robust & reliable
- harsh environments
- near range photogrammetry & laser scanning

LMS-Q560

- echo signal digitization
- digital signal processing
- off-line full waveform processing

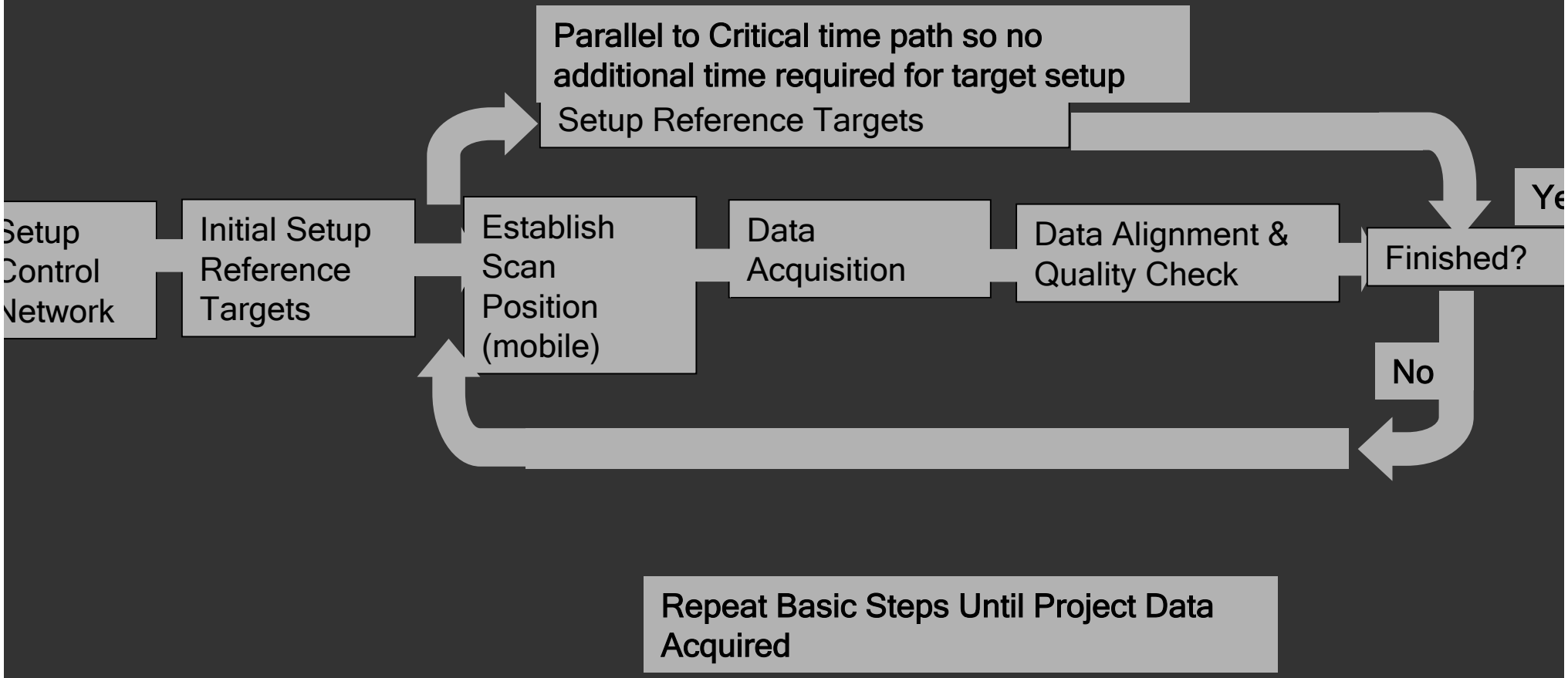
LPM-321

- echo digitization
- online waveform analysis

New Features:

- 2-in-1 3D scanner: high speed / long range
- high-speed online waveform processing
- online multi-target point cloud (True3D)
- accurate echo waveform assessment
- integrated GPS receiver
- display and keypad
- attachable battery
- internal data storage
- integrated WLAN / LAN
- tilt sensor
- laser plummet

Field Operations Workflow



Set Up Reference Targets

- Set up reference targets over survey markers (typically 8-10 targets)
- Cylindrical targets can be identified and located up to 400 ft

- All target setups are performed in parallel with data acquisition.

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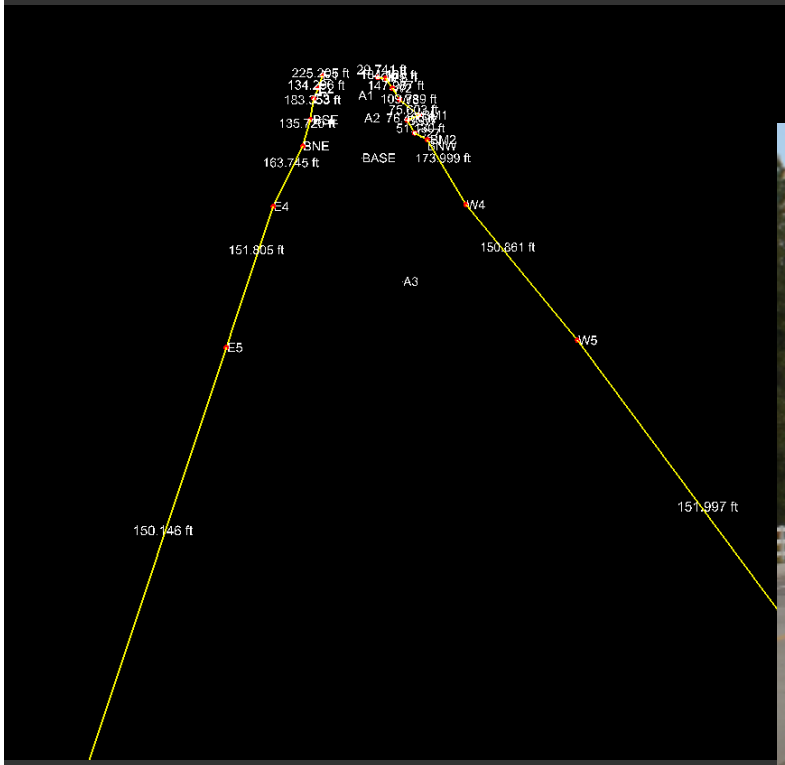
Establish Control



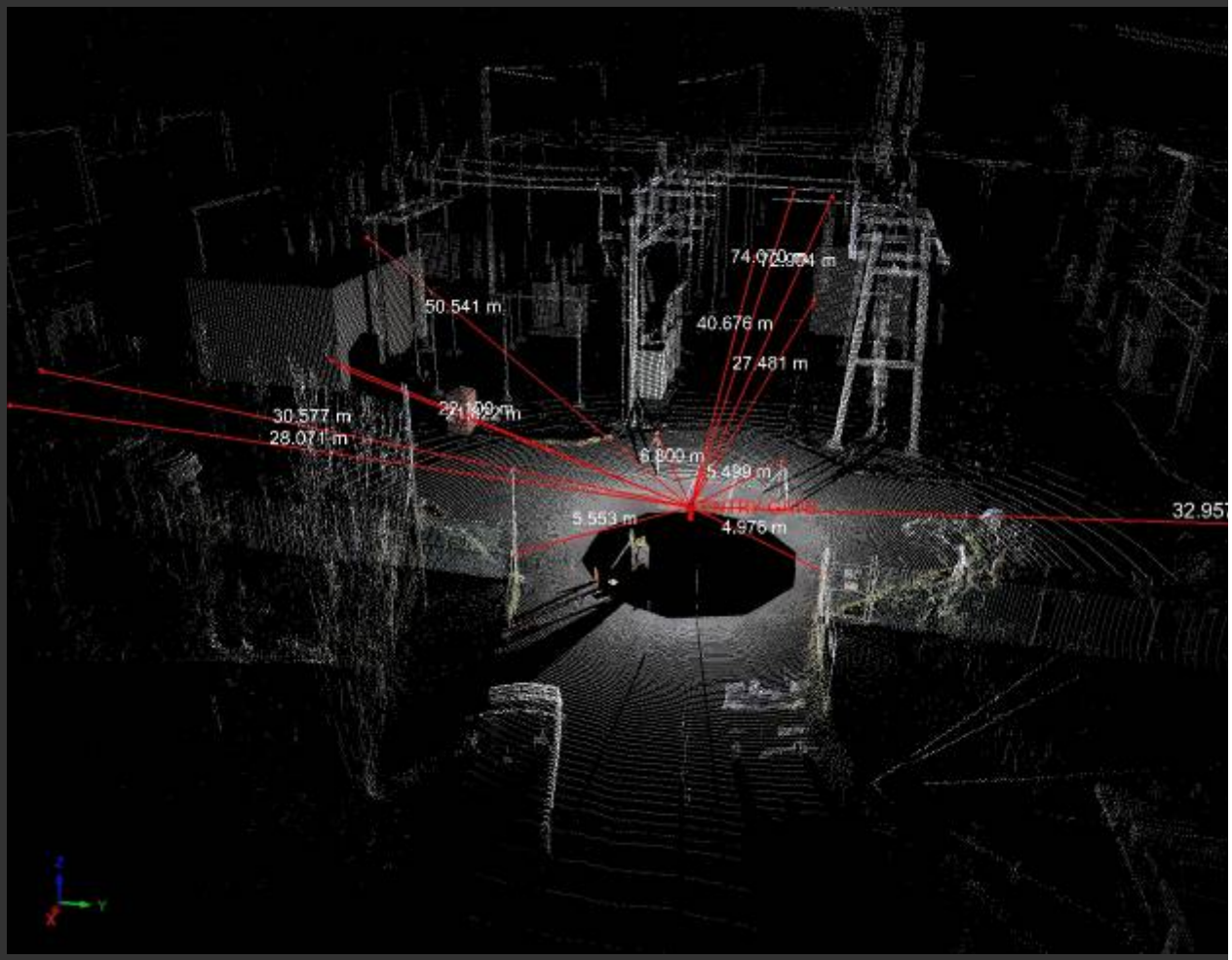
• Control network references set up along corridor at about 150ft (50m) Identified with standard survey markers, i.e. nails, rebar, paint, etc.

