5-8-2015

Lighten Everyone's Load: LIDAR Applications to Support Engineers, Planners, Scientists and More

Michael J. Olsen
Oregon State University

Lighten Everyone's Load:
Lidar Applications to Support engineers, planners, scientists, and more

Michael J. Olsen
Assistant Professor, Geomatics
School of Civil and Construction Engineering
Oregon State University

PORTLAND STATE VIKINGS

TREC
Transportation Insight for Vibrant Communities

Portland State University TREC Seminar
May 8, 2015

Michael J. Olsen, PhD, E.I.T.

Assistant Professor of Geomatics
School of Civil and Construction Engineering
Oregon State University

PhD. University of California, San Diego
Research: Lidar to model and analyze seacliff erosion

MS and BS, University of Utah, liquefaction hazard mapping

Primary Research Interests:
Lidar, 3D modeling, scientific visualization, computer programming, Coastal geomorphology, geohazard engineering, Geographic Information Systems

Civil & Construction Engineering Geomatics Faculty at OSU

Robert Schultz
Professor, 1962

Tracy Arras
Senior Instructor, 2003

Mike Olsen
Assistant Professor, 2009

Dan Gillins
Assistant Professor, 2013

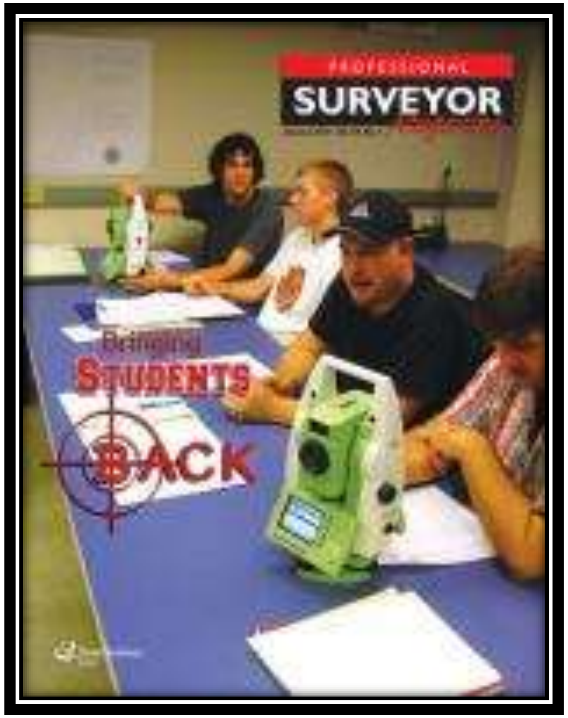
Christopher Parrish
Associate Professor 2014

Jihye Park,
Assistant Professor, 2015

Oregon State University

Many additional geospatial faculty in other departments

Industry Partnership

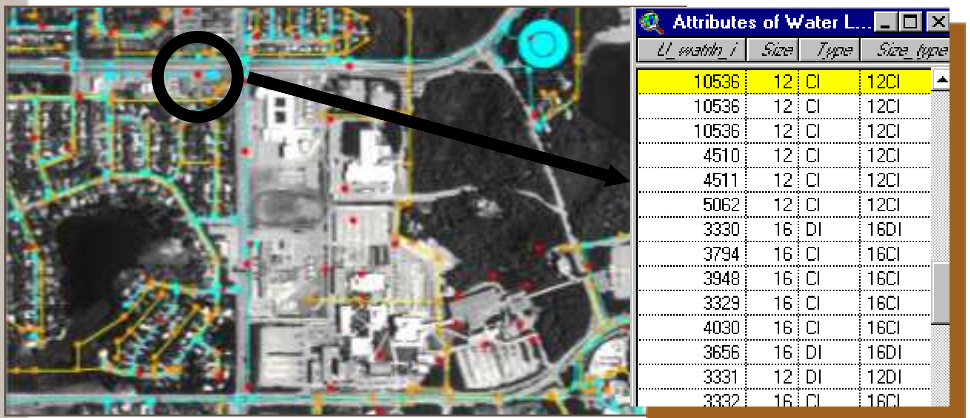


- Recruit top students
- Expand course work and research to reflect industry advances
- Keep surveying as an integral part of our Civil Engineering program
- Provide the latest equipment, software, and workflows
- Prepare students to become licensed surveyors
- Produce work-ready graduates

Oregon State University

Courses and Graduate Research!

Courses and Graduate Research!



