Geospatial Positioning at Oregon DOT

Ken Bays, PLS
Lead Geodetic Surveyor
Oregon Dept. of Transportation

Civil GPS Service Interface Committee
U.S. States & Local Government Session
17 September 2012

Oregon DOT Geometronics Unit

Ron Singh, Chief of Surveys, Manager

Geometronics

- Photogrammetry
- Survey Operations
- Right-of-Way Engineering
- Geodetic Control

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Geometronics

Mark Armstrong
NGS Geodetic Advisor

- **Photogrammetry**
- **Survey Operations**
- **Right-of-Way Engineering**
- **Geodetic Control**

Overview of ODOT Updates

- Oregon Coordinate Reference System
- Oregon Real-time GPS Network
  - Oregon DOT transition to NAD83(2011)(Epoch 2010.00
- Moving towards Engineering Automation
- LIDAR Scanning

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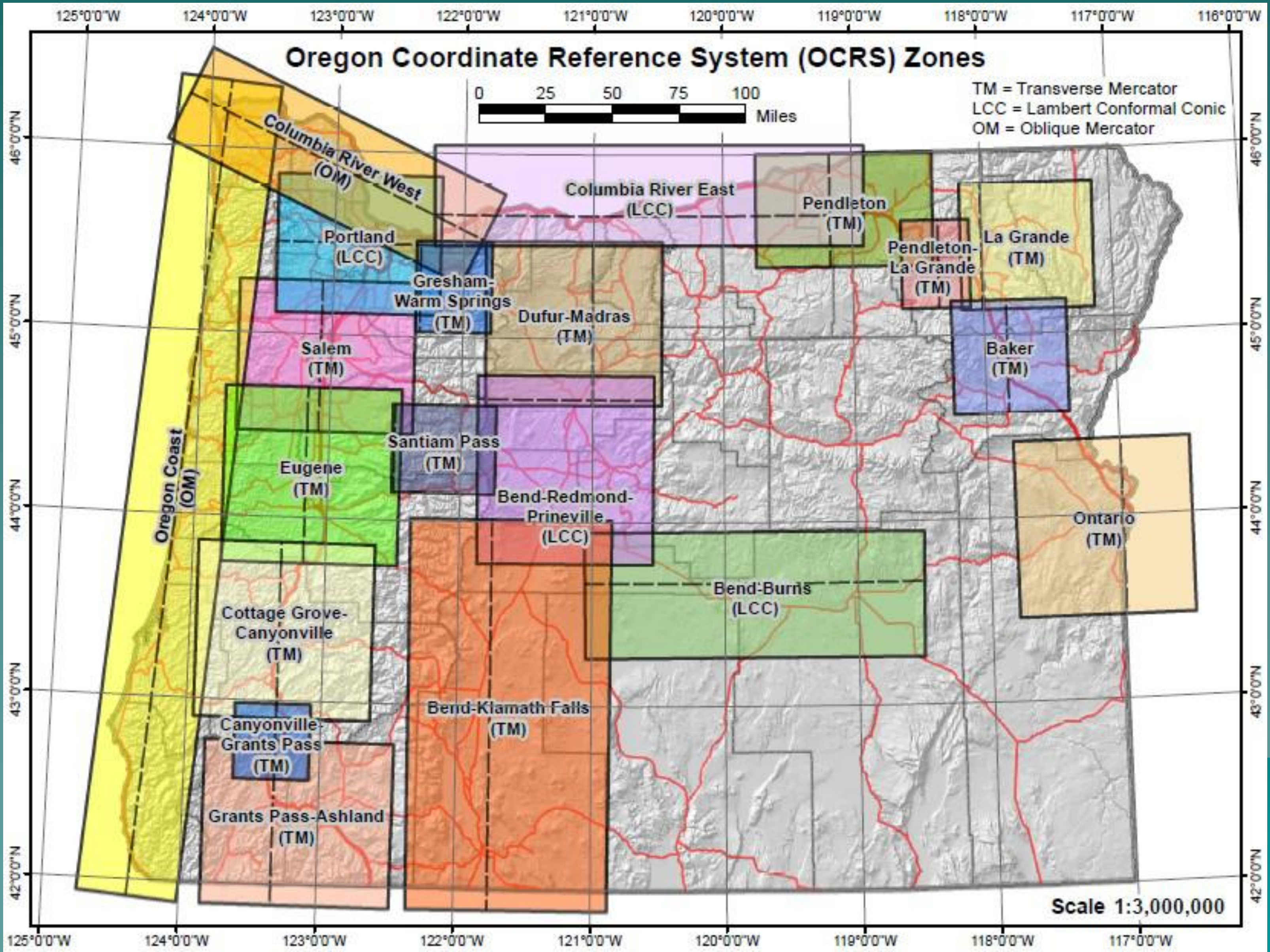
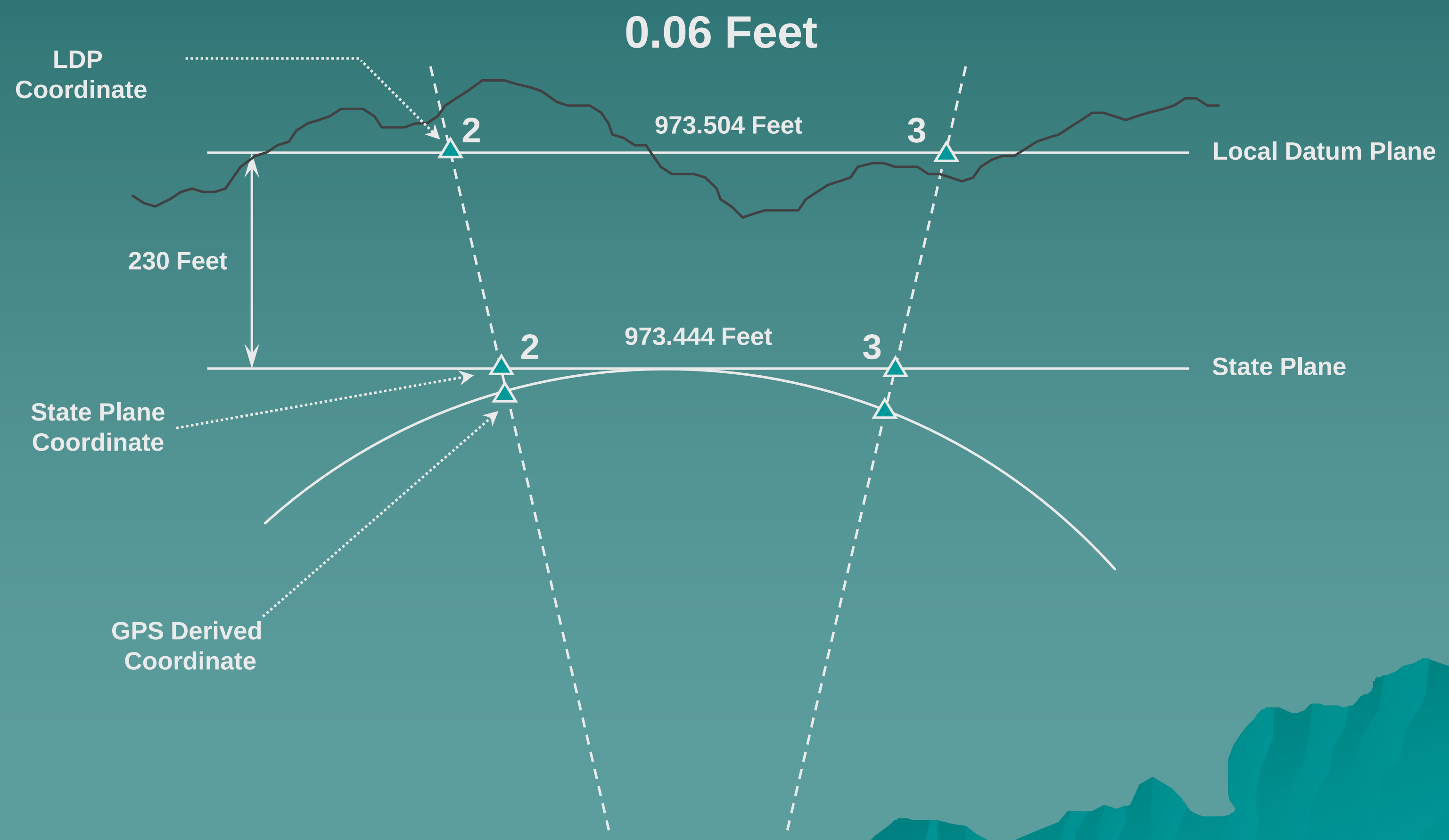
Oregon Coordinate Reference System (OCRS)



Distortion Due to Elevation



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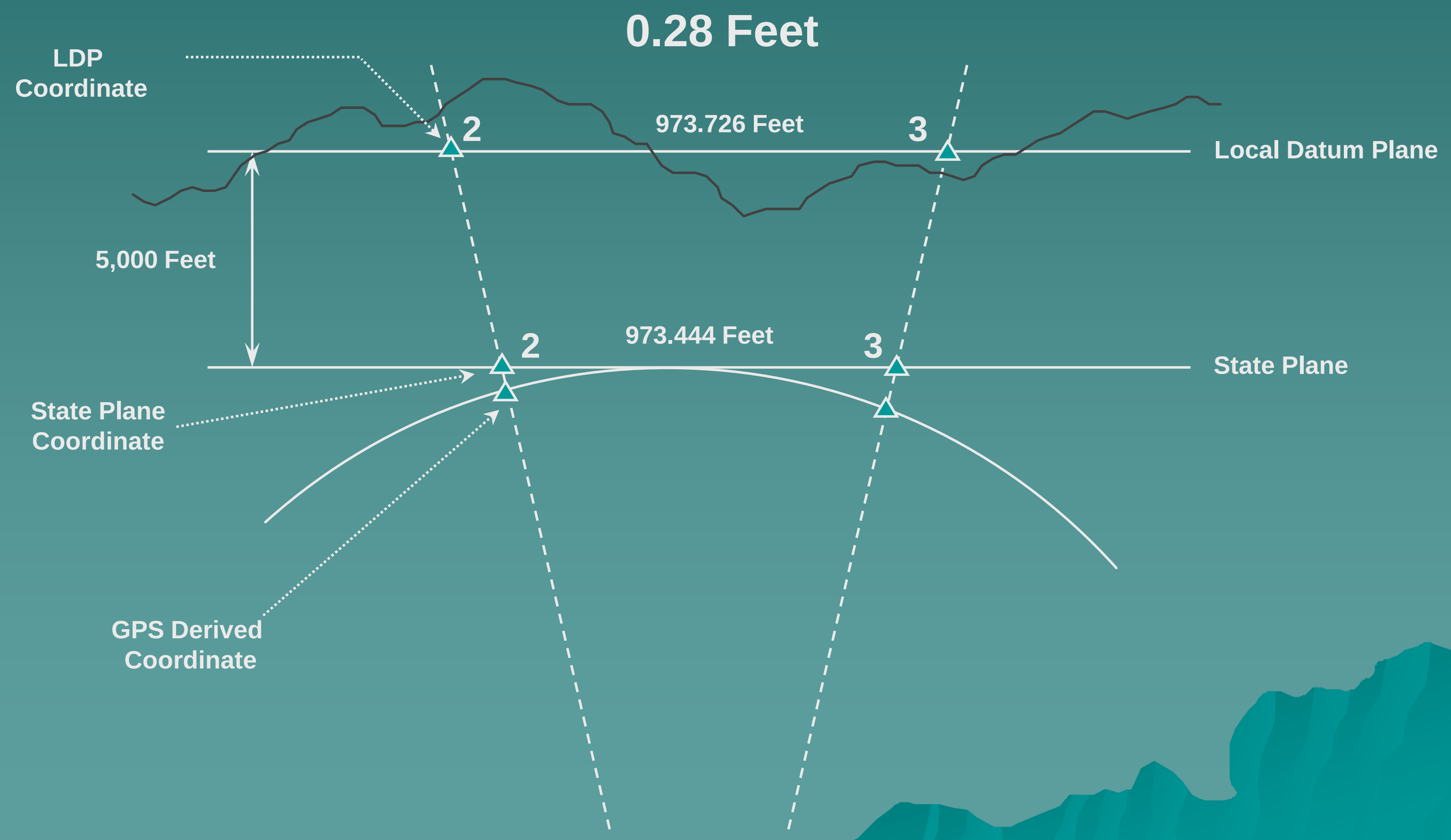
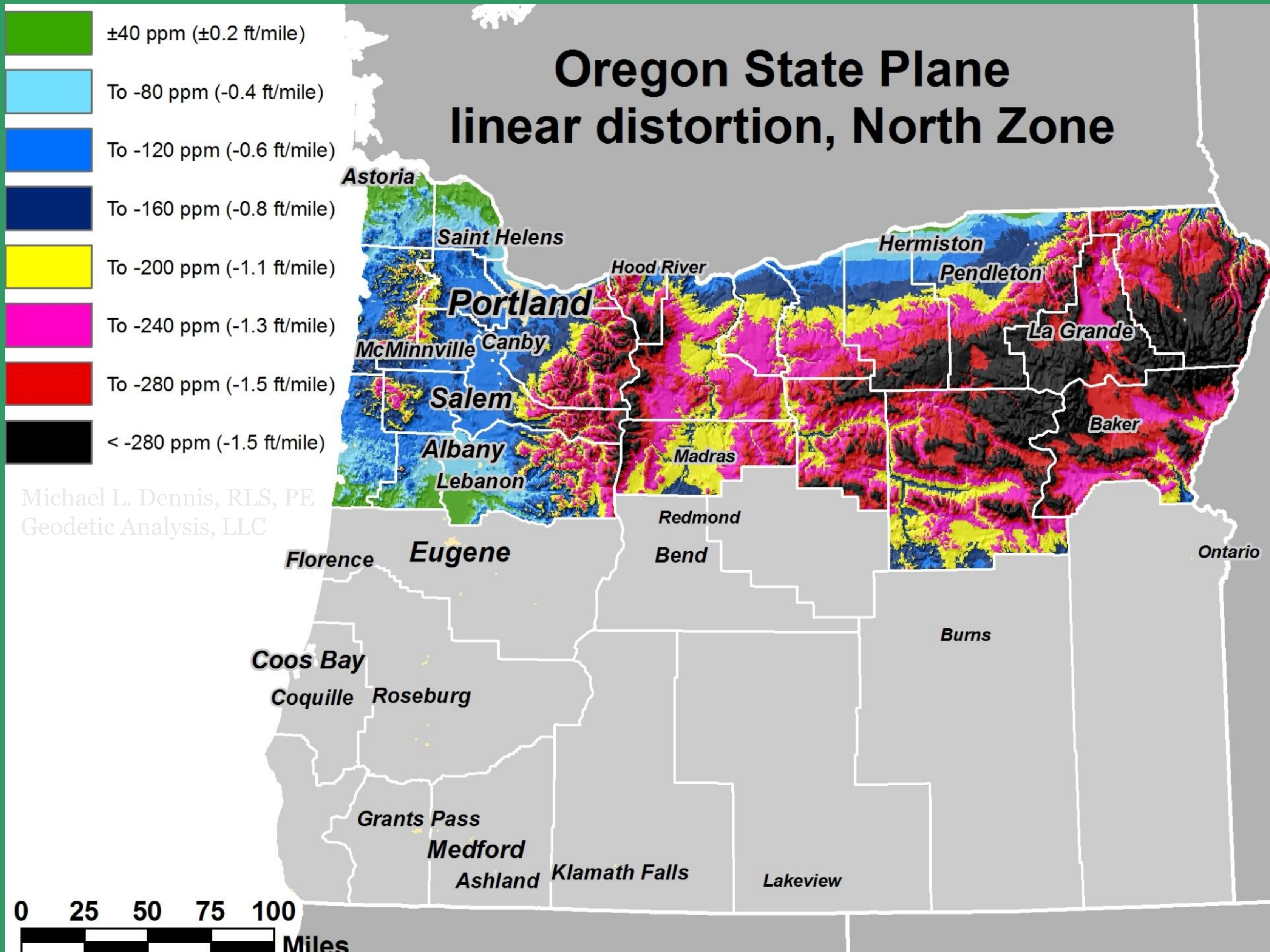
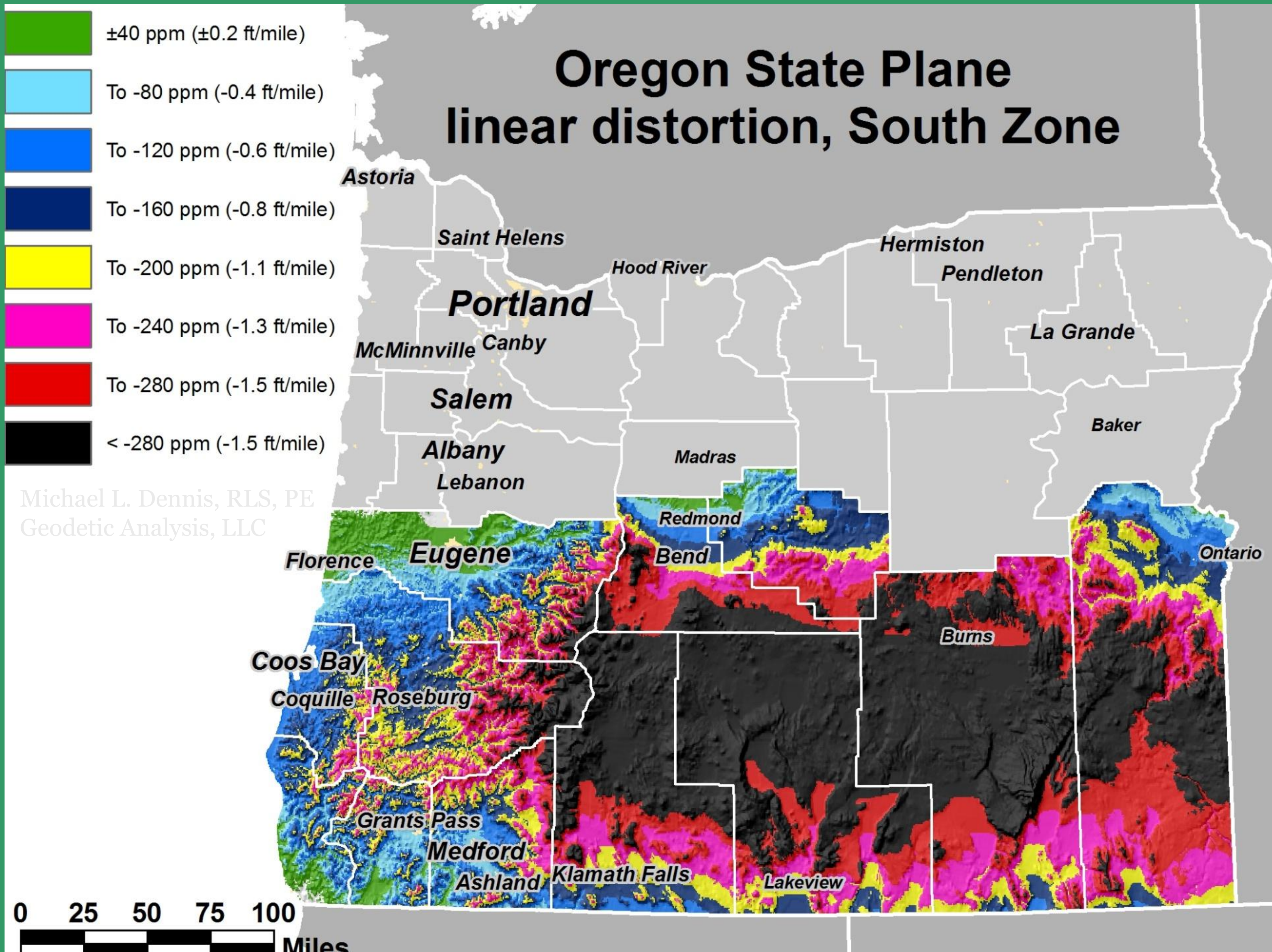