Locate reference targets with no traffic interference

Optimum height for maximum coverage

Types of Registration for Static Scanning

- Target Registration
  - Most effective
  - Instantaneous Geo-referencing
  - Individual target error reading for registration accuracy
- Multistation Adjustment (cloud to cloud)
- Coarse Registration
- Backsighting



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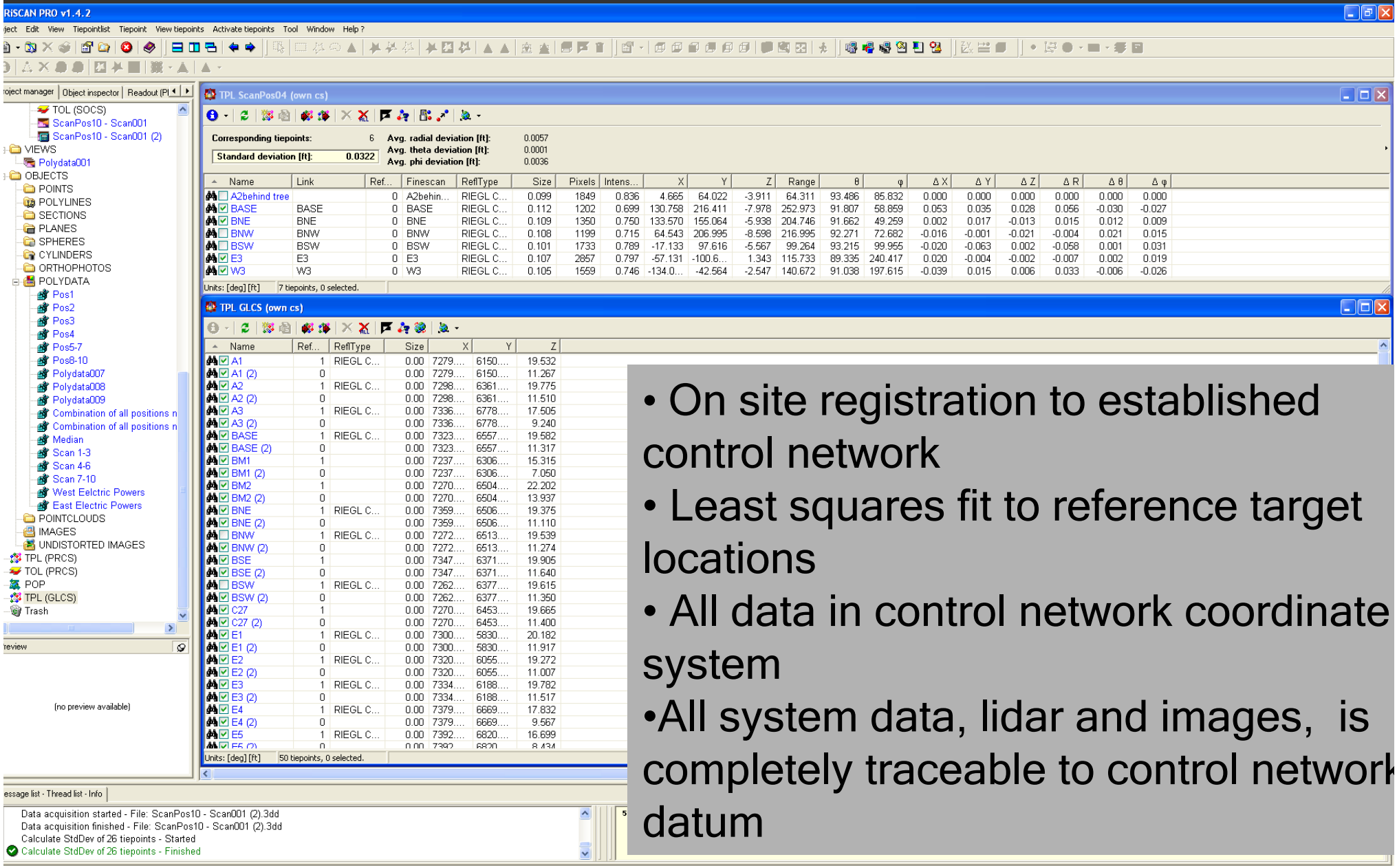
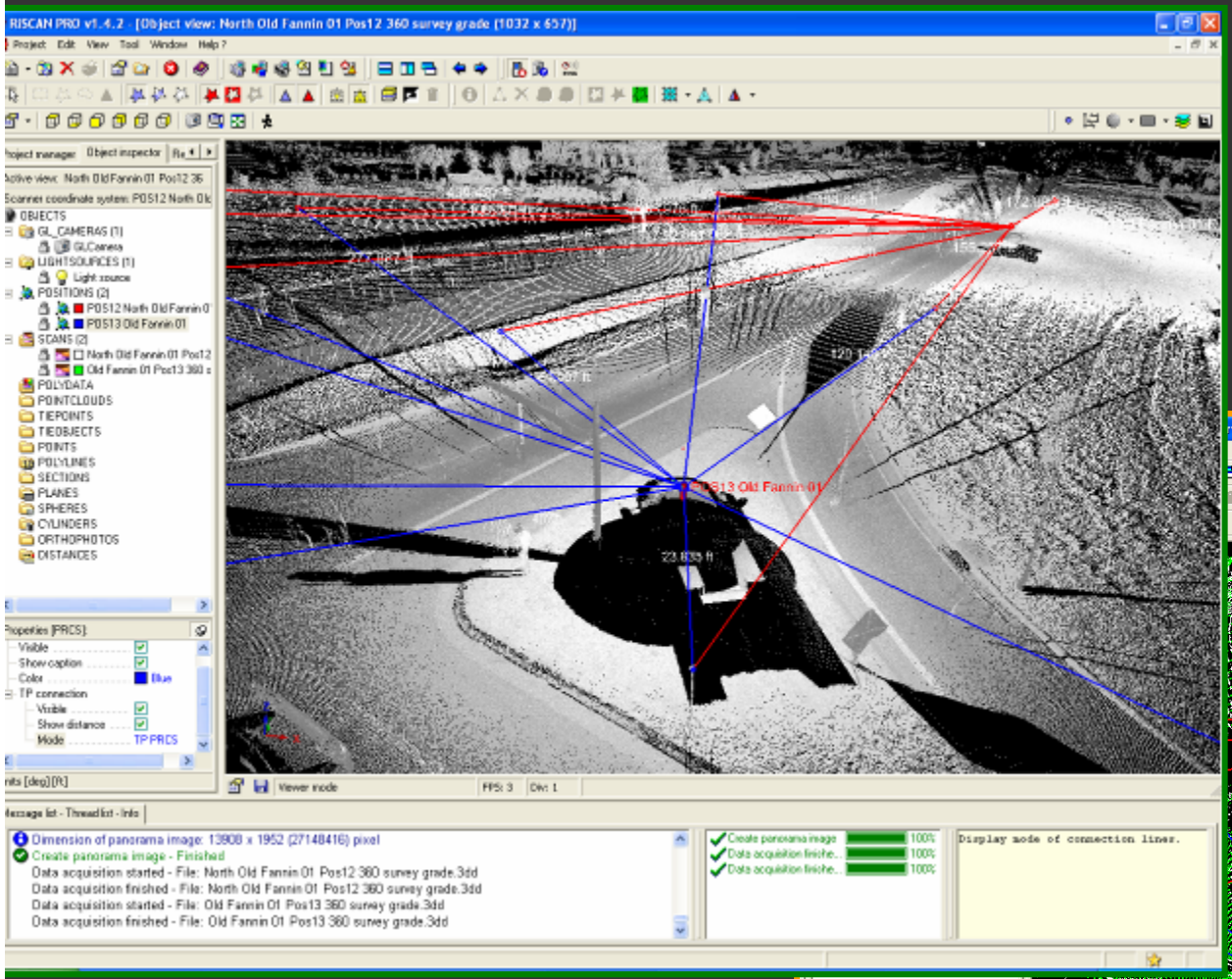
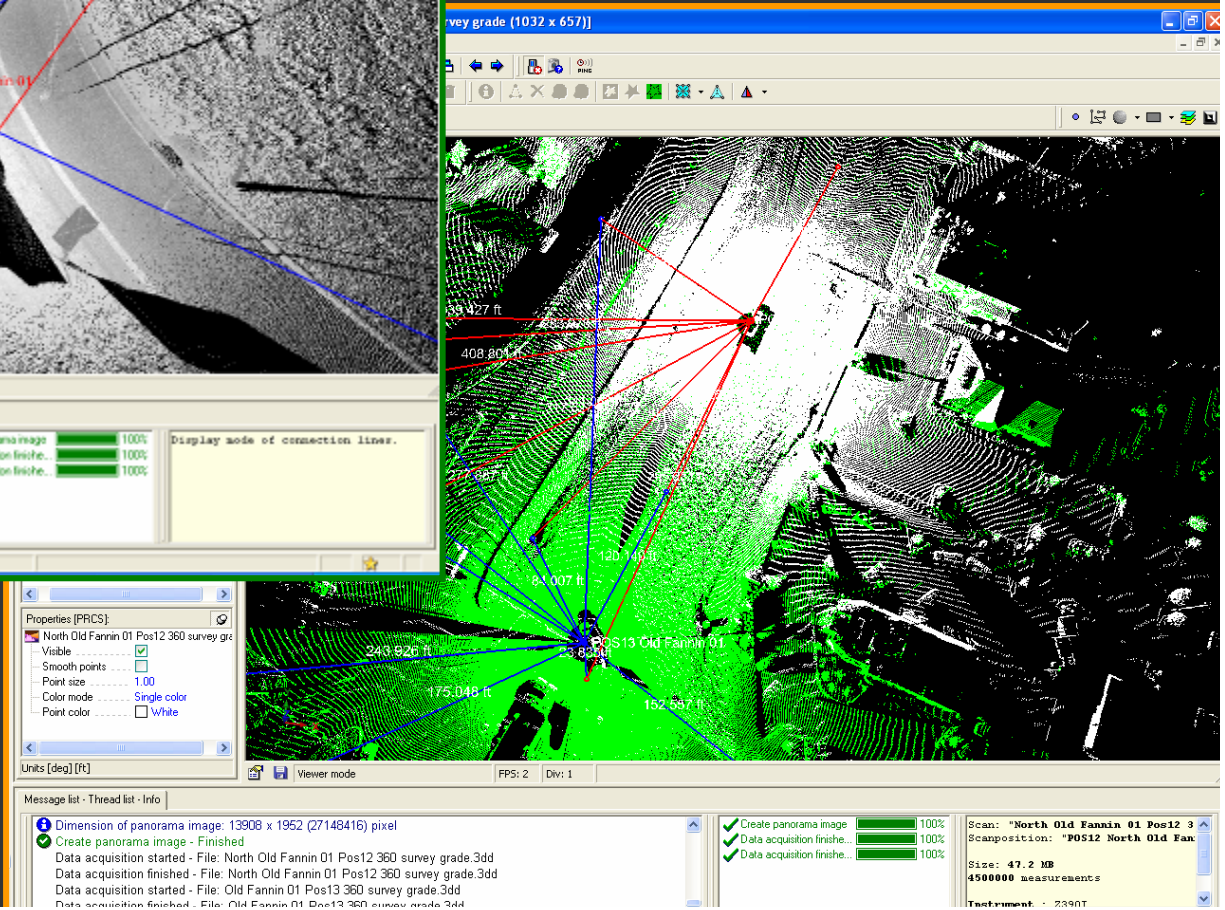
Field Operations: Quality Assurance