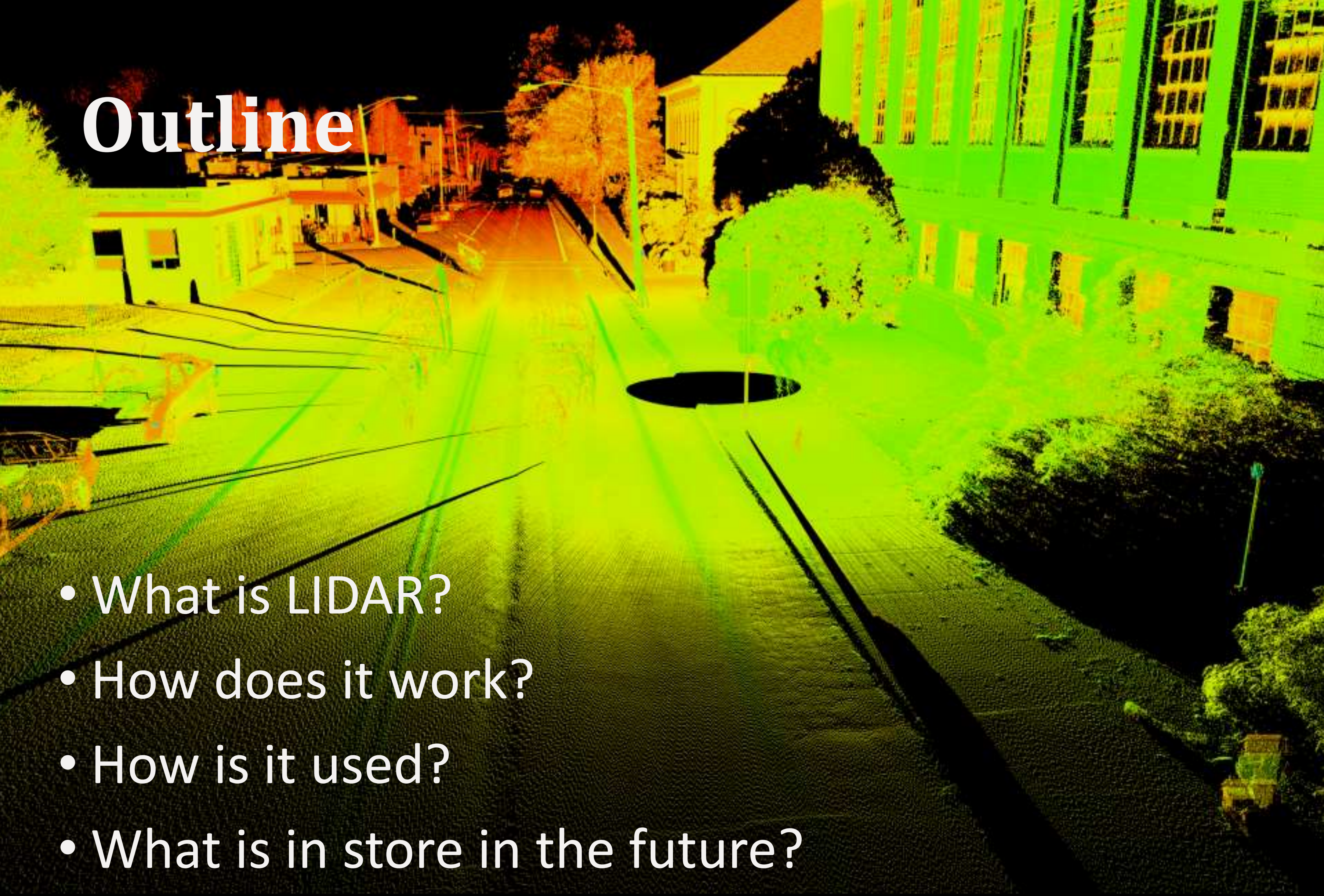
GIS - Municipal Utility System

3D information modeling

LIDAR, SFM, & 3D, Virtual Reality

Property Surveying

Outline



- What is LIDAR?
- How does it work?
- How is it used?
- What is in store in the future?

Lidar (Laser Scanning)