Oregon State Plane
linear distortion, North Zone
±40 ppm (±0.2 ft/mile)
To -80 ppm (-0.4 ft/mile)
To -120 ppm (-0.6 ft/mile)
To -160 ppm (-0.8 ft/mile)
To -200 ppm (-1.1 ft/mile)
To -240 ppm (-1.3 ft/mile)
To -280 ppm (-1.5 ft/mile)
< -280 ppm (-1.5 ft/mile)
Michael L. Dennis, RLS, PE
Geodetic Analysis, LLC
Astoria
Saint Helens
Hood River
Hermiston
Pendleton
Portland
Canby
McMinnville
La Grande
Salem
Baker
Albany
Madras
Lebanon
Redmond
Bend
Florence
Eugene
Ontario
Burns
Coos Bay
Coquille
Roseburg
Grants Pass
Medford
Ashland
Klamath Falls
Lakeview
0 25 50 75 100
Miles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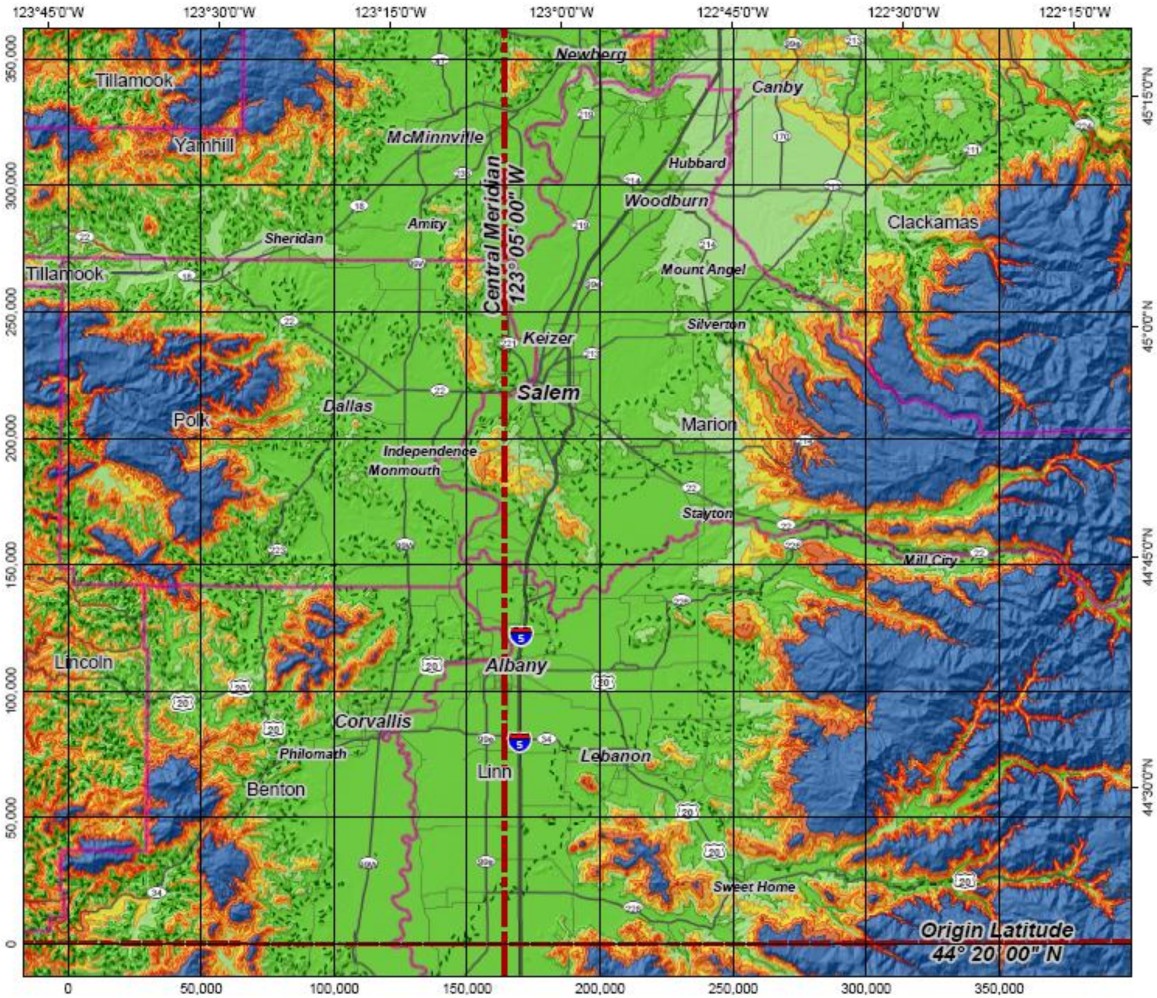
Redmond
Florence
Eugene
Bend
Ontario
Burns
Coos Bay
Coquille
Roseburg
Grants Pass
Medford
Ashland
Klamath Falls
Lakeview
0 25 50 75 100
Miles

Problems with SPC System

- Does not represent ground distances
- Does not minimize distortion over large areas
- Does not support modern surveying accuracy requirements

Oregon Coordinate Reference System



Oregon Coordinate Reference System
Salem Zone

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	44° 20' 00" N
Central meridian:	123° 05' 00" W
False northing:	0.000 m
False easting:	50 000.000 m
Central meridian scale:	1.000 010 (exact)

Grid North

0 5 10 15 20 25 Miles

NOTE: Map grid is shown in units of international feet.

Linear distortion

- Zero distortion
- < -50 ppm (< -0.25 ft/mi)
- ±10 ppm (±0.05 ft/mi)
- 10 - 20 ppm (0.05 - 0.1 ft/mi)
- 20 - 30 ppm (0.1 - 0.15 ft/mi)
- 30 - 40 ppm (0.15 - 0.2 ft/mi)
- 40 - 50 ppm (0.2 - 0.25 ft/mi)
- > +50 ppm (> +0.25 ft/mi)

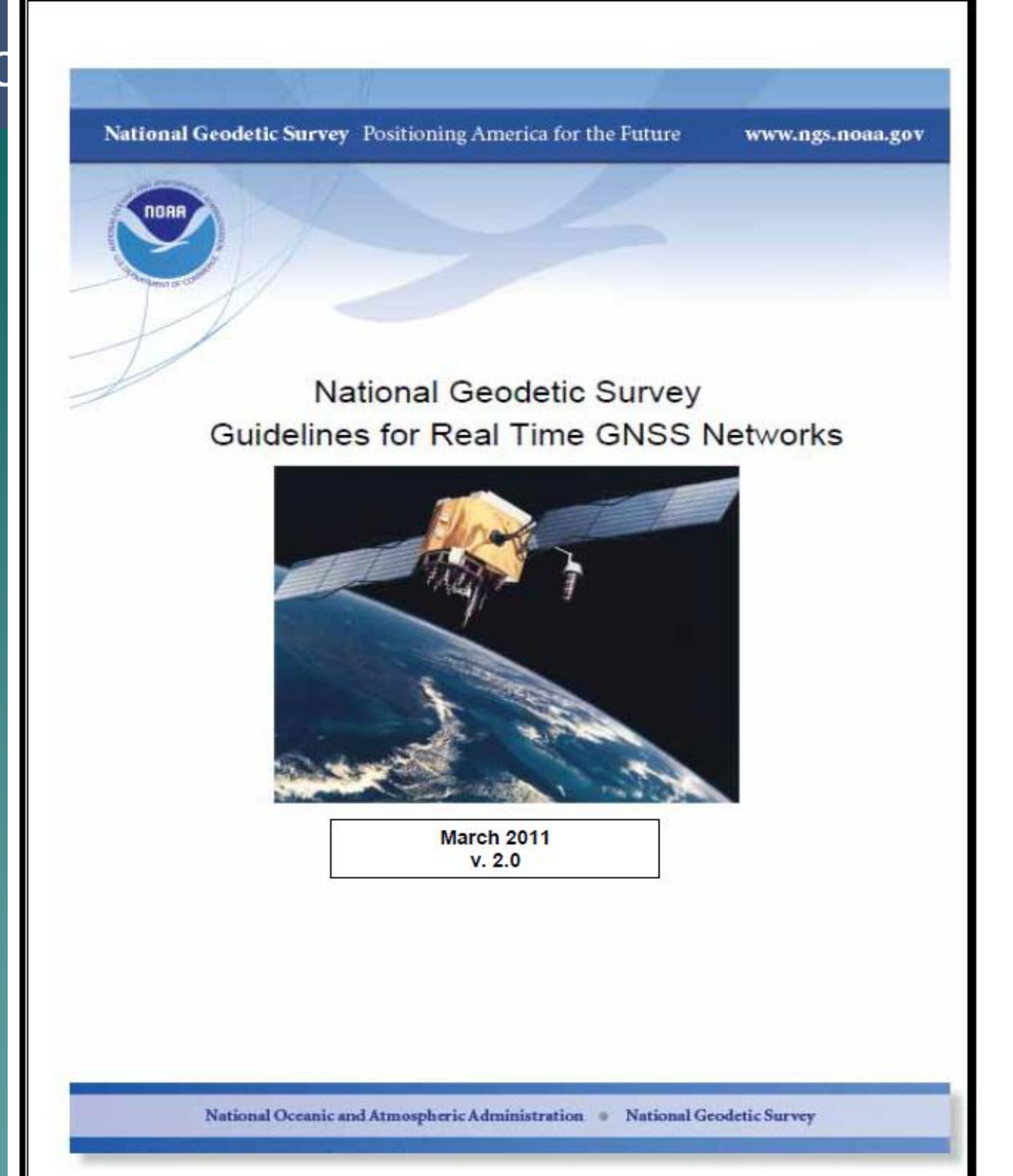
Prepared by:
Michael L. Dennis, RLS, PE
Geodetic Analysis, LLC
8775 S Cliff Ranch Road
Pima, AZ 85543
mld@geodeticanalysis.com

OCRS Update

- 20 zones created in Oregon
- Enabling legislation passed by Oregon State Legislature
- On-line OCRS Tool has been developed
- Several software manufacturers have added the OCRS zones in their coordinate system managers

Oregon Real-time GPS Network

- Update to NAD83(2011)Epoch 2010.00
  - Plan developed
  - NGS Guidelines for Real Time Networks/ possible "certification
  - OPUS-Projects Least Squares Adjustment
    - Fix "computed" CORS in and surrounding Oregon
  - User Support for epoch change:
    - Fiducial passive marks for users
    - Oregon State U: NAD83 Epoch Converter