- On site registration to established control network
- Least squares fit to reference target locations
- All data in control network coordinate system
- All system data, lidar and images, is completely traceable to control network datum

Field Operations: Quality Assurance





Immediate graphical feedback to operator displaying scanner registration to control network RiScan Pro feedback traces scan data back to control network datum

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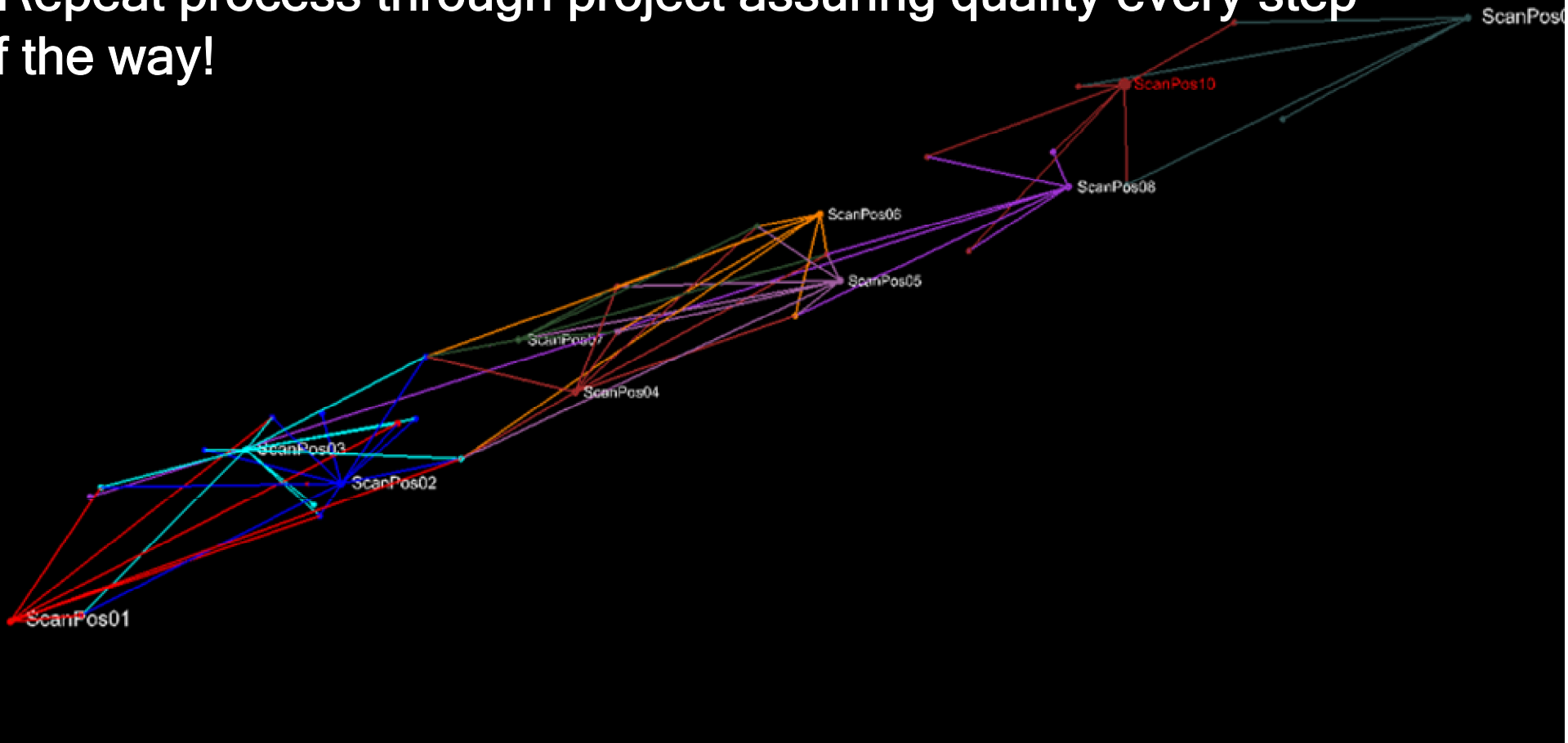
Field Operations: Quality Assurance

- Repeat process through project assuring quality every step of the way!