Light Detection and Ranging

Active System

Laser Range

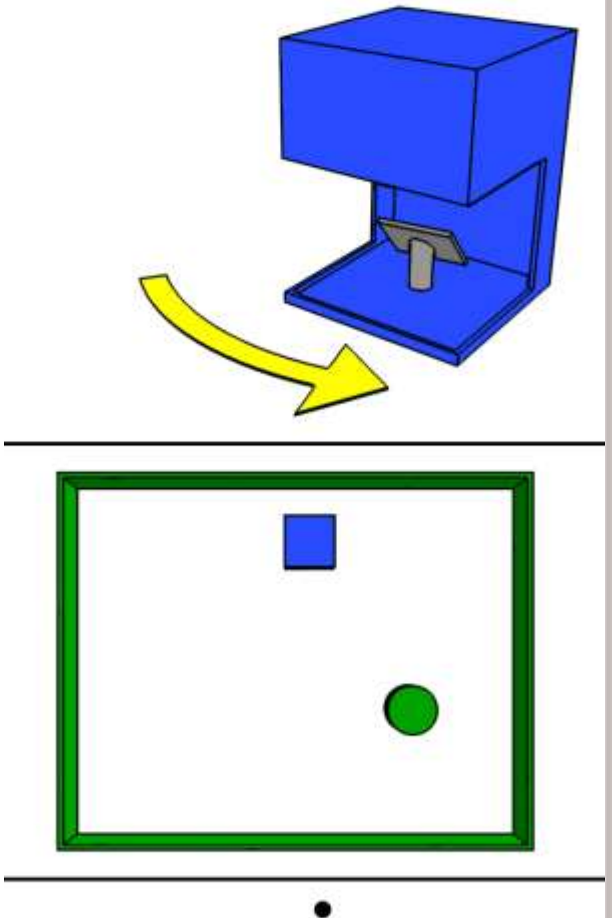
Single/Multiple Returns

Angle Determination

3D Point Cloud

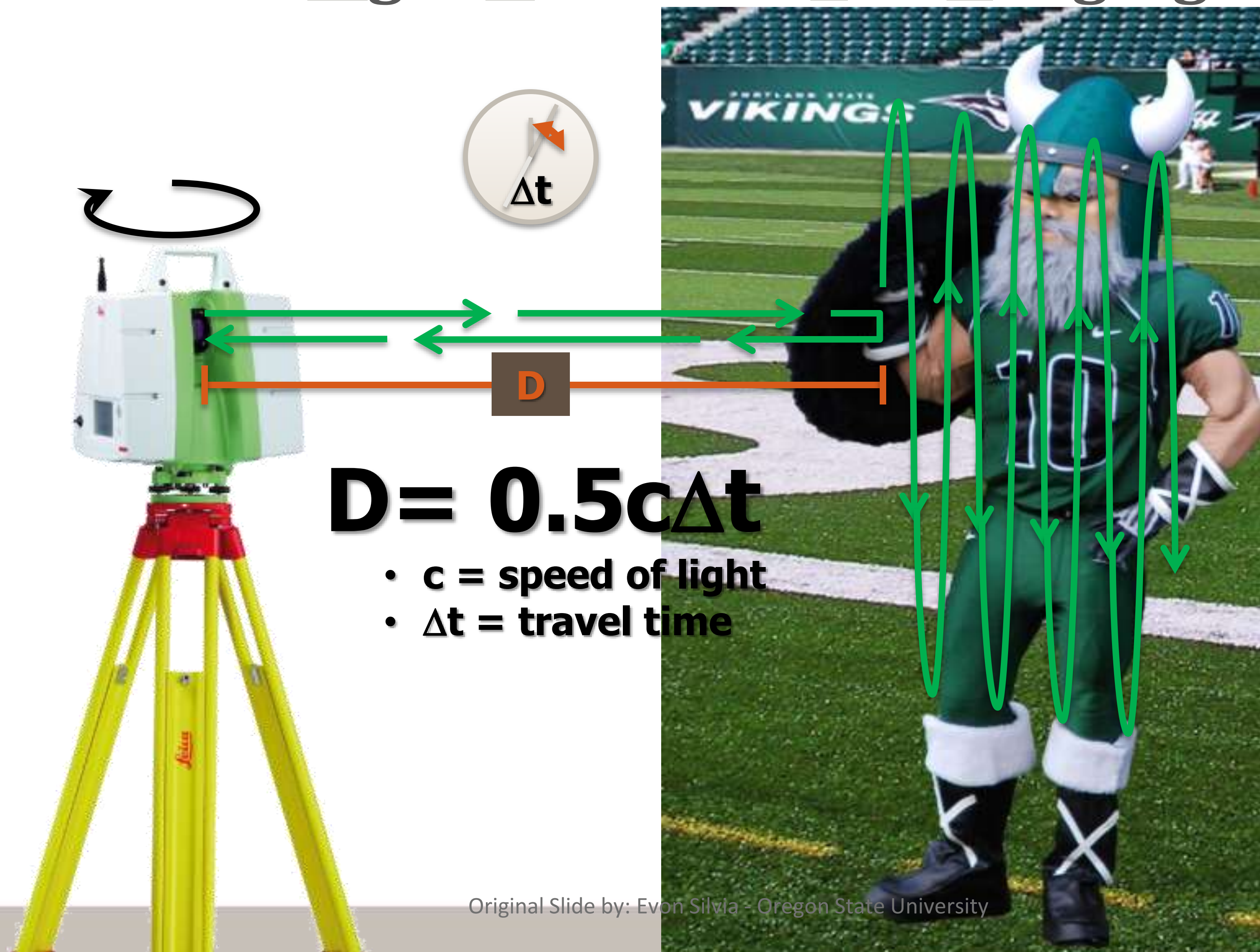
Intensity

RGB Color



What is Lidar?

LiDAR = Light Detection and Ranging



$$D = 0.5c\Delta t$$

- c = speed of light
- Δt = travel time

LiDAR Rap v1.0 by M$lice