National Geodetic Survey Positioning America for the Future www.ngs.noaa.gov

National Geodetic Survey
Guidelines for Real Time GNSS Networks

March 2011
v. 2.0

National Oceanic and Atmospheric Administration • National Geodetic Survey

http://www.ngs.noaa.gov/PUBS_LIB/NGS.RTN.Public.v2.0.pdf

OREGON DEPARTMENT OF TRANSPORTATION - GEOMETRONICS UNIT

Guidelines for Positioning the Oregon Real Time Network

With NGS National Spatial Reference System Validation

Mark L. Armstrong, Lead Author

DRAFT v.1.0, 7-01-2011

Major Elements of ODOT's Plan

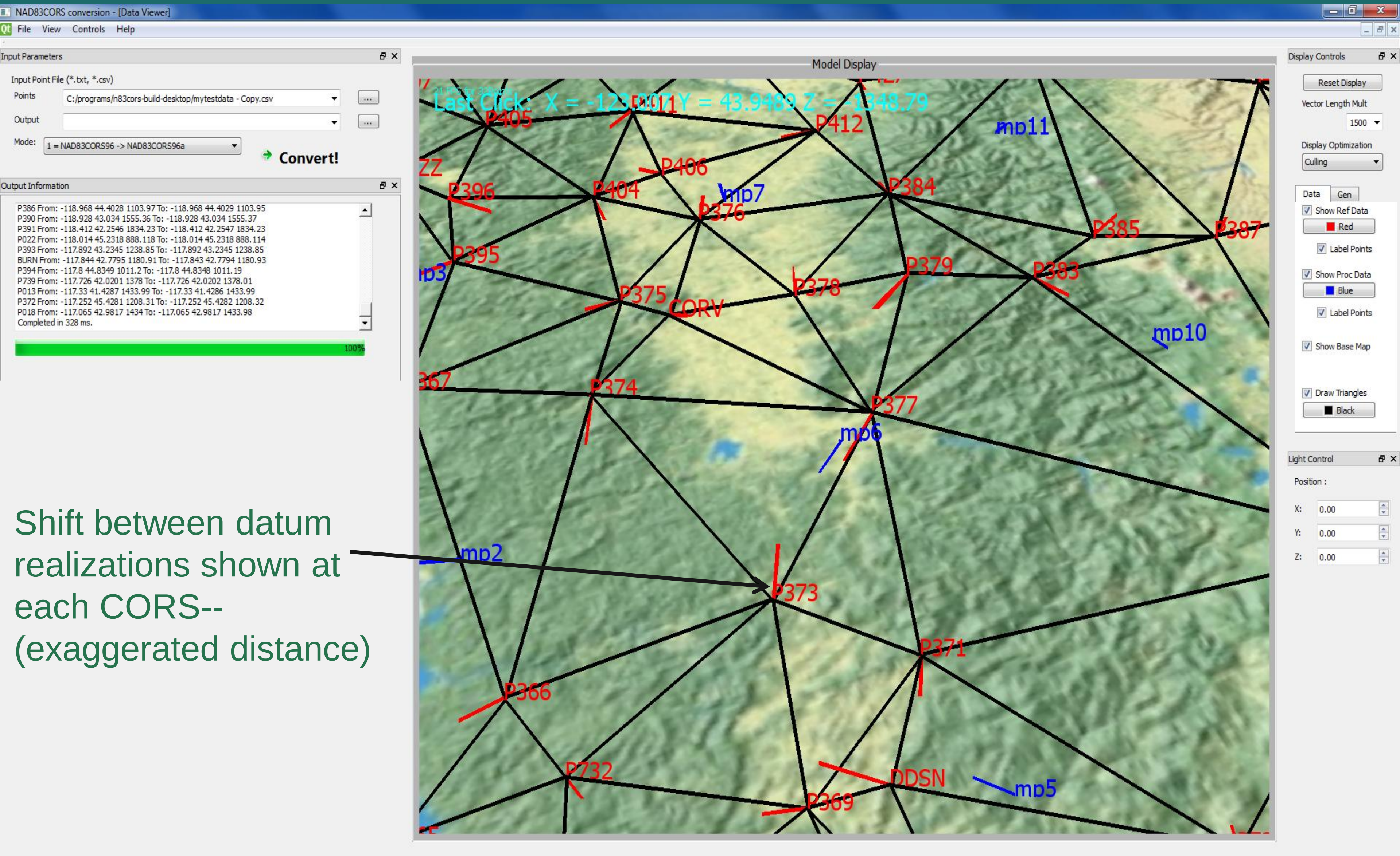
- *Process/Adjust with NGS OPUS Projects online*
- *Pick NGS MYCS sites to fix in adjustment*
  - *All are "**computed sites**" with at least 2 ½ years of data*
    - *Versus "**modeled sites**" with less than 2 ½ years of data.*
- *Use 5 days of data during high pressure period over the state*
- *Check adjustment with other least squares software*
- *A minimum of 10% of the stations in the ORGN will be NGS CORS*
- *Site standards meet NGS CORS requirements*
- *Test final coordinates using ORGN real-time correctors*
- *Provide fiducial points on passive control that users of ORGN real-time correctors can check in to.*
- *Provide user support to ease changeover*

OPUS-Projects (OP)

- A valuable addition to the NGS OPUS suite
- Currently in beta format
  - Has integrated Epoch 2010.00 positions for CORS
  - Has integrated ANTEX IGS08 antenna calibrations
- OP Provides:
  - Uploading of GPS data via the OPUS portal
  - Processing baselines via NGS PAGES software
  - Least squares adjustment of data via GPSCOM software
  - Google Earth-based map view of project and baselines
  - Improved positioning over OPUS-Static averaging of single base line positions
- Software author: Dr. Mark Schenewerk, NGS

Oregon Data Conversion Tool

Oregon Data Conversion Tool



Shift between datum realizations shown at each CORS--(exaggerated distance)

What the "Tool" will do:

- **Converts users positions back and forth from:**
  - NAD 83 (CORS96) Epoch2002.00

    to/from

  - NAD 83 (2011) Epoch2010.00

Who is developing the "Tool"

- Michael Olsen, Assistant Professor of Geomatics, Oregon State University, is developing the mathematical algorithms and software.
- Cooperation, input, and assistance from:
  - Oregon DOT Geometronics Unit
  - Mark Armstrong, NGS State Geodetic Advisor for Oregon

Why do ORGN users in Oregon need this Tool?

- Will ensure continuity within projects
  - User may keep a single datum realization for a project spaced over the change from the superseded to the new datum realization.
- Provides an immediate datum realization transition solution until user projects are solely within the new datum realization
- "Keep my phone from ringing off the hook!"
- Note: For surveying/enginnering accuracy, should perform an calibration/localization and not rely on this tool.

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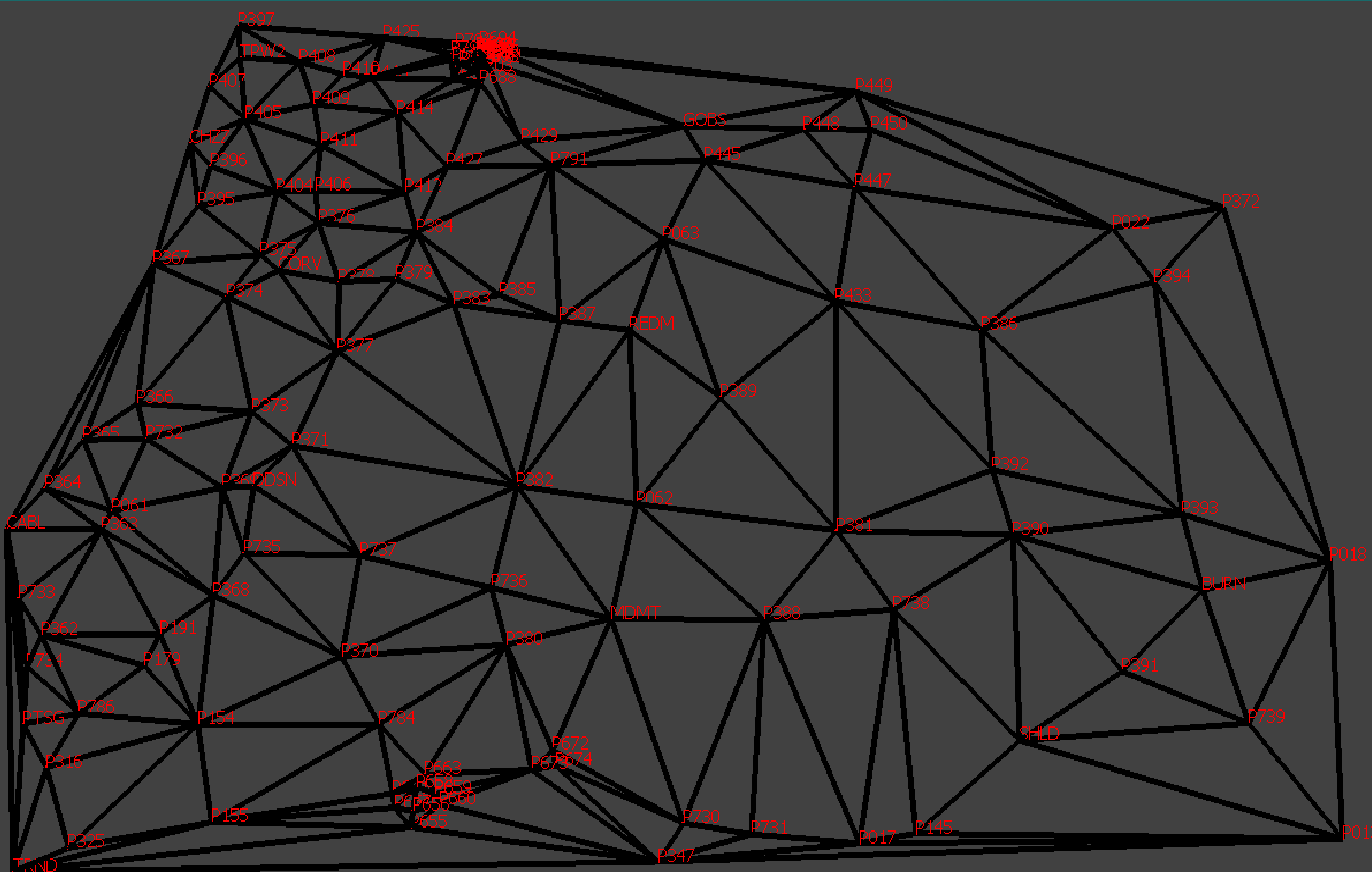
The CORS Position Delaunay Triangle Network



- Oregon DOT is poised for field-to-finish automation:
  - Surveying: pre-design & construction
  - 3-D Digital Design: machine control ready
  - 3-D Digital As-Builts
  - Digital Signature technology & legislation
  - Construction Administration

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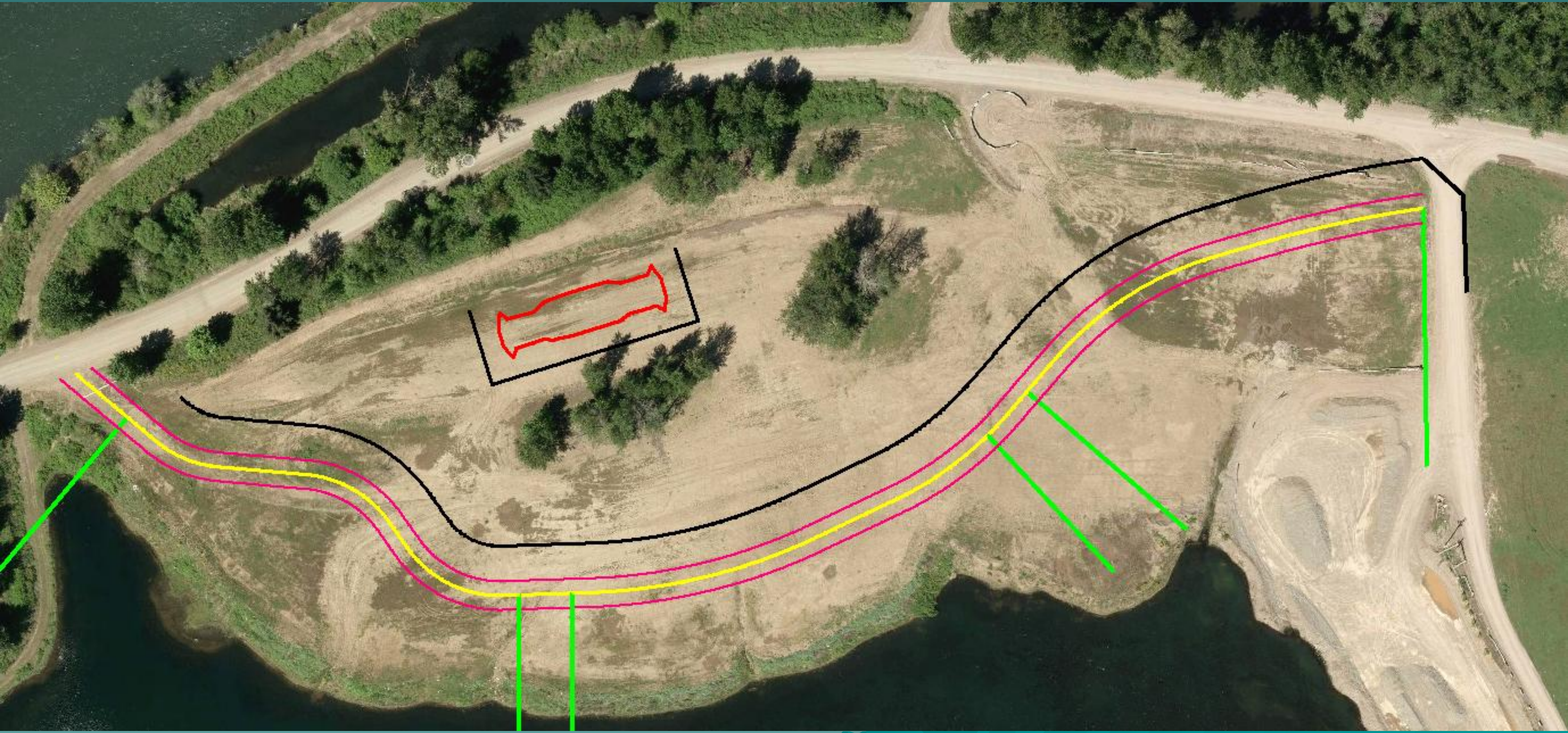
2010 Design to Dozer Demonstration

Computer Controlled Heavy Equipment

Pre-design Survey

- Geodetic Control:
  - Oregon Real-time GPS Network
- Coordinate System:
  - Oregon Coordinate Reference System
- Digital signatures for Professional Filed Documents

3-D Design



3-D Design

Design input into heavy equipment

Computer Controlled Construction

Section of Sub-grade completed

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Visualization of Paved Surface

- Engineering Automation, i.e., 3-D digital as-builts contribute to the enabling technology for “connected vehicle” highway safety programs.

LIDAR Use in Oregon

- Airborne
  - Fixed Wing (high altitude)
  - Helicopter (low altitude)
- Terrestrial
  - Static
  - Mobile

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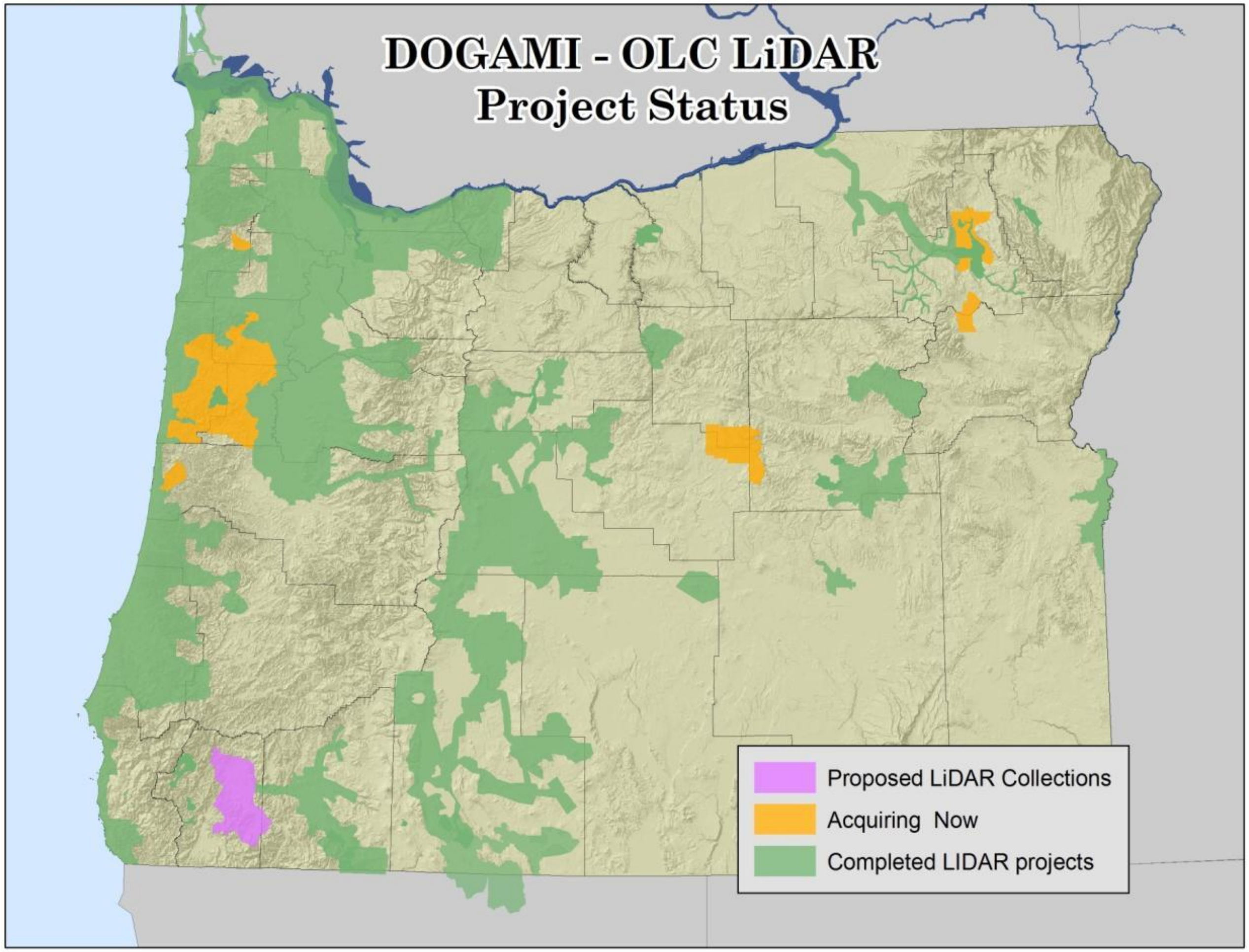