Processing: Image Recalibration

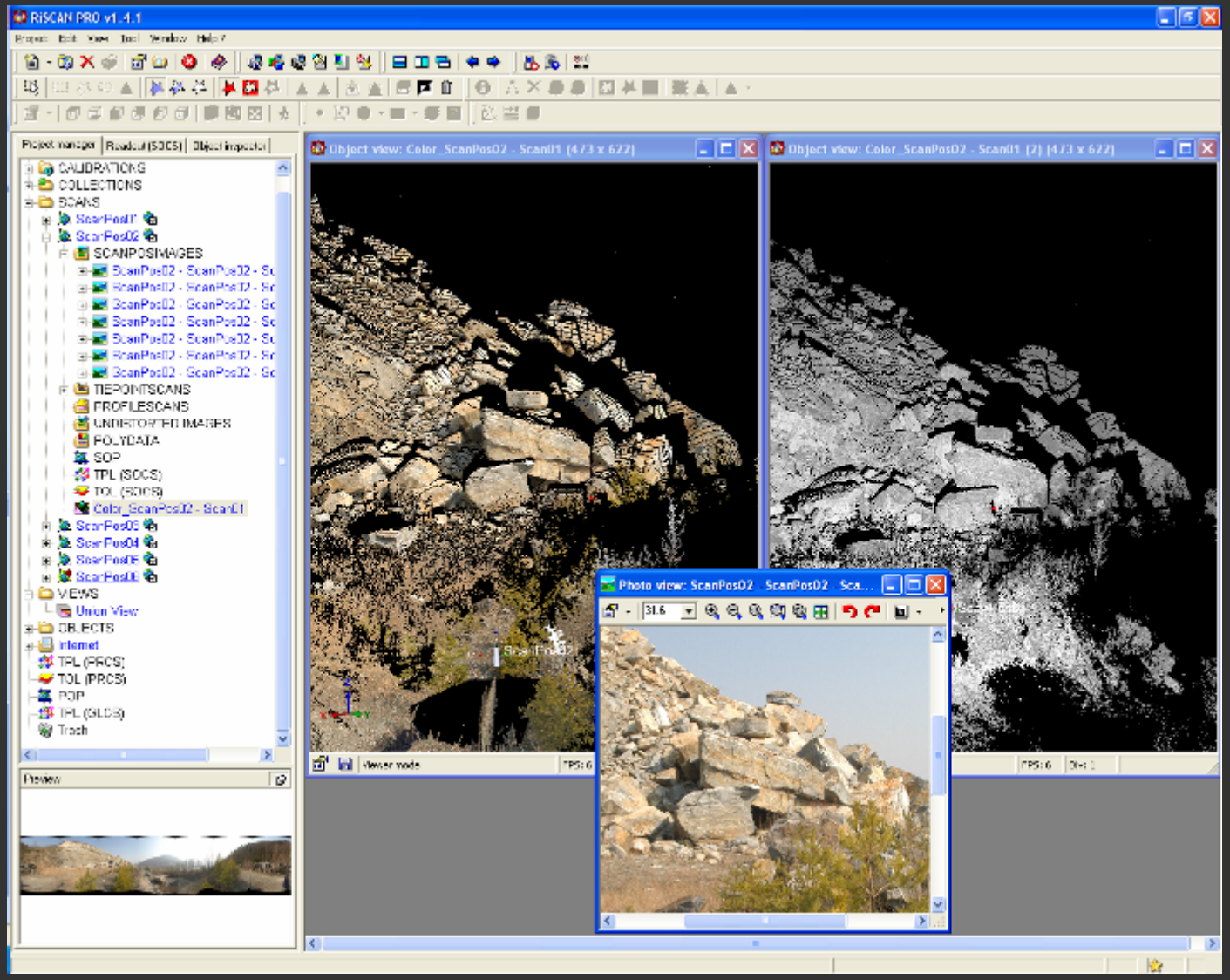


Image data is mapped accurately and easily to spatial data.

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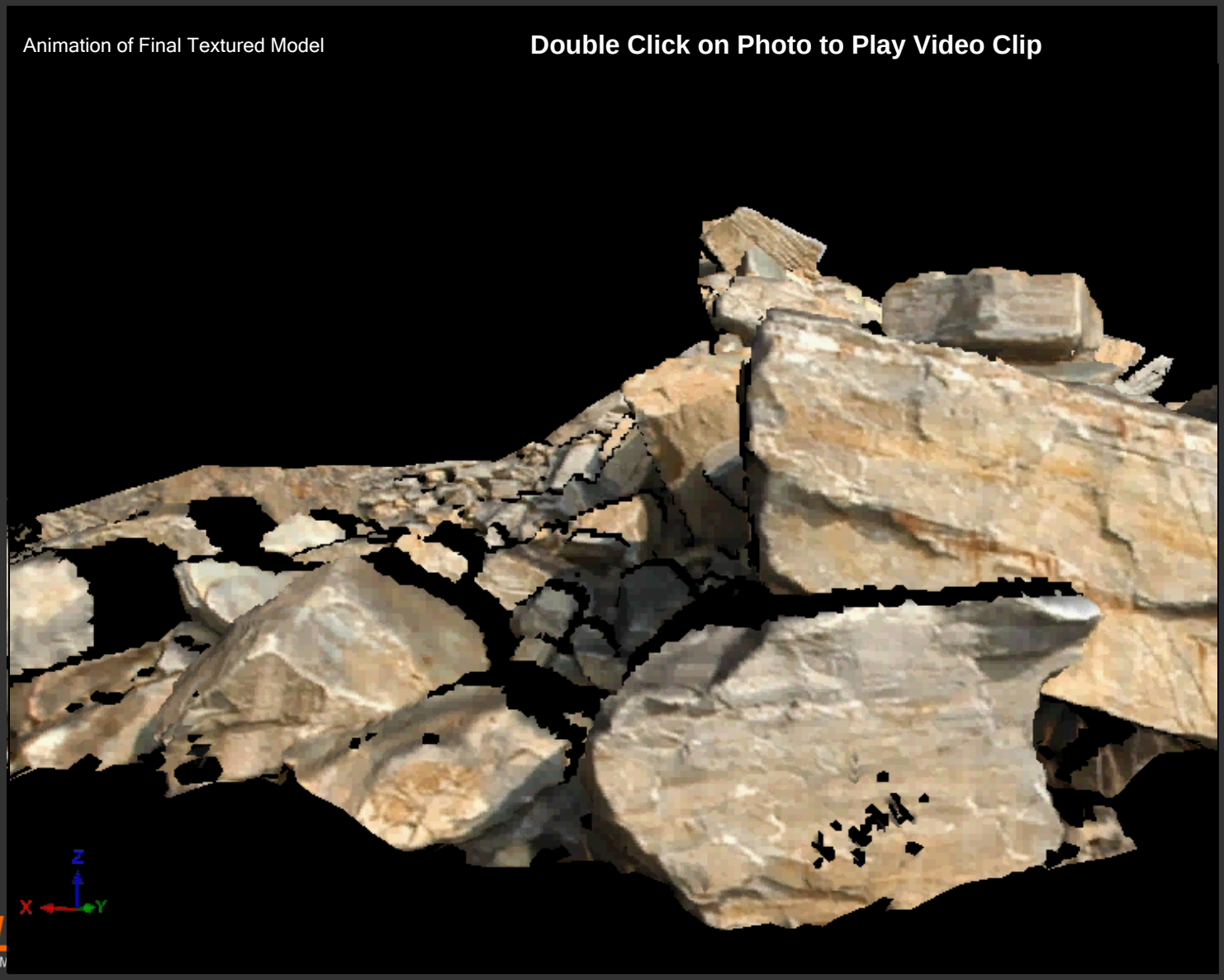
RGB visualization of Lidar



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Post Processing in Microstation