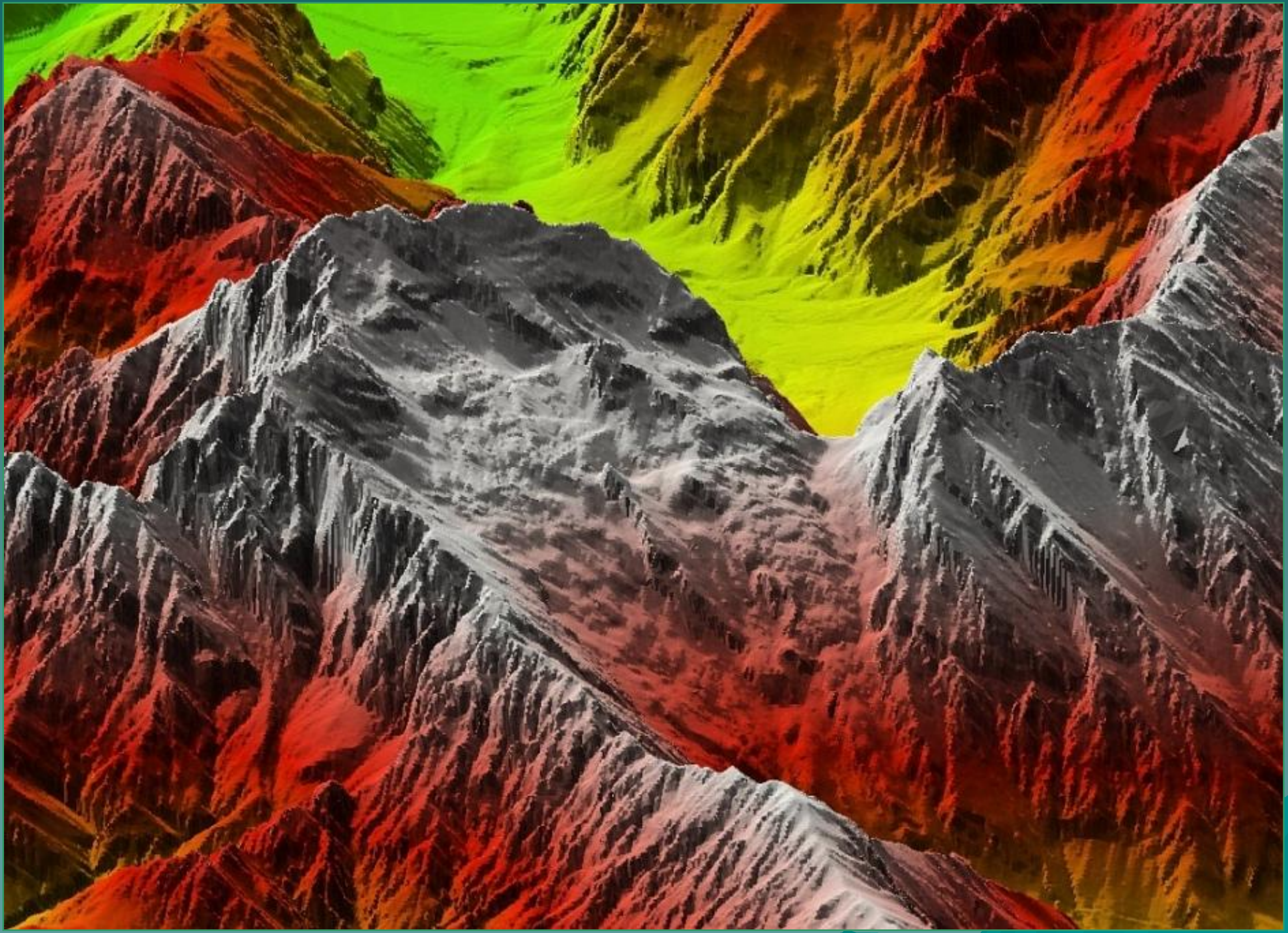

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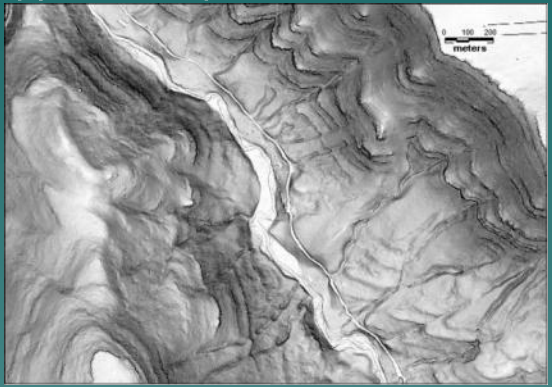
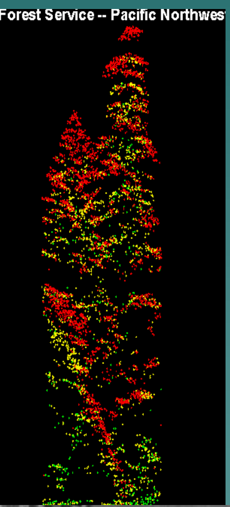
OLC DATA PRODUCTS

3 ft pixel bare earth DEM ESRI format (quad tiles)

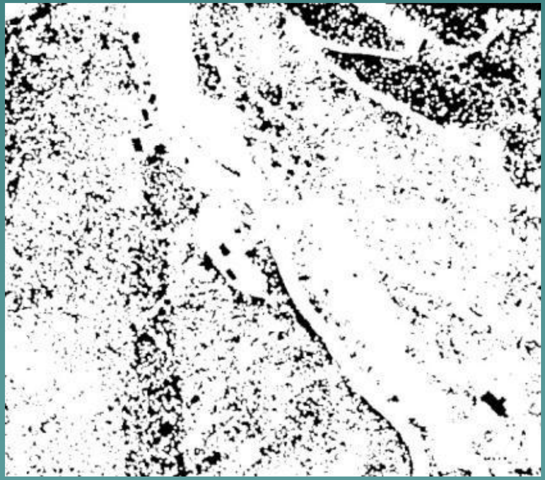


3 ft pixel first return DEM ESRI format (quad tiles)

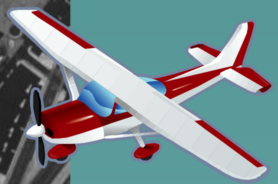


Point cloud, LAS format 1/100 quad tiles
All returns
Ground Points

1 ft pixel intensity images (tiled by $^{1}/_{100}{}^{th}$ quad)



Ground point density grid



Aircraft Trajectories and date-stamped flightlines

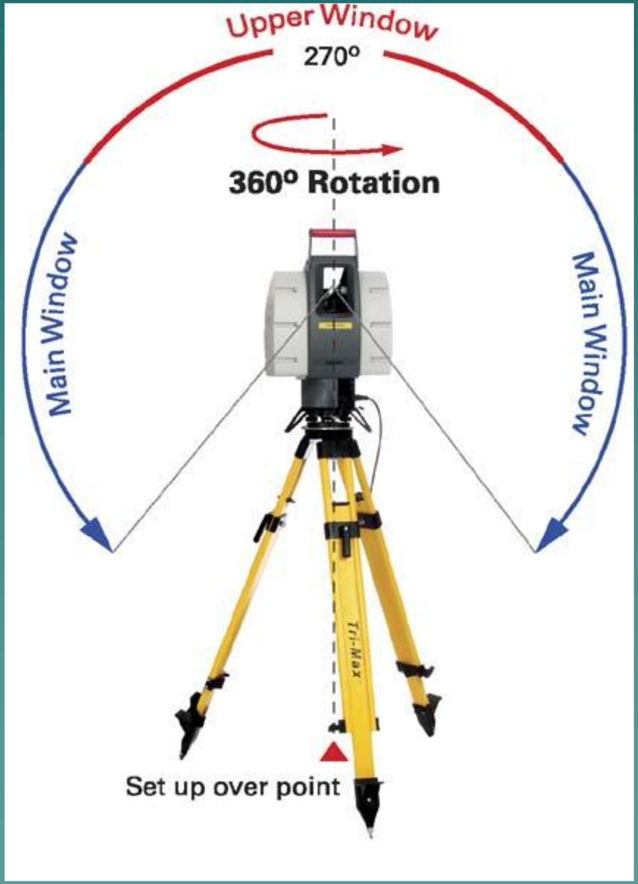
Report and metadata !!

AIRBORNE (FIXED WING)

- Find landslides, old cuts and grades
- Measure and estimate fills and cuts
- Find stream channels, measure gradients
- Measure the size and height of buildings, bridges
- Locate and measure every tree in the forest
- Characterize land cover
- Model floods, fire behavior
- Locate power lines and powerpoles
- Support archeological investigations
- Map wetlands and impervious surfaces
- Define watersheds and viewsheds
- Map road center and sidelines
- Find law enforcement targets
- Map landforms and soils
- Assess property remotely
- Monitor quarries, find abandoned mines
- Enhance any research that requires a detailed and accurate 2D or 3-D map

STATIC SCANNING

STATIC SCANNING

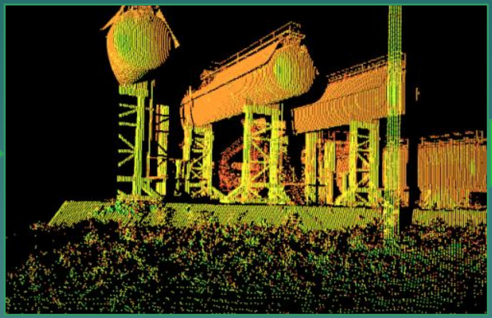


- Captures the geometry of existing physical objects
- Allows Virtual Surveying in office
- Facilitates Solid Object Modeling

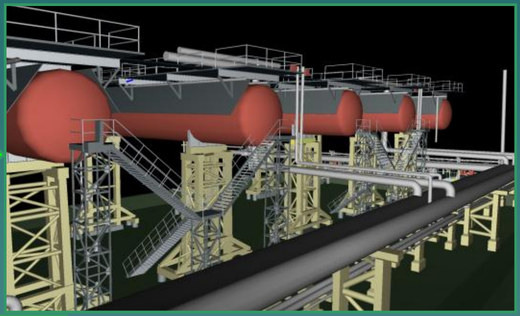
STATIC SCANNING

- 2-6mm accuracy
- Structures: inaccessible, unsafe, delicate
- Complex Geometry
- Fast Data Collection (thousands of points/sec)
- Extensive Detail
- Immediate Results

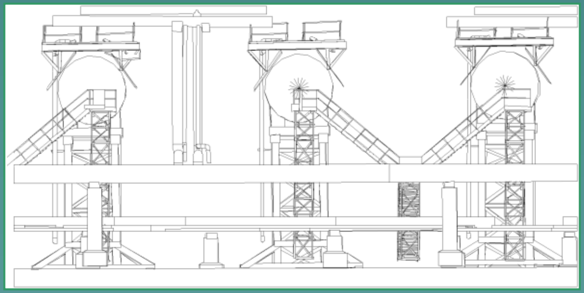
STATIC SCANNING TYPICAL WORKFLOW



ACQUISITION



MODELING



2D / 3D CAD

STATIC USES

- Virtual Surveying
- Mapping
- Reverse engineering
- Non-contact inspection
- Structure analysis and testing
- Determine fit before shipping to site
- As-built surveys
- Historical archive

STATIC SCANNING PRODUCTS

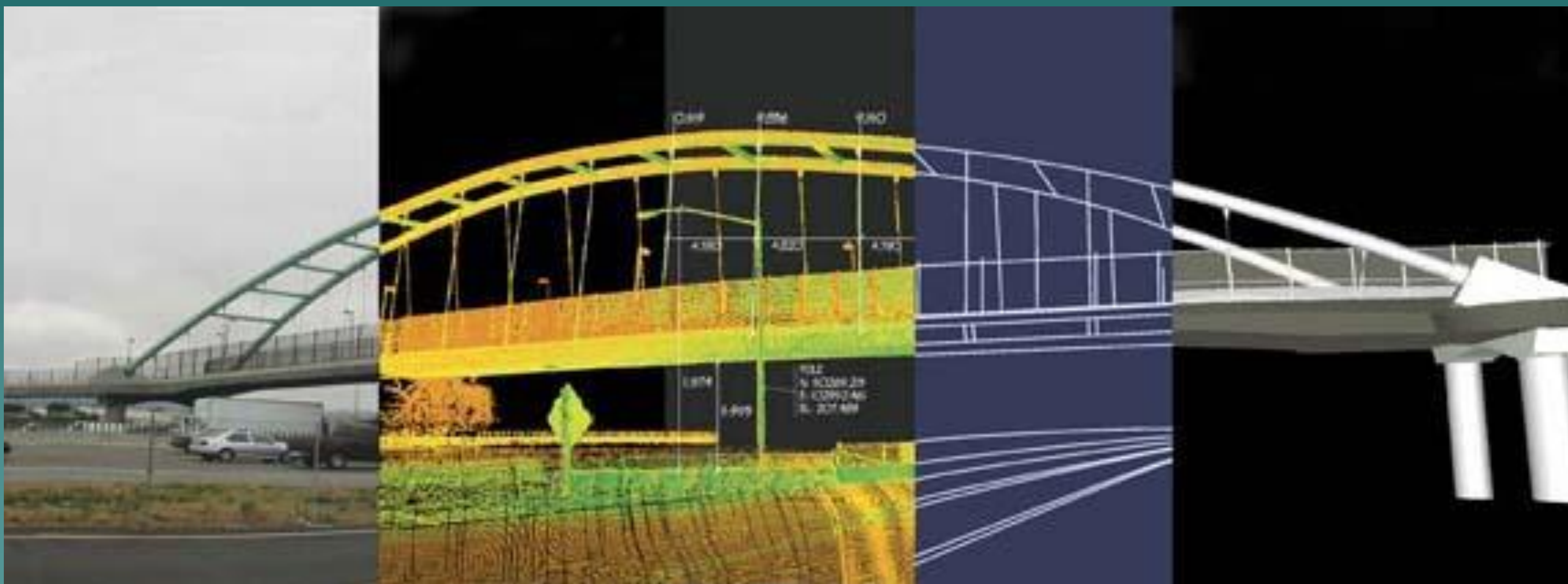
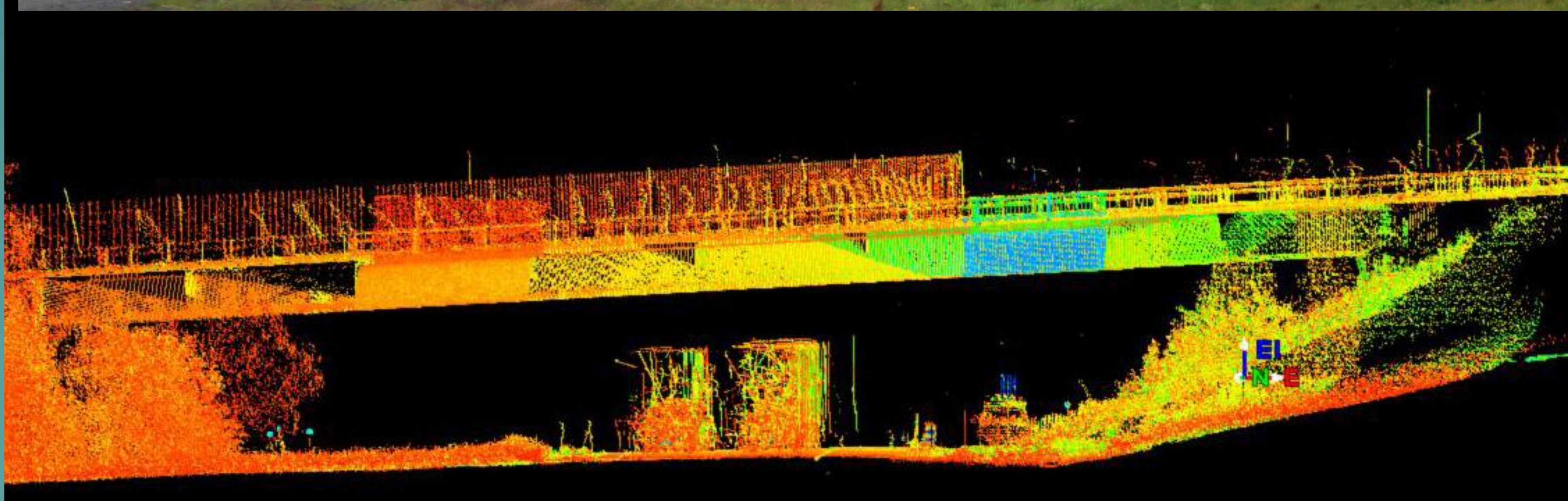


Photo Scan Vector Solid Objects



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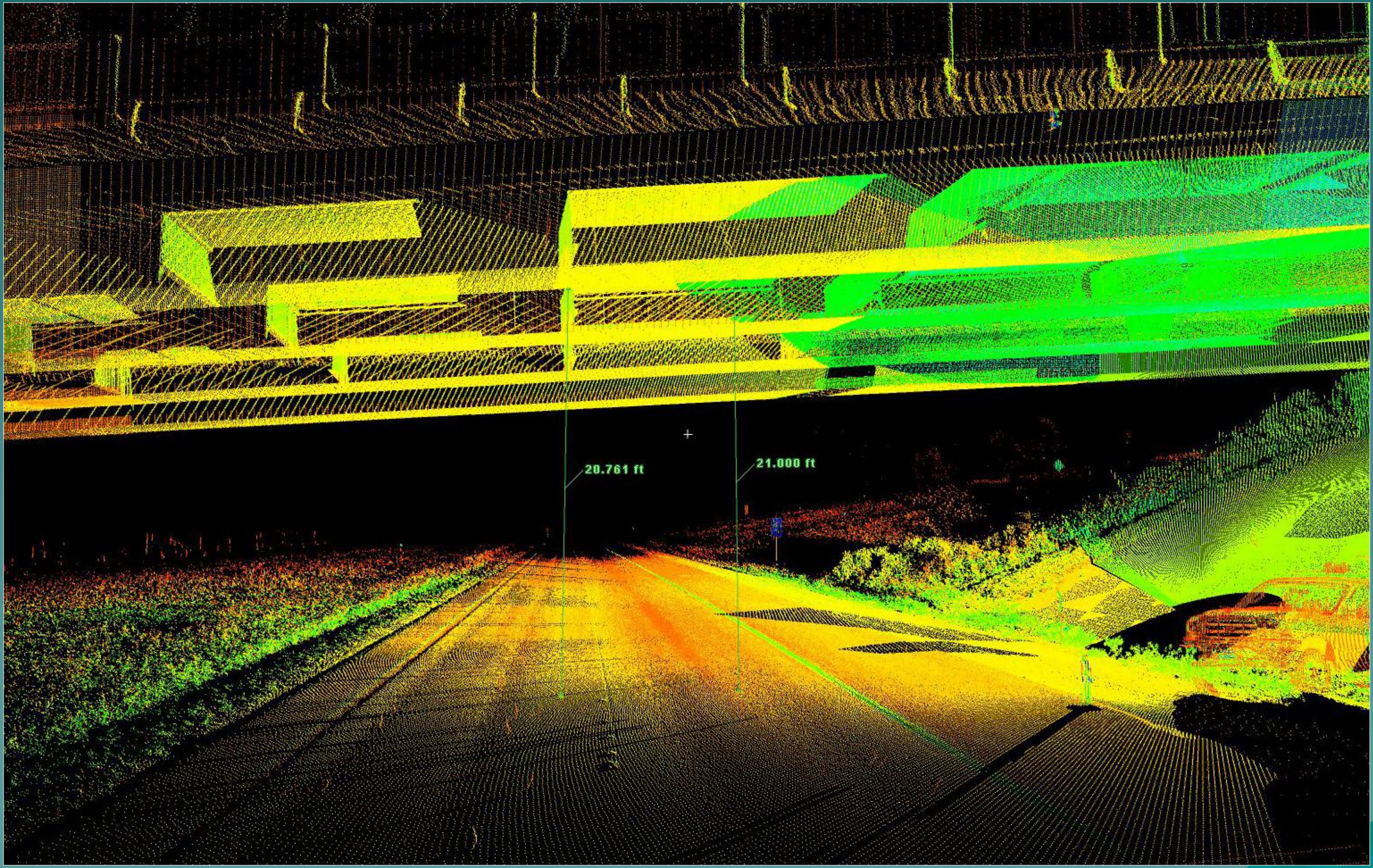

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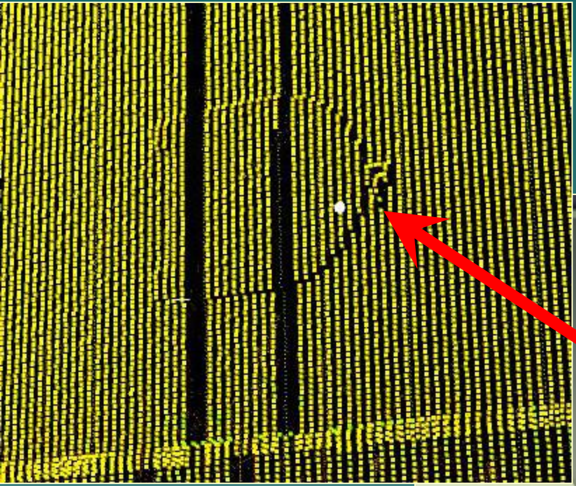

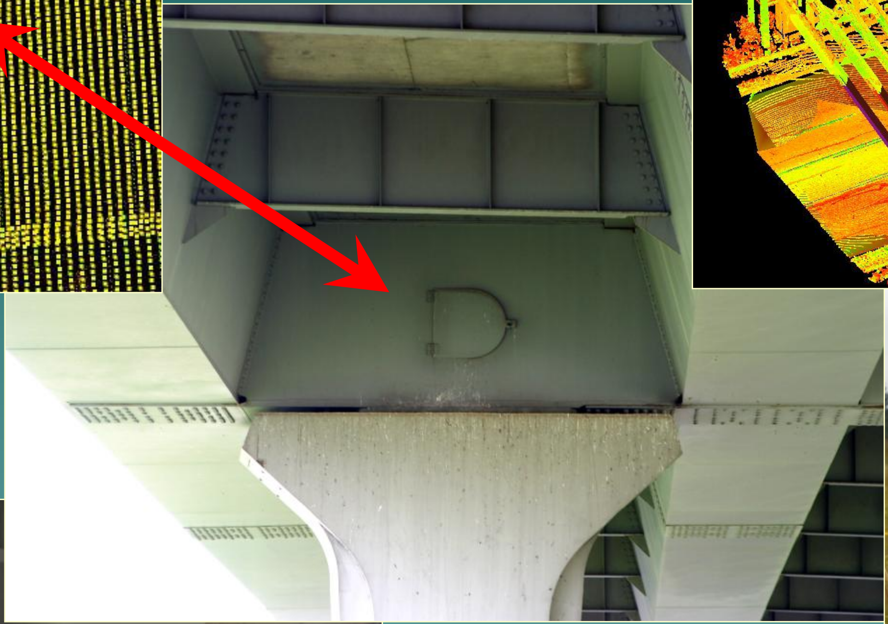

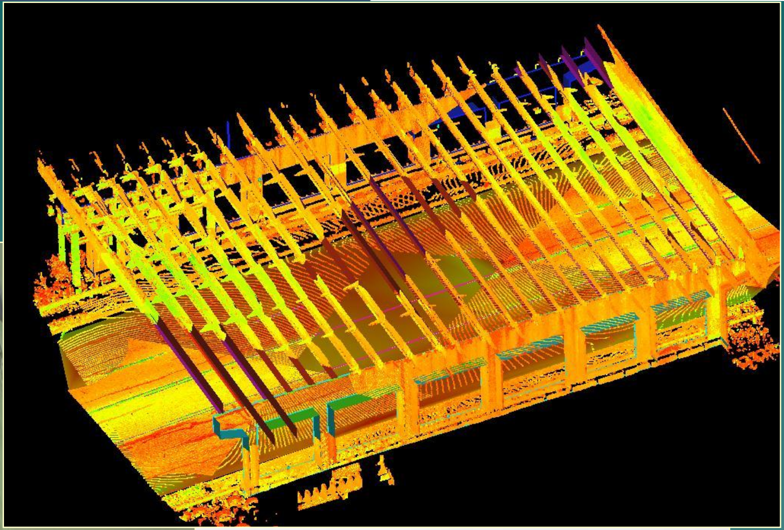

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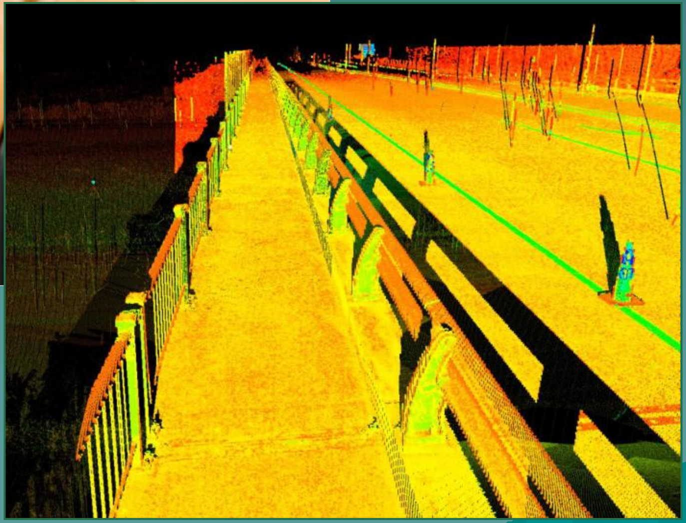

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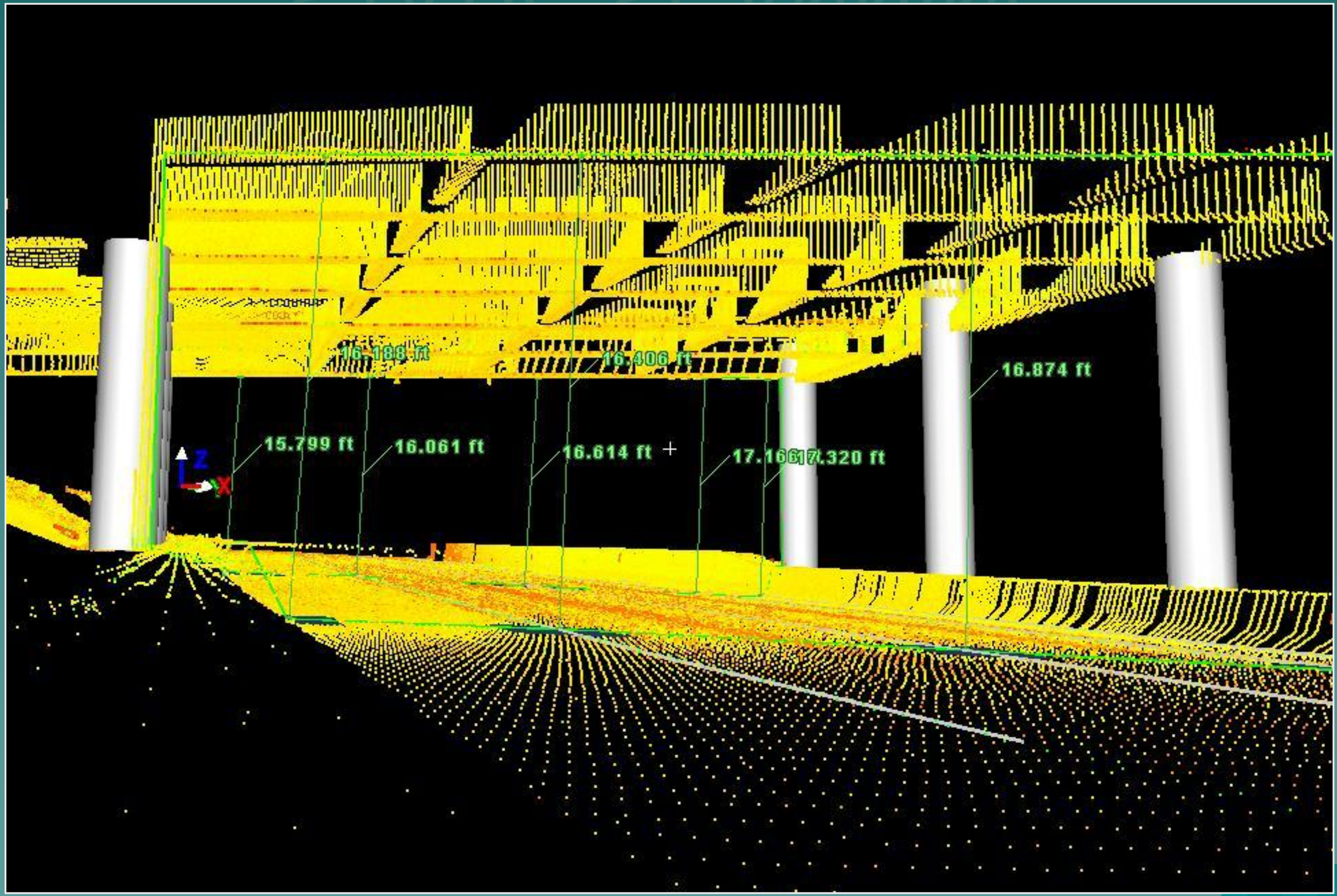