TopoDOT

ombines spatial
D data with
alibrated images
n MicroStation

Specialized tool
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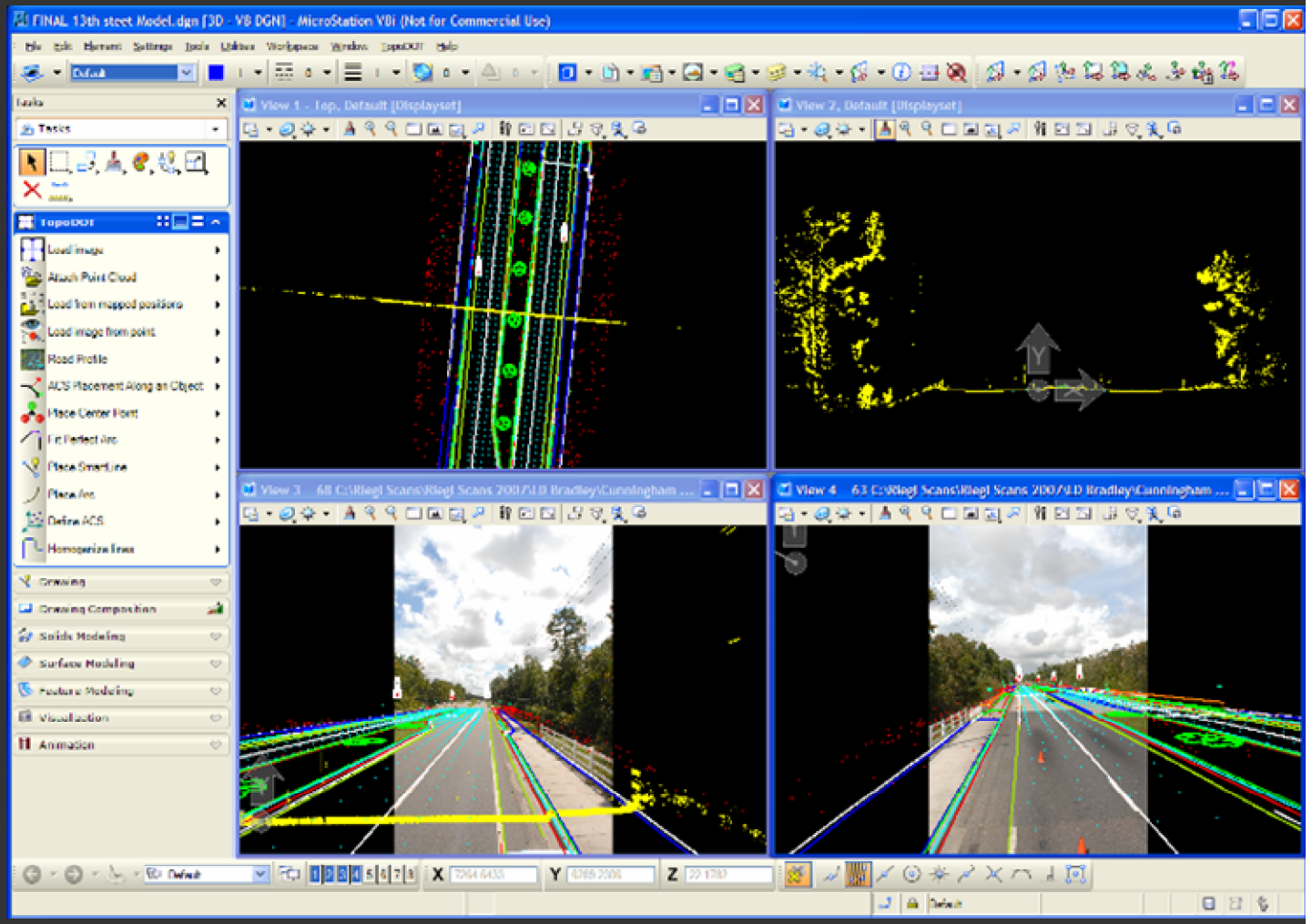
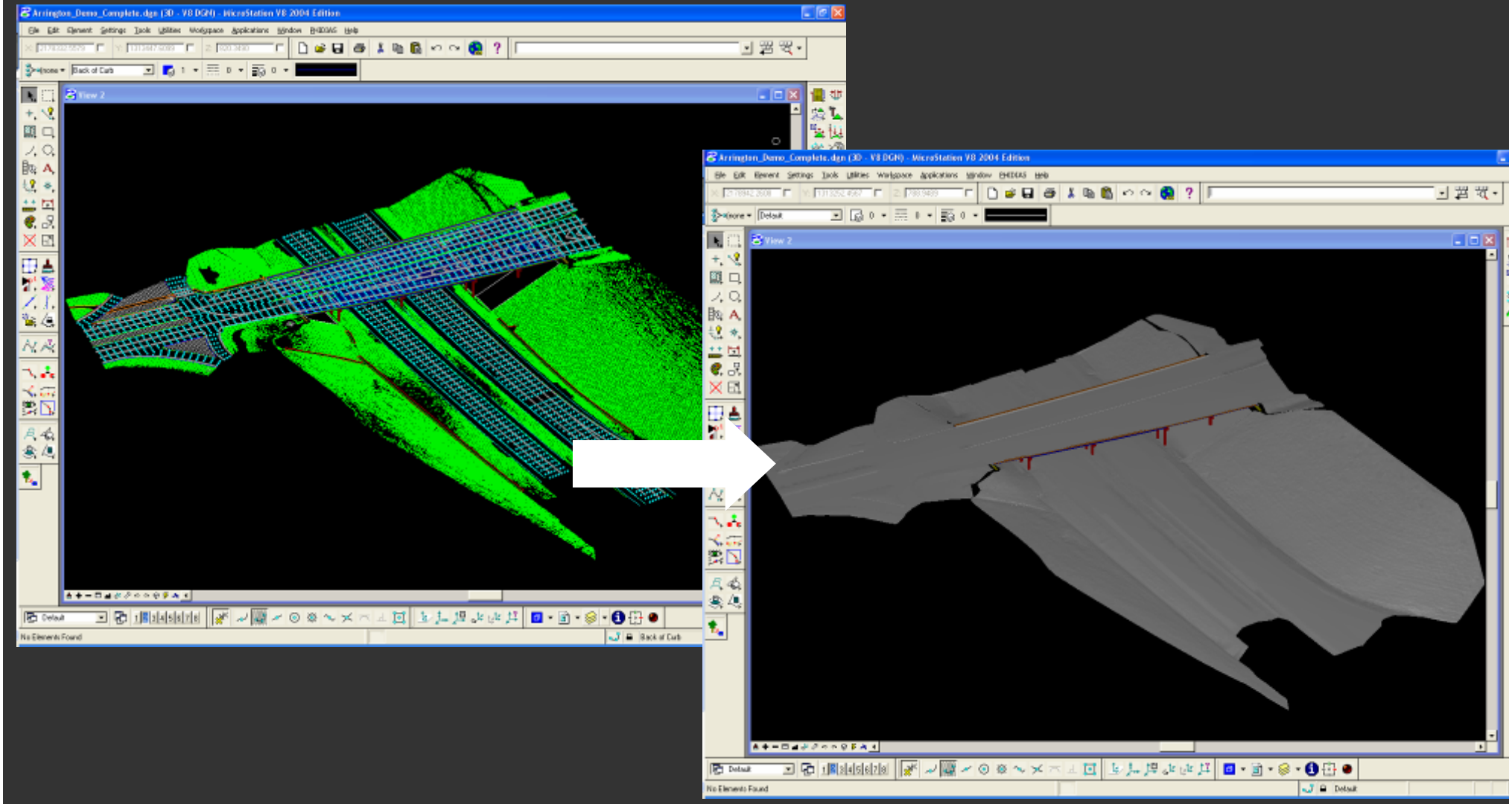
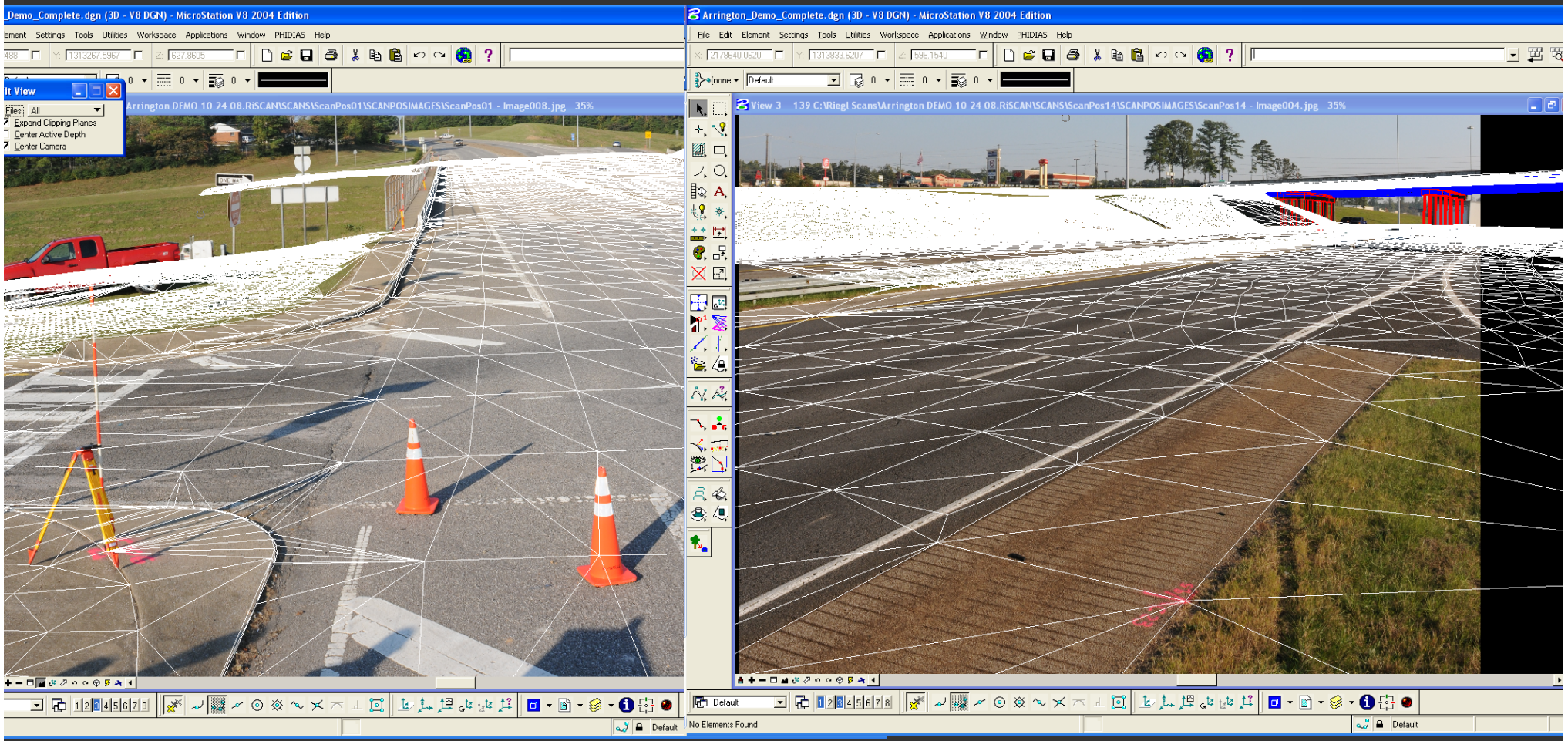
xtraction of
eatures



DTM Surfacing



DTM's With Calibrated Image Overlay



Near Range Operations

Point cloud with RGB

Near Range Operations

Photograph of area.

Near Range Operations

Calibrated Intensity Information

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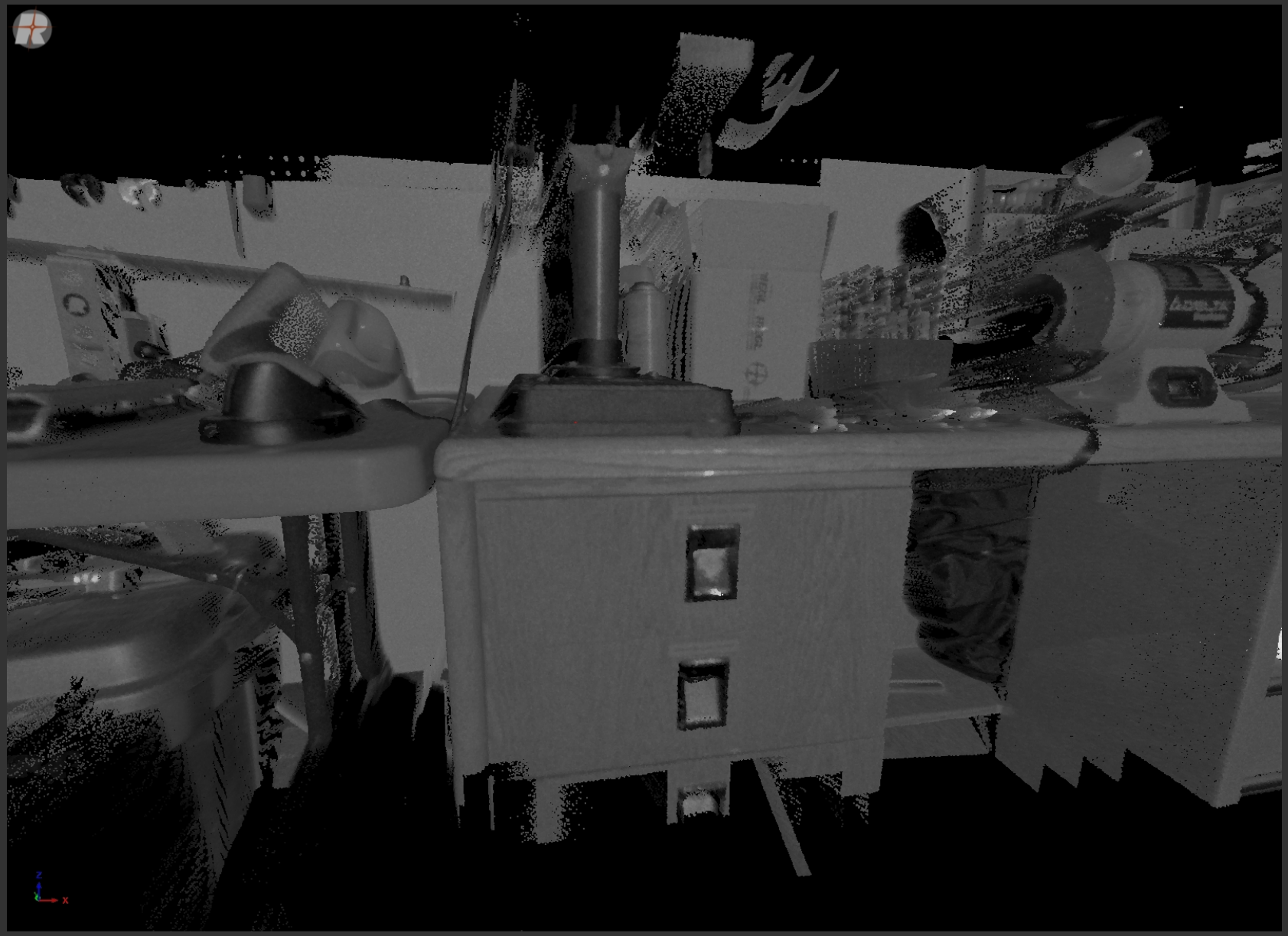
Near Range Operations



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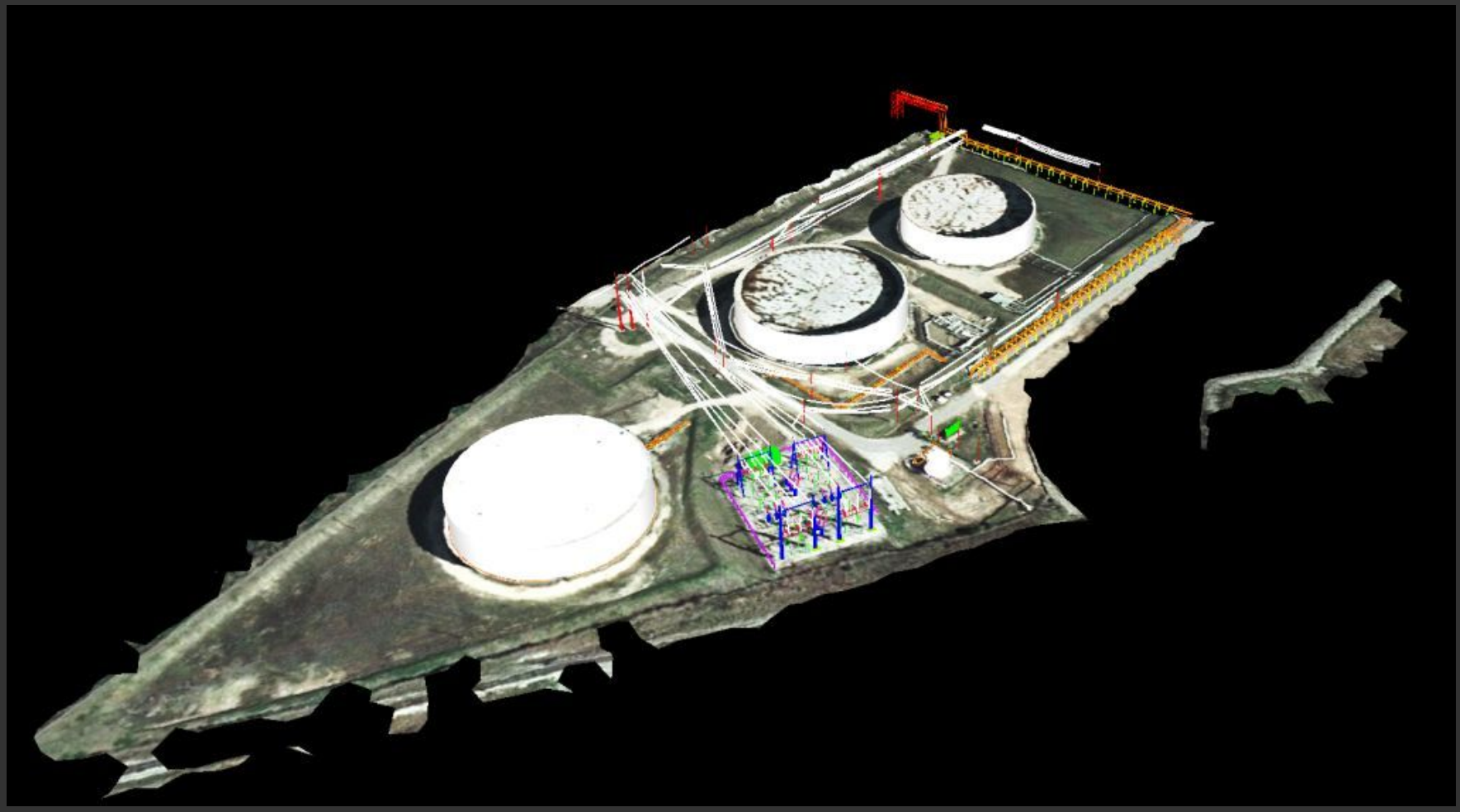
Laser Mapping