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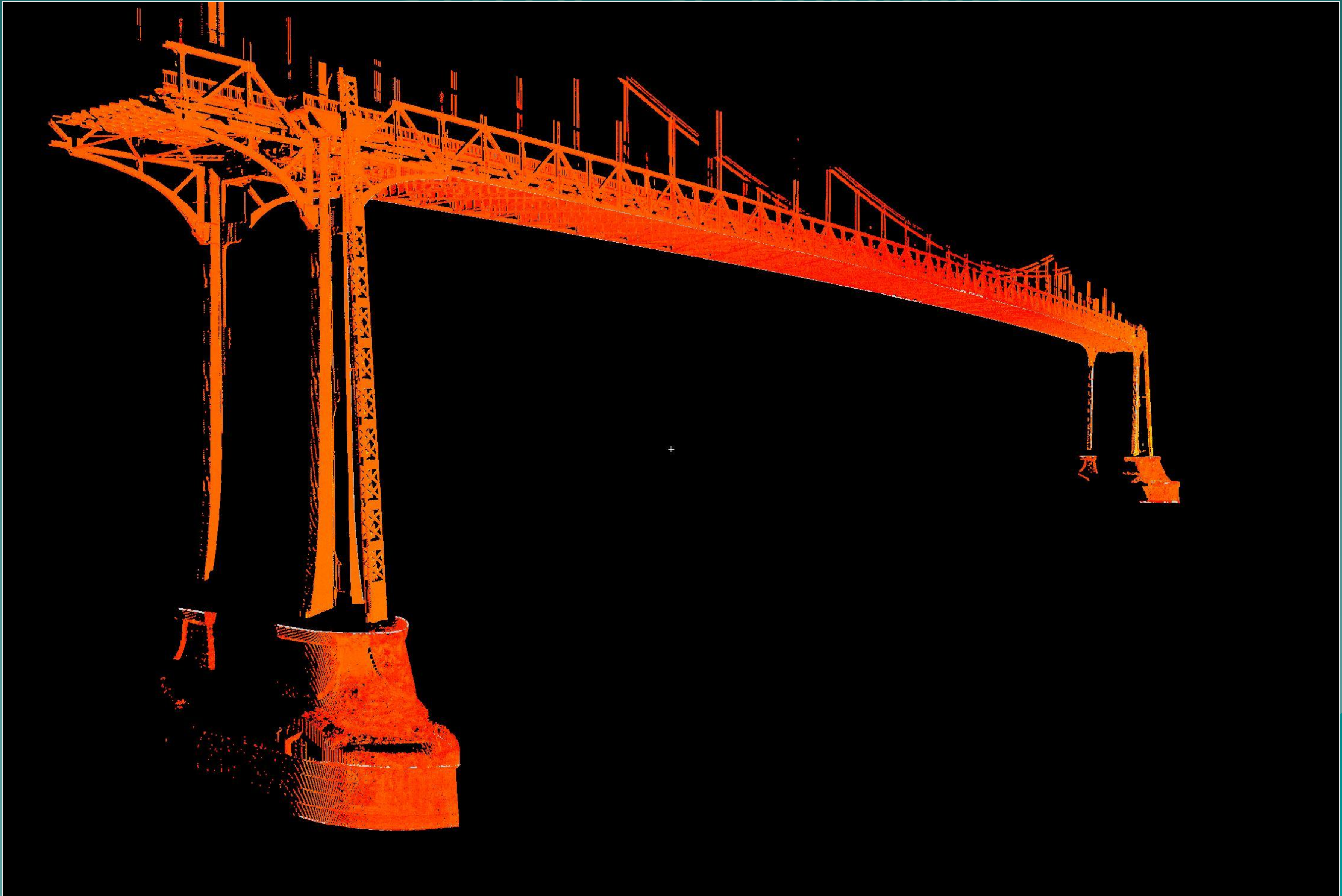
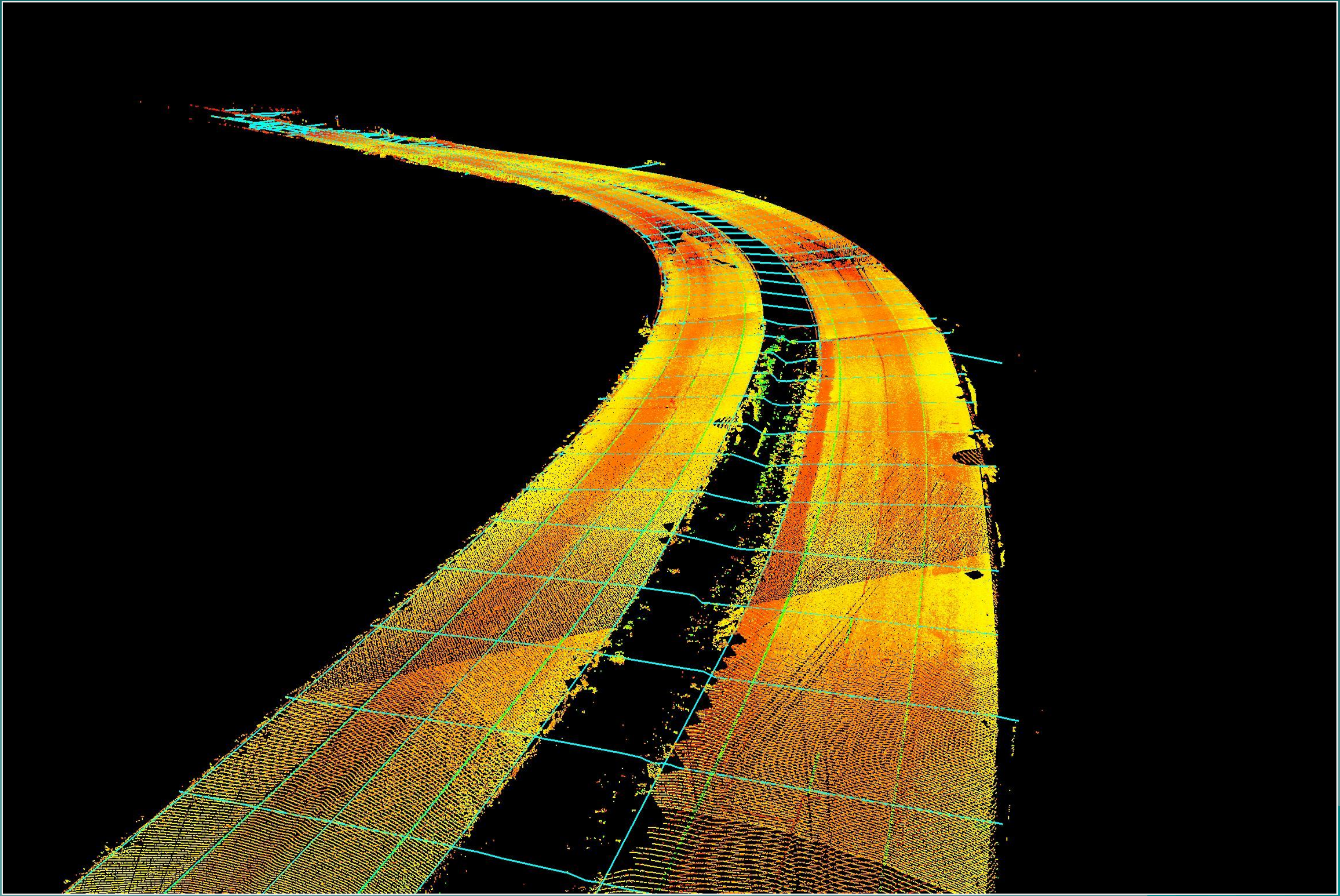
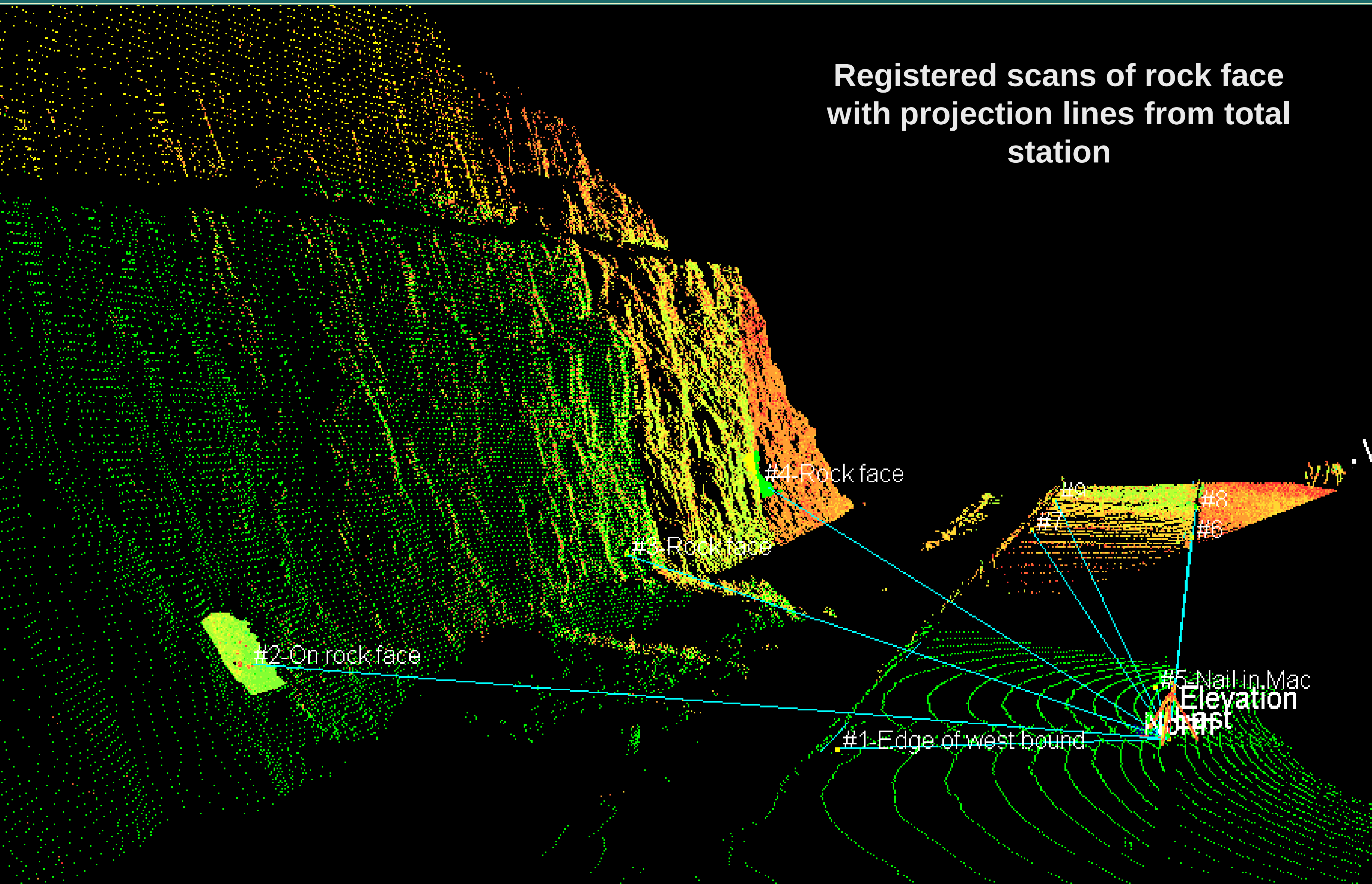
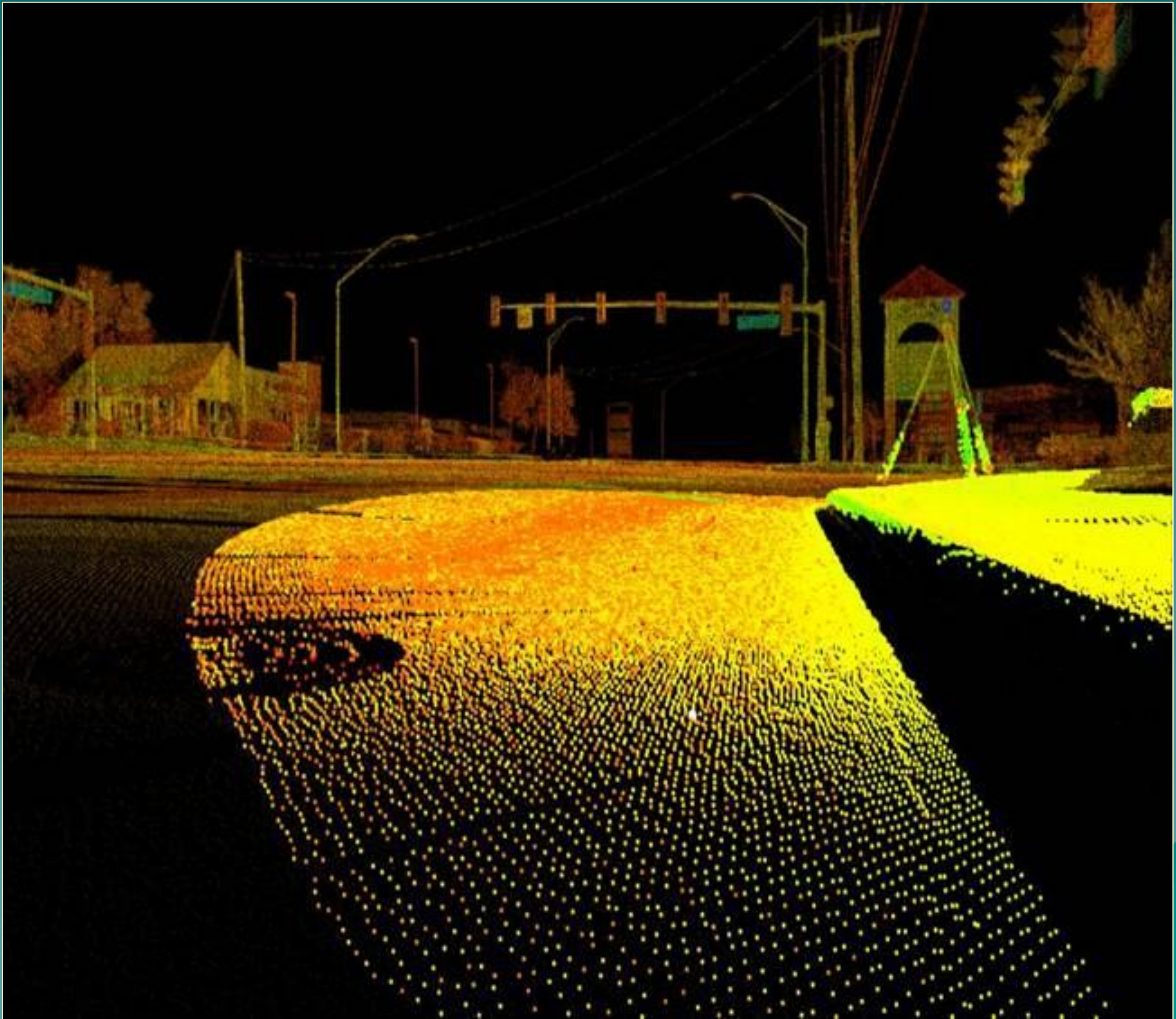
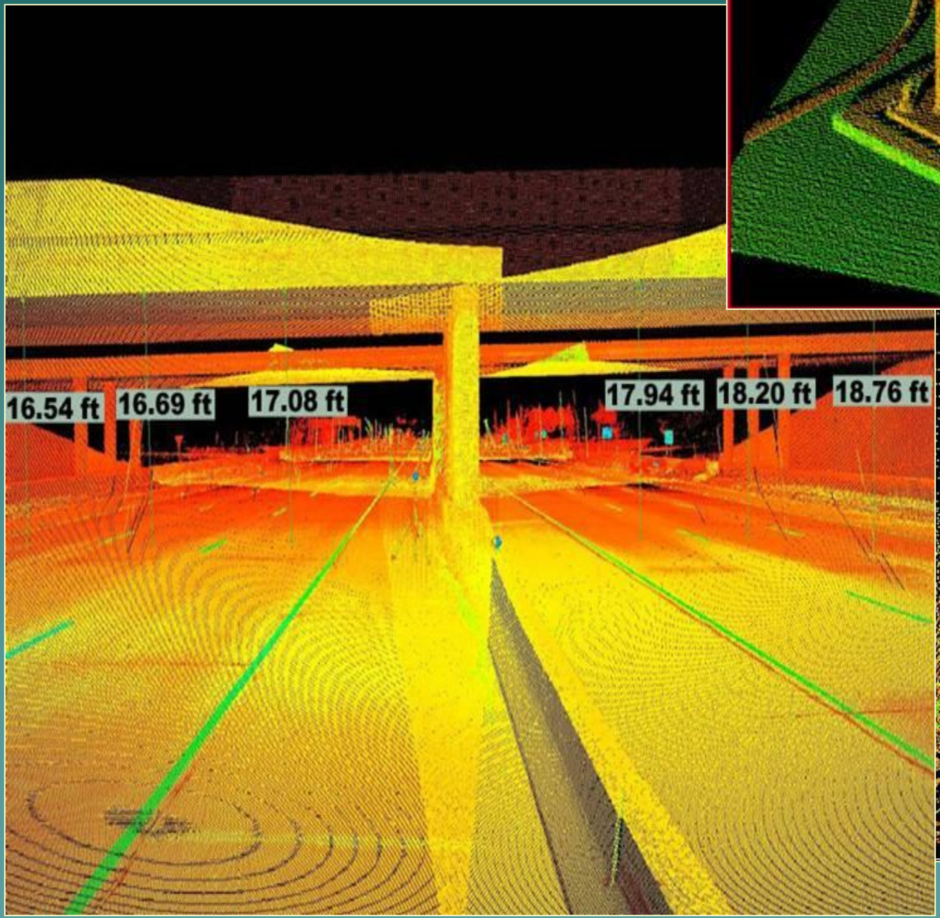


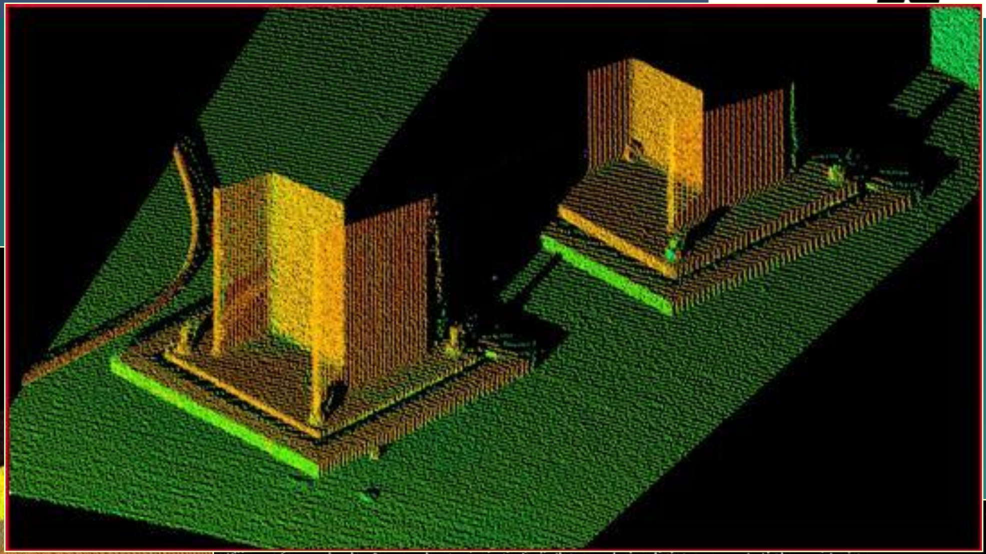


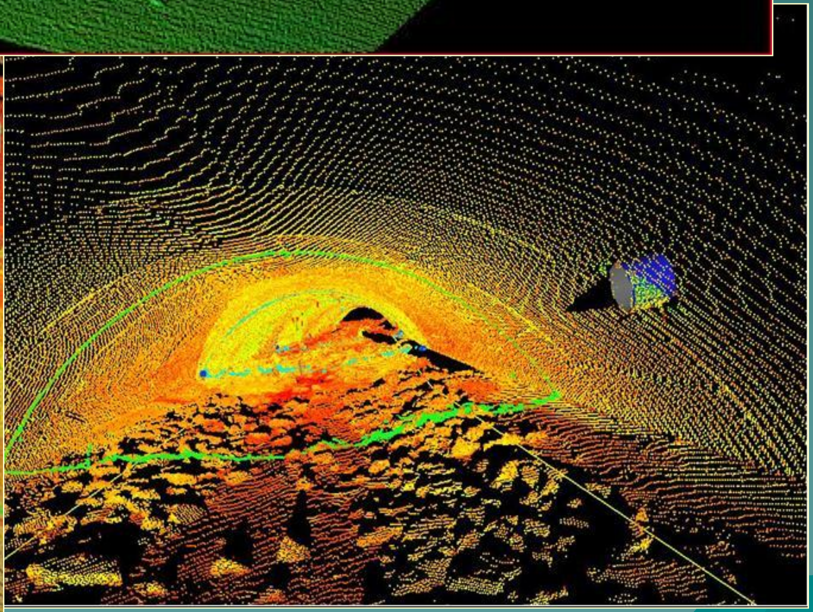
Registered scans of rock face with projection lines from total station