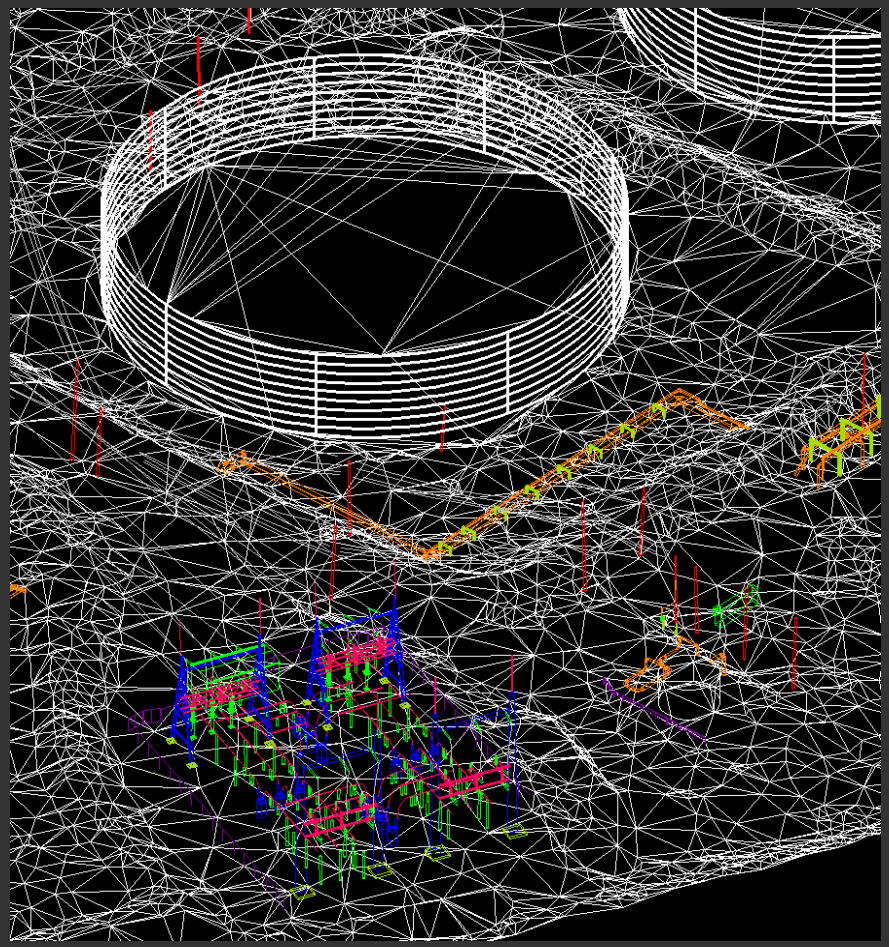
Processing

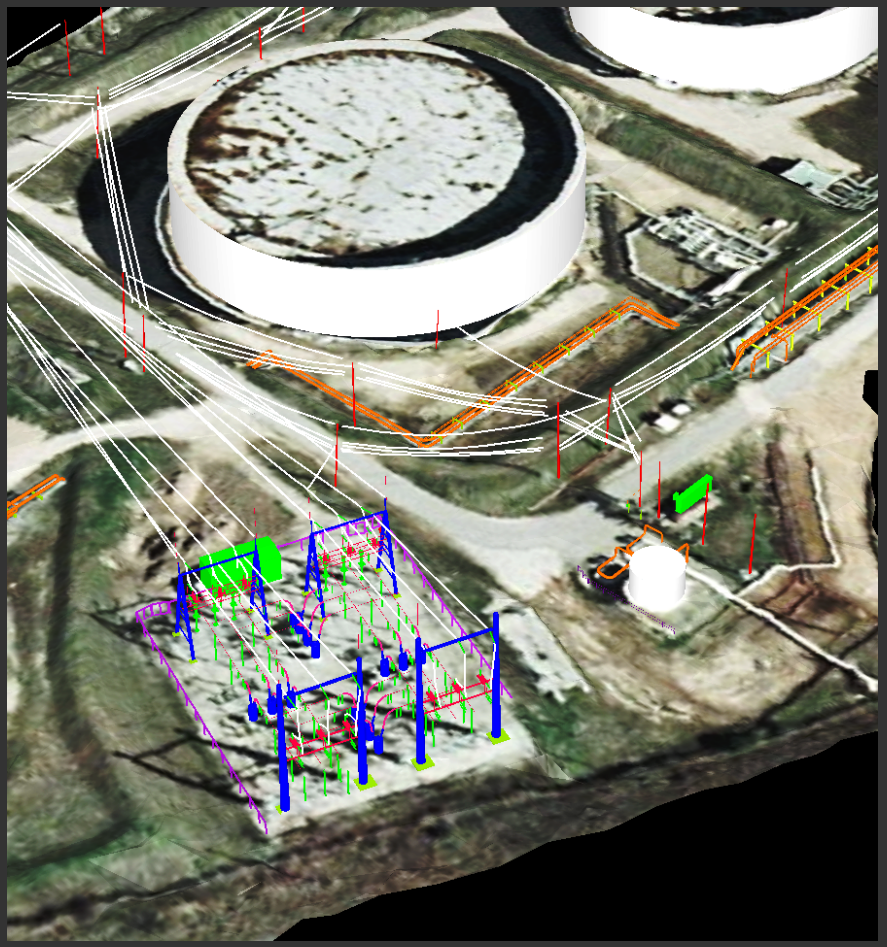
DTM with rendered model



Processing

Wireframe and Rendered Model DTM





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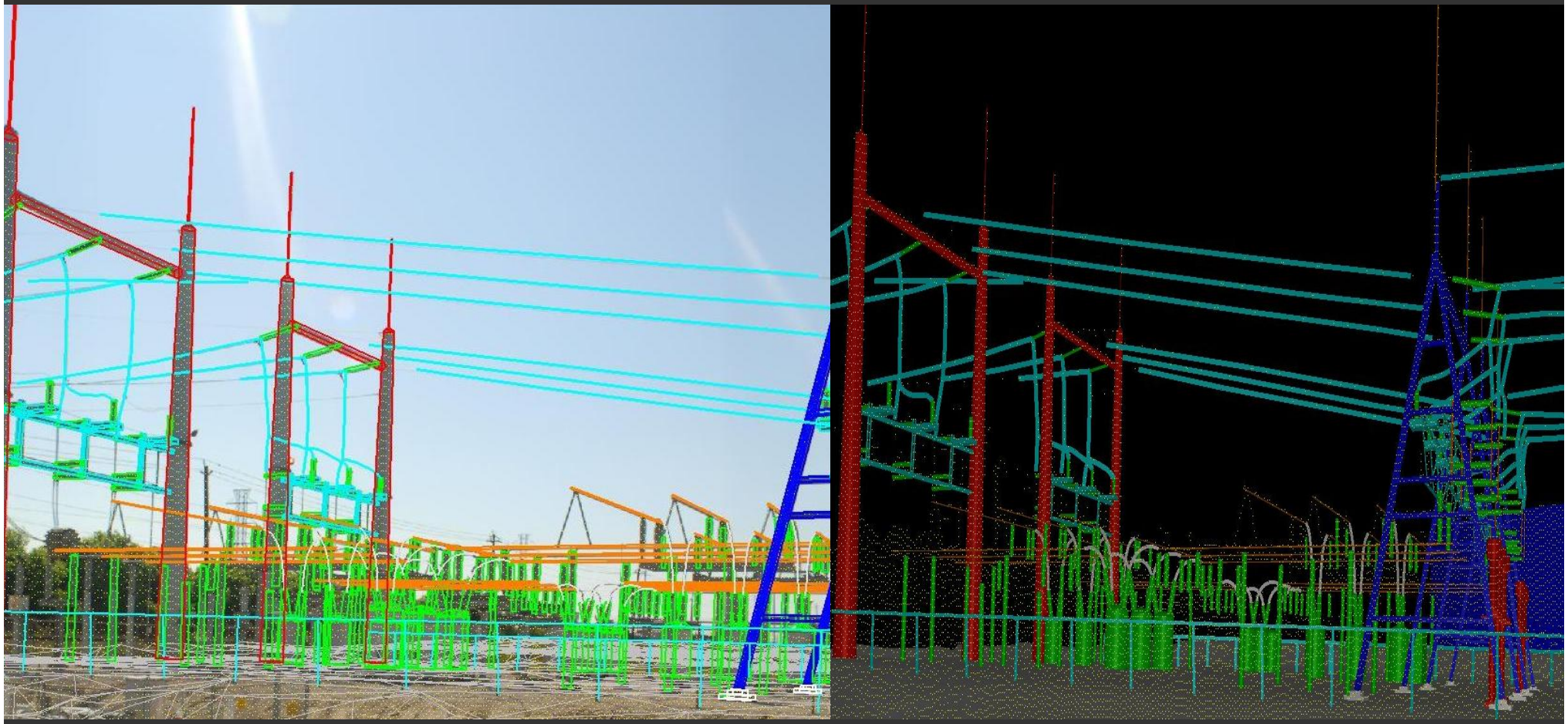
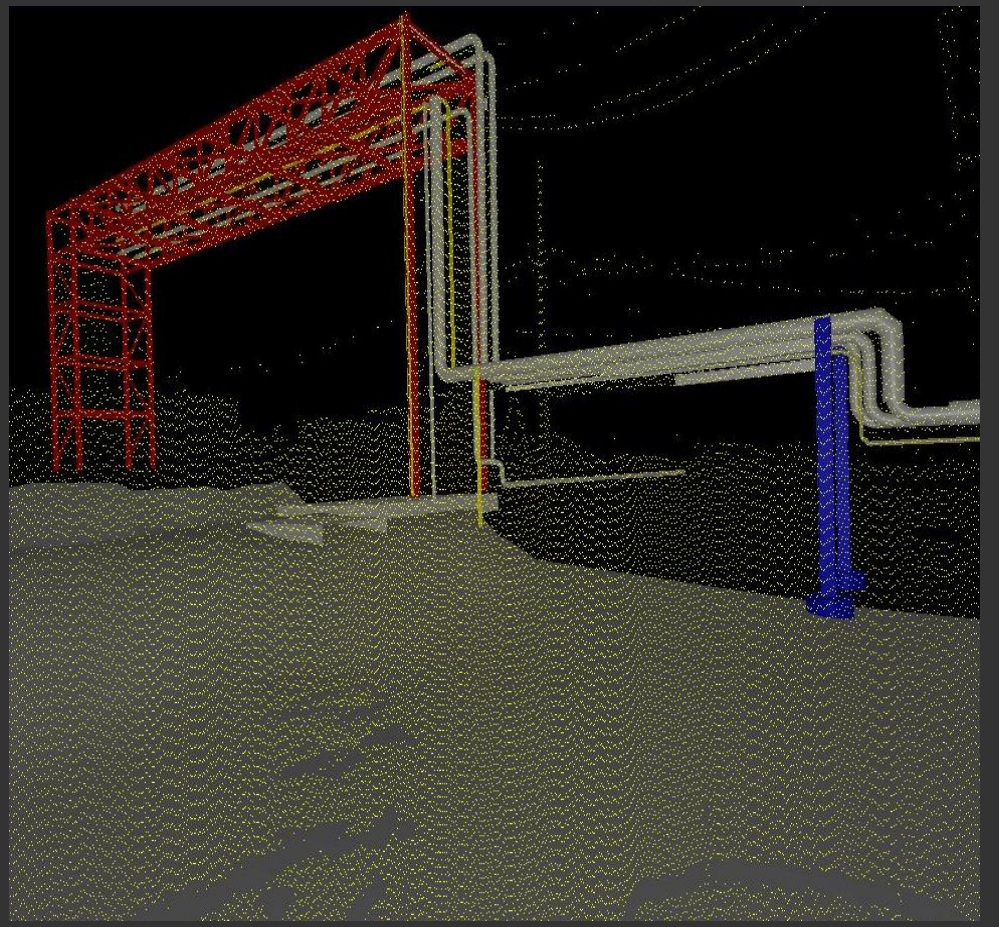
Processing