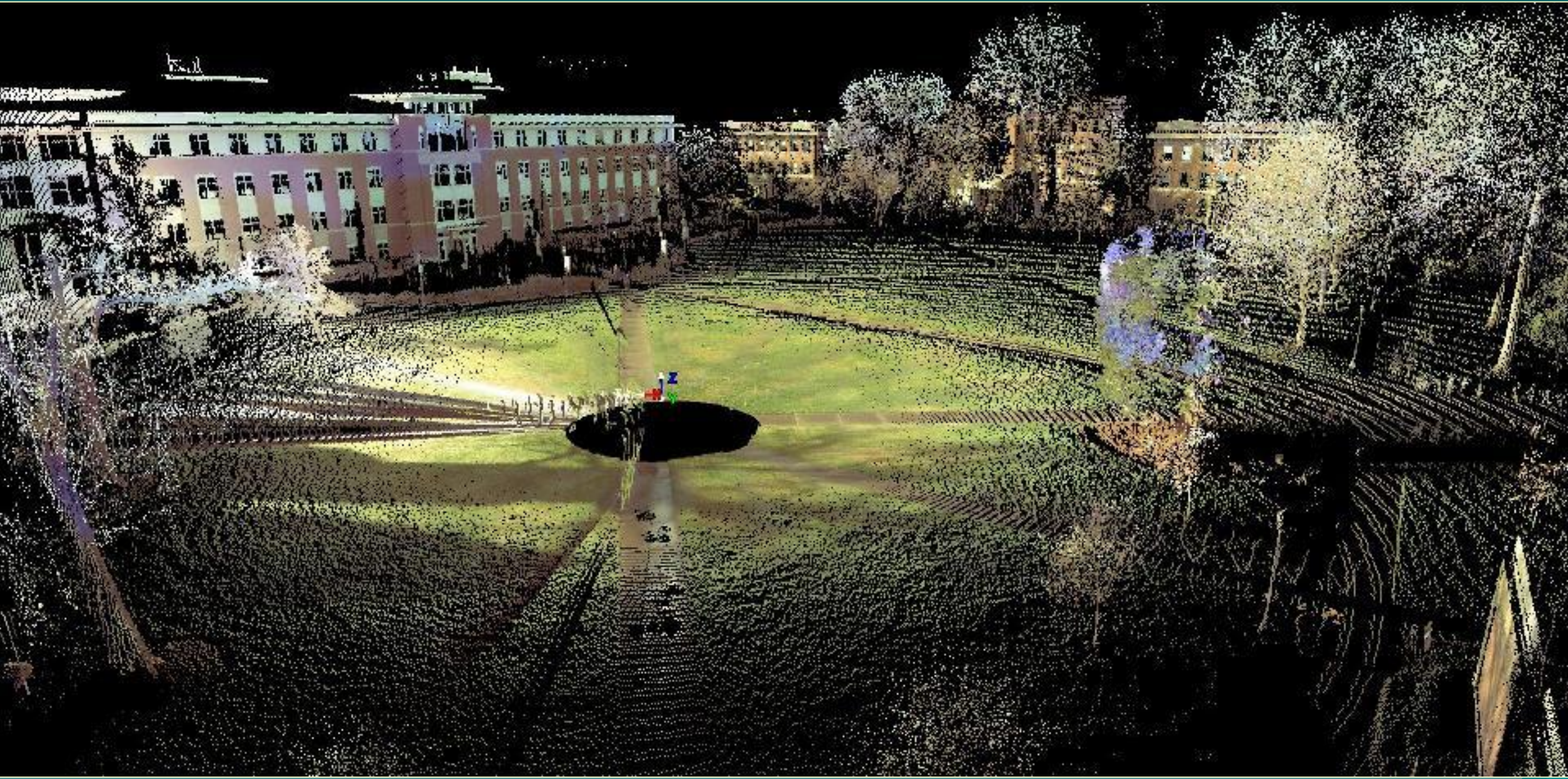





16.54 ft
16.69 ft
17.08 ft
17.94 ft
18.20 ft
18.76 ft








1506a
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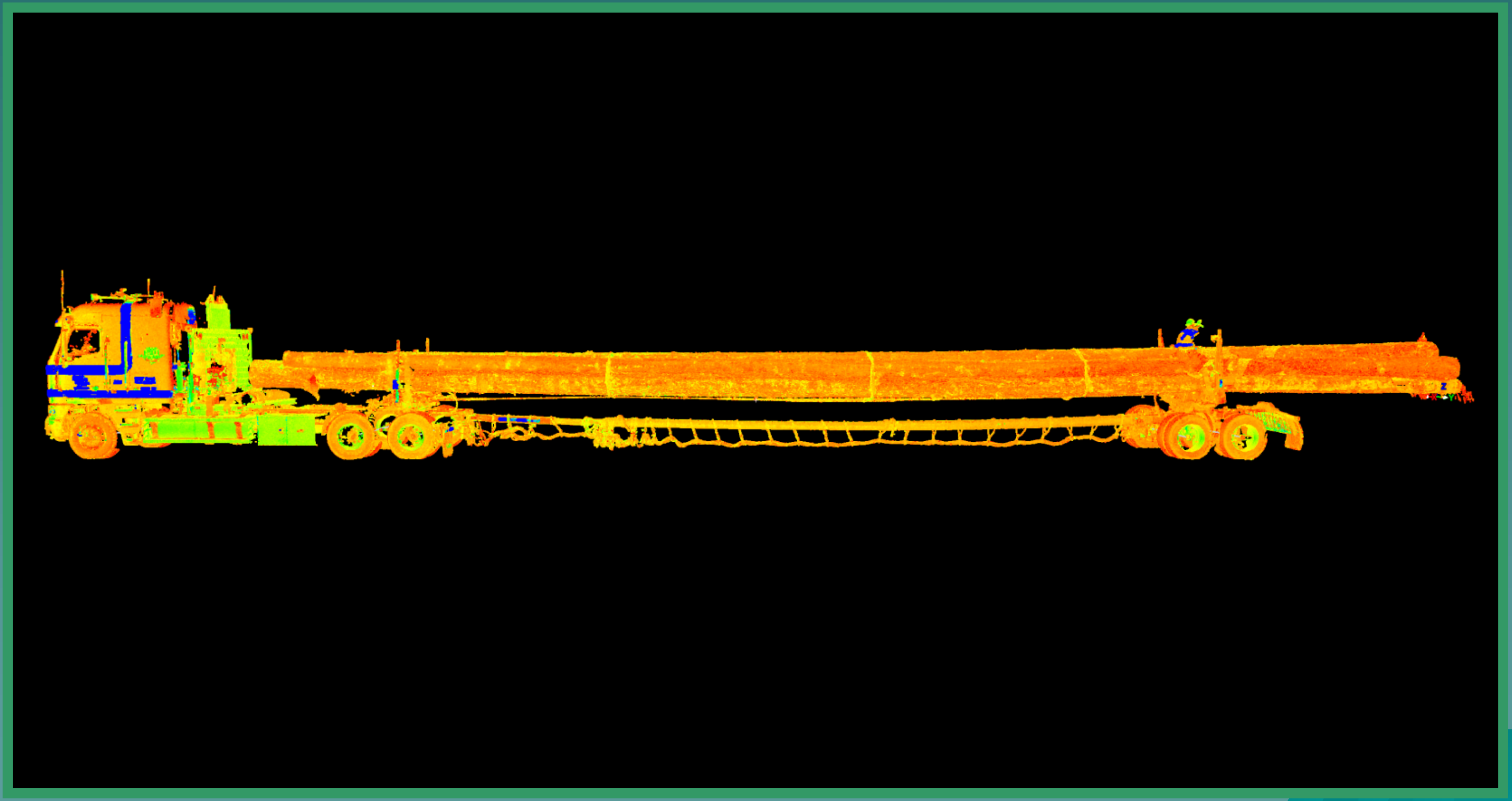

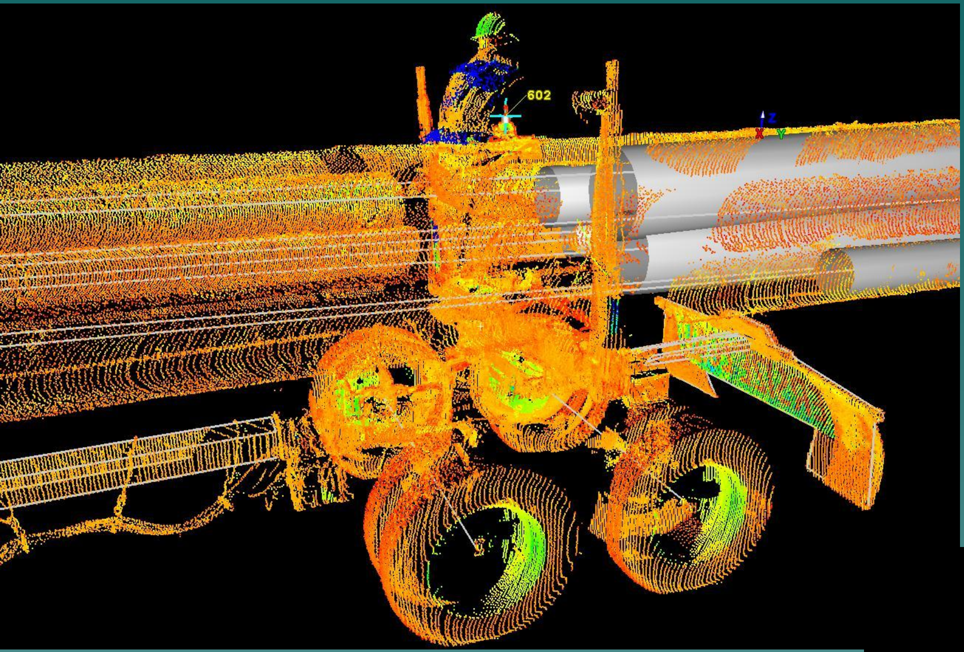
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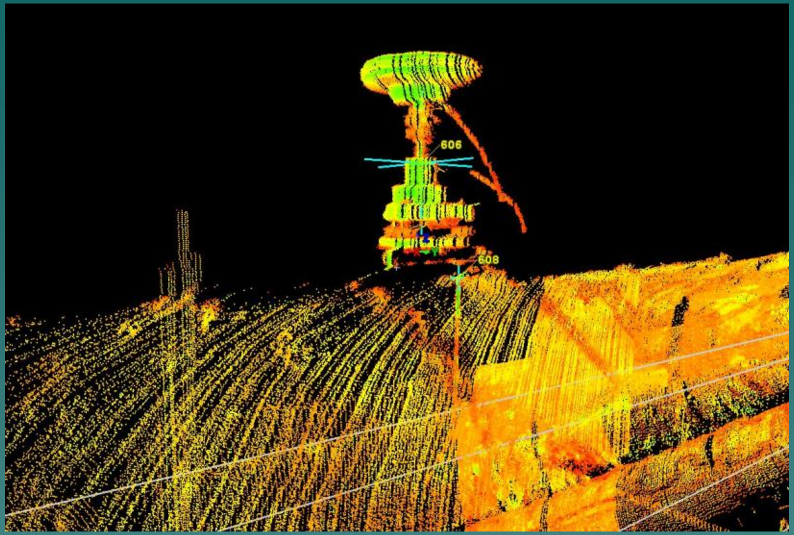
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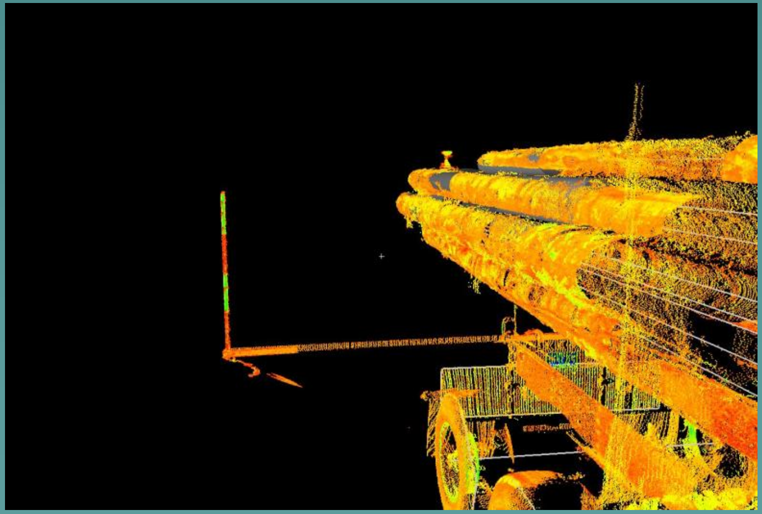
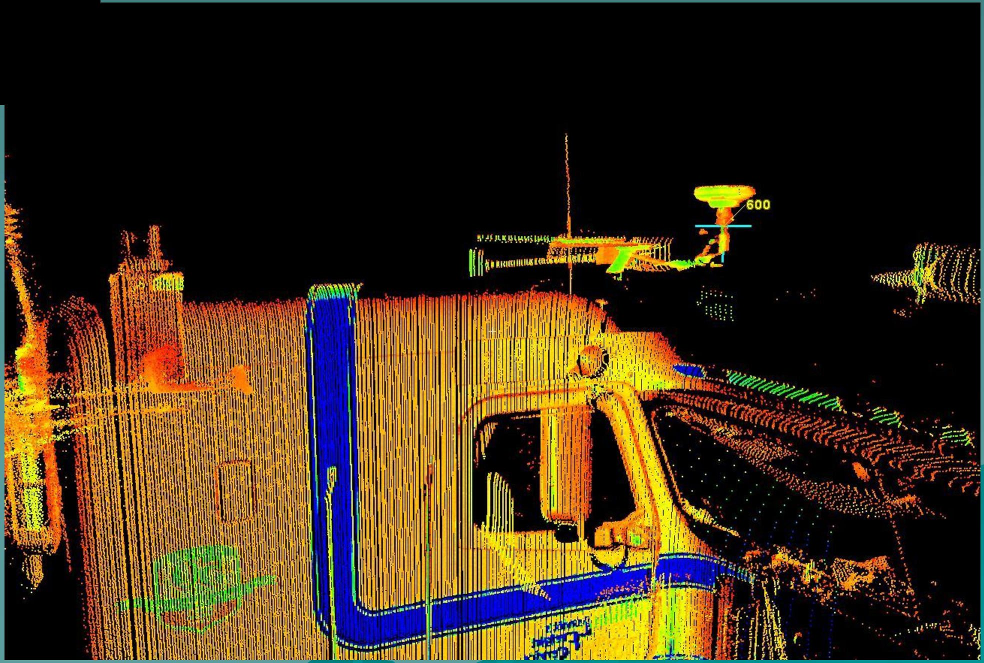
608