Point Cloud Picture Overlay and 3D Model

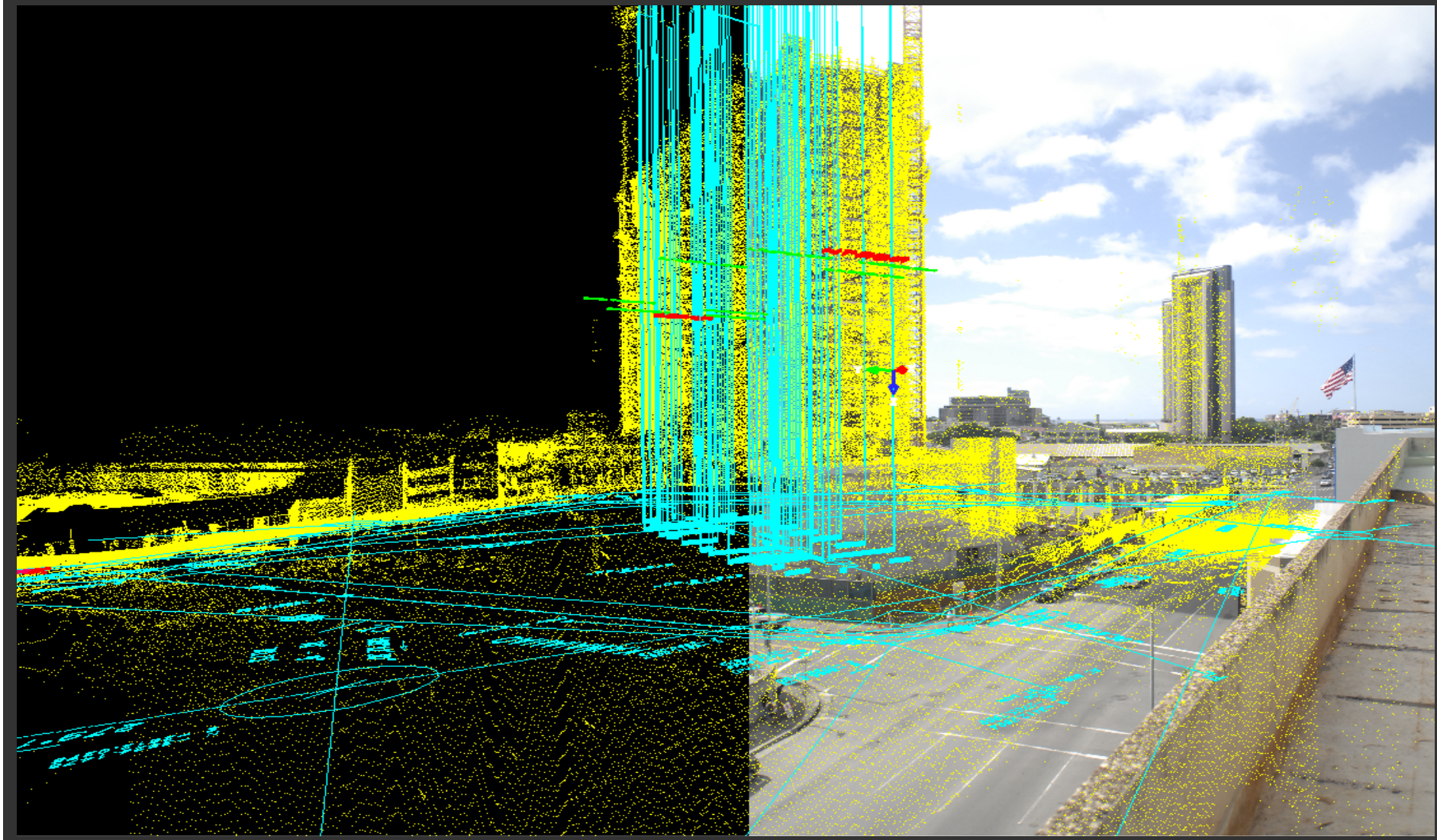


Processing

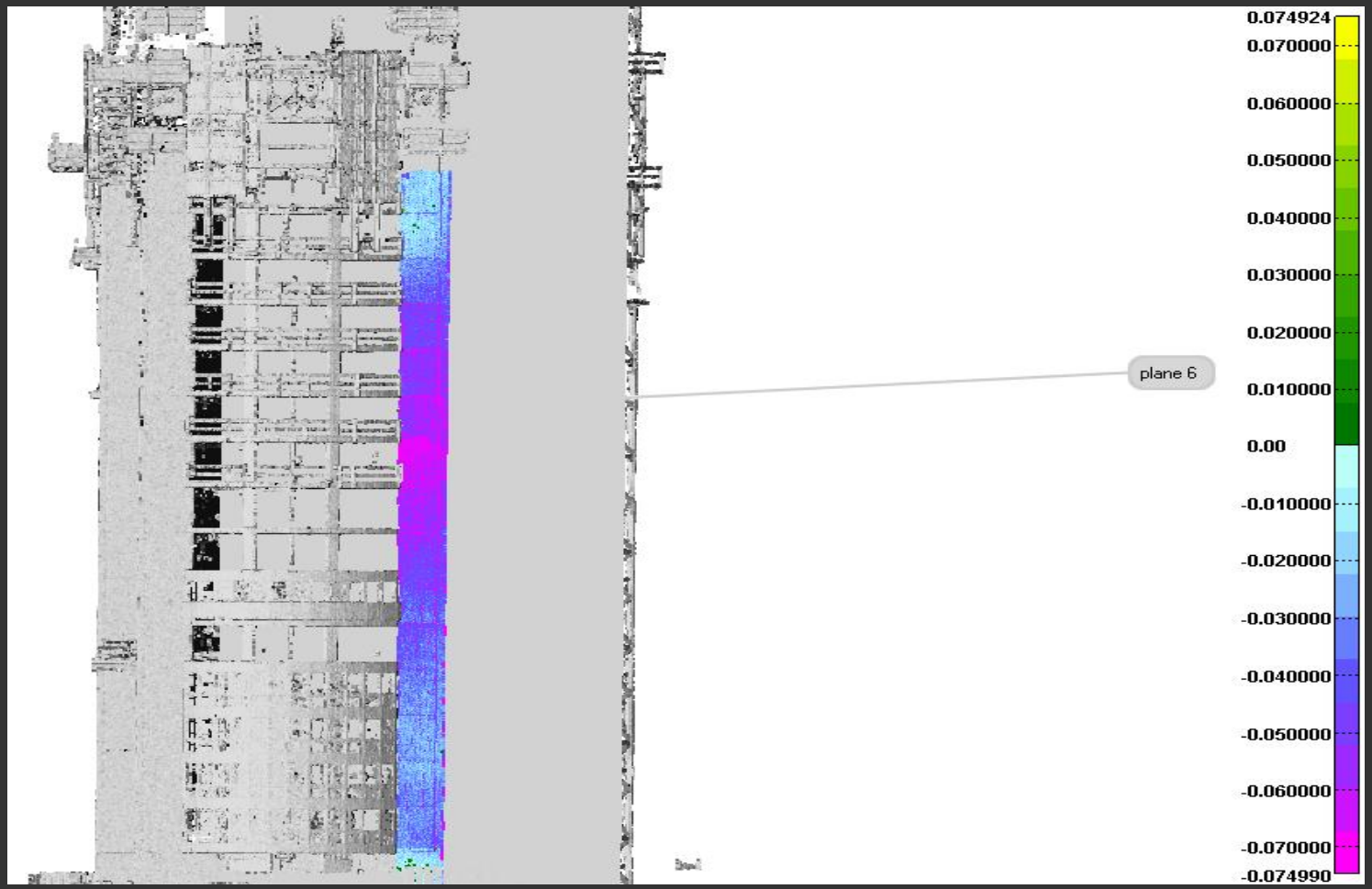
Wire Frame and point cloud and 3D model with point cloud



Cad Model integrated with point cloud and images to analyze Tower



Mapping Structural Distortion in Condo Tower



System Benefits

•Reduced field time for data acquisition

•Complete capture of existing condition:
Scan data
Calibrated photo imagery
Survey control

•Increased accuracy over traditional methods

•Superior 3D deliverables

Q & A