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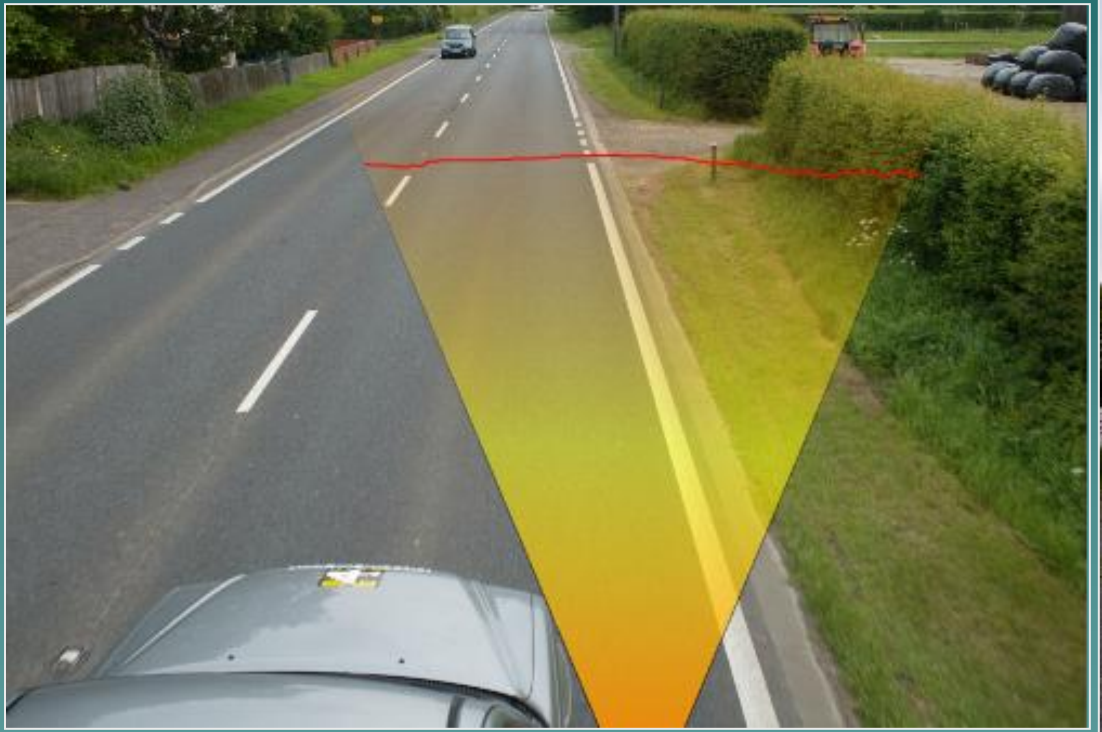
MOBILE SCANNING DATA

MOBILE SCANNING

TERRESTRIAL



terrapoint USA

MOBILE SCANNING

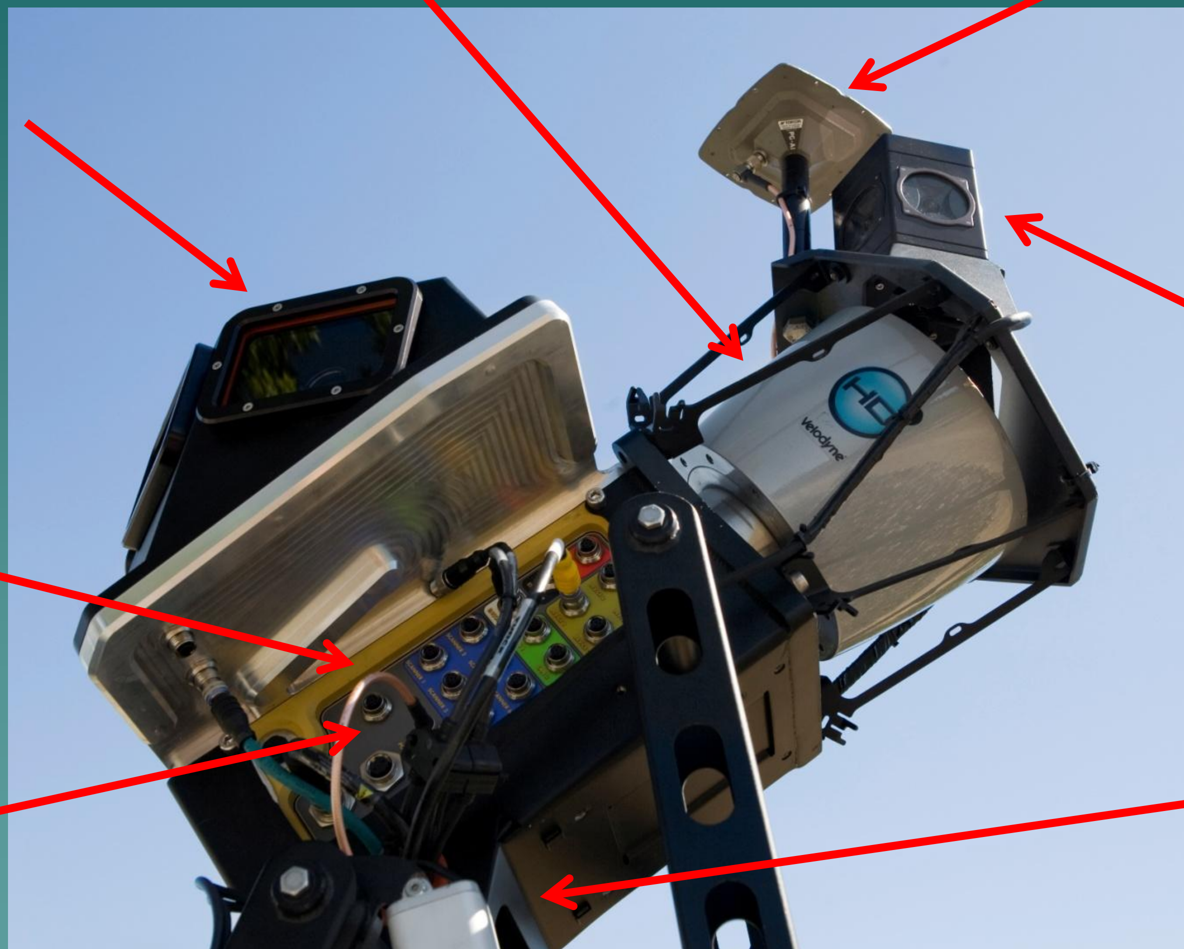
- GPS Positioning
- Inertial Measurement Unit (IMU)
  - Roll
  - Pitch
  - Yaw
- Extremely Fast Data Collection (millions points/sec)

IP-S2 HD System

HD Laser Scanner

GNSS Antenna

Prosilica HD Camera Array



360° Camera

IP-S2 Box

Hydraulic Lift Mount

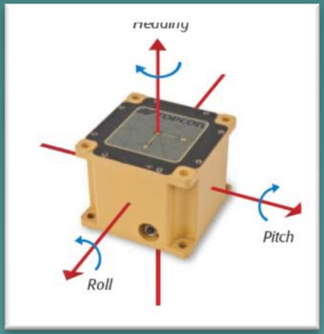
Internal IMU

Oregon Department of Transportation

How it all works

IP-S2 uses data from various sensors to obtain an accurate position and or

GNSS Receiver Delivers the Position Information to the System (Latitude, Longitude and Altitude)
40 Channel GPS L1/L2 & GLONASS L1/L2



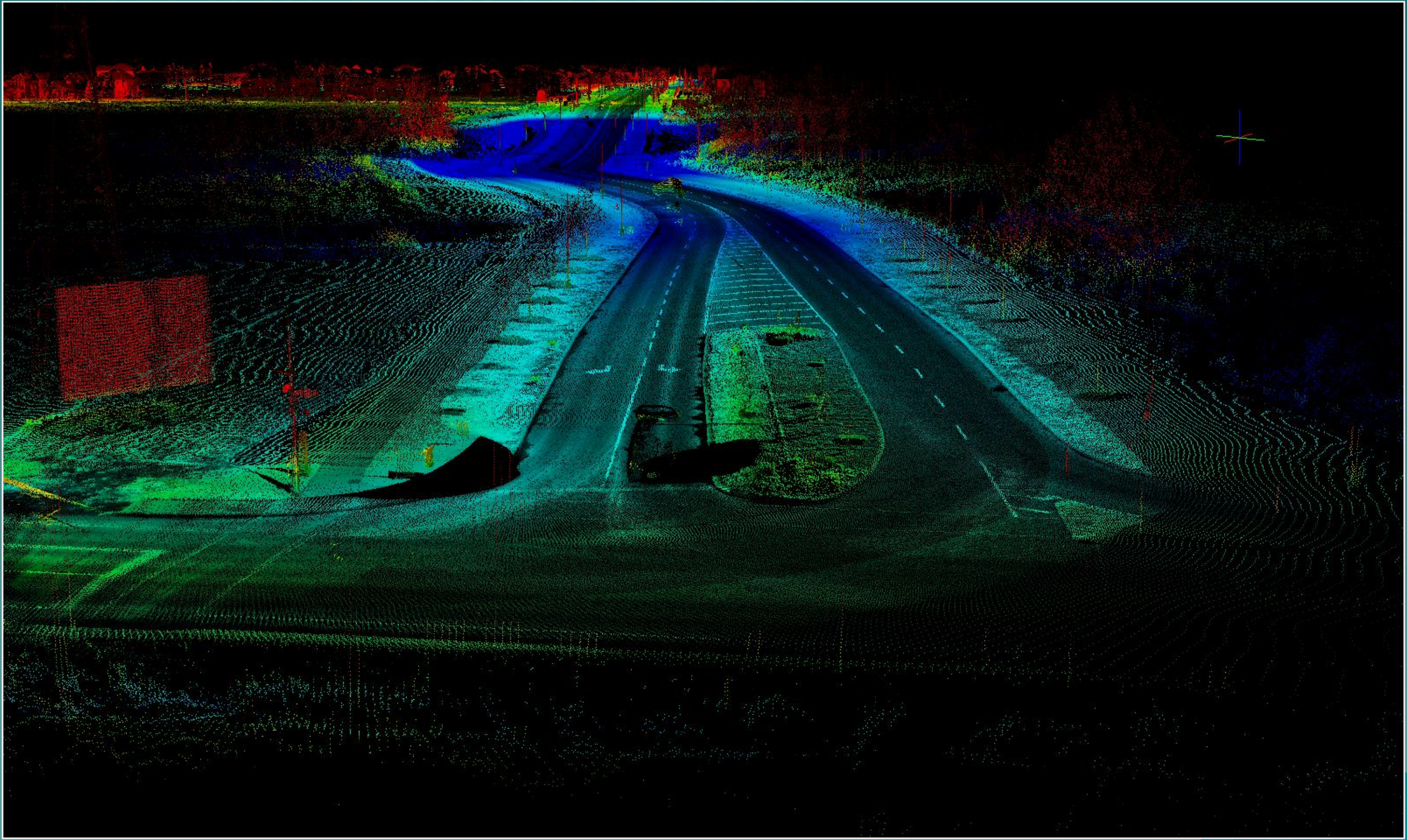
IMU (Inertial Measurement Unit) Supplies Accurate Altitude Data for the System (Roll, Pitch and Heading information)
Either 1°/hr or 3°/hr Gyro Bias

Vehicle Odometry Information is Obtained Via External Wheel Speed Sensors or From the Vehicle's CAN Bus
(Used to estimate the velocity and position based off a known location)

MOBILE SCANNING USES

- Long Linear (from the road viewpoint) Mapping
- Virtual Surveying
- Asset Inventory & Management
  - Faster, safer than GPS handhelds in roadway
  - Approaches
  - Culverts
  - Signs
  - Guardrails

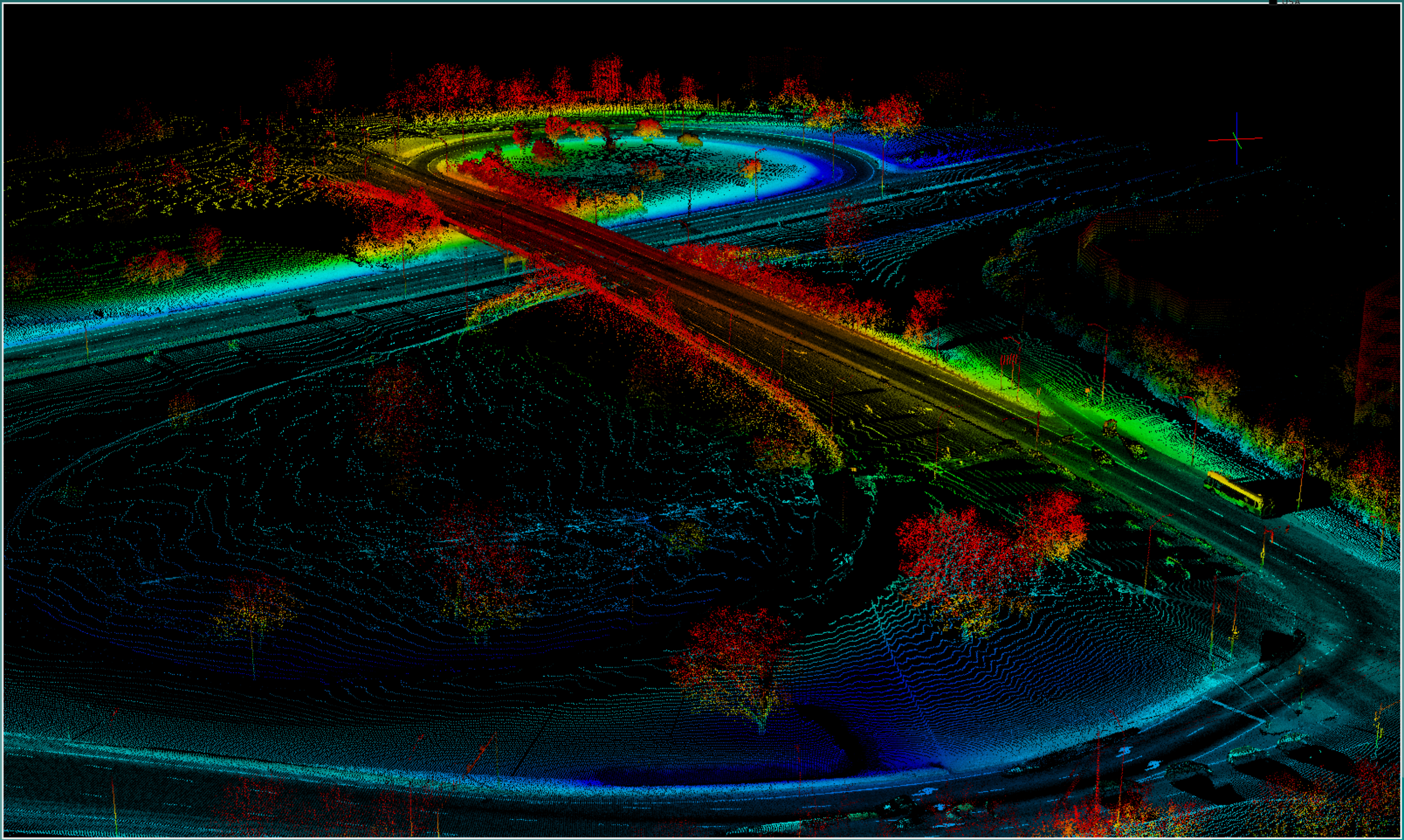
MOBILE SCANNING TERRESTRIAL



MOBILE SCANNING

TERRESTRIAL

terrapoint



CURRENT LIMITATIONS AND OBSTACLES

LIMITATIONS AND OBSTACLES

- Massive Files
- Limited Lossless Compression
- Limited Data Transmission Bandwidth
- Lack of Standards
- Limited use in Civil Design Software

CAUTIONS

STAY CURRENT

- Low Maturity
- Hardware Ahead of Software
- Rapidly Changing

BE AWARE OF…

- Data Sources (often combined)
- Limitations
- Accuracies
- Coordinate Systems
- Metadata

Summary

- Status of the Oregon Coordinate Reference System
- Status of the Oregon Real-time GPS Reference Network's changeover to a NAD38(2011)Epoch 2002.00
- Status of the Engineering Automation Efforts
- Status of Mobile Scanning

Oregon Department of Transportation

Ken Bays
Lead Geodetic Surveyor
Oregon DOT
503-986-3543
kenneth.bays@odot.state.or.us

Oregon Real-time GPS Network
www.TheORGN.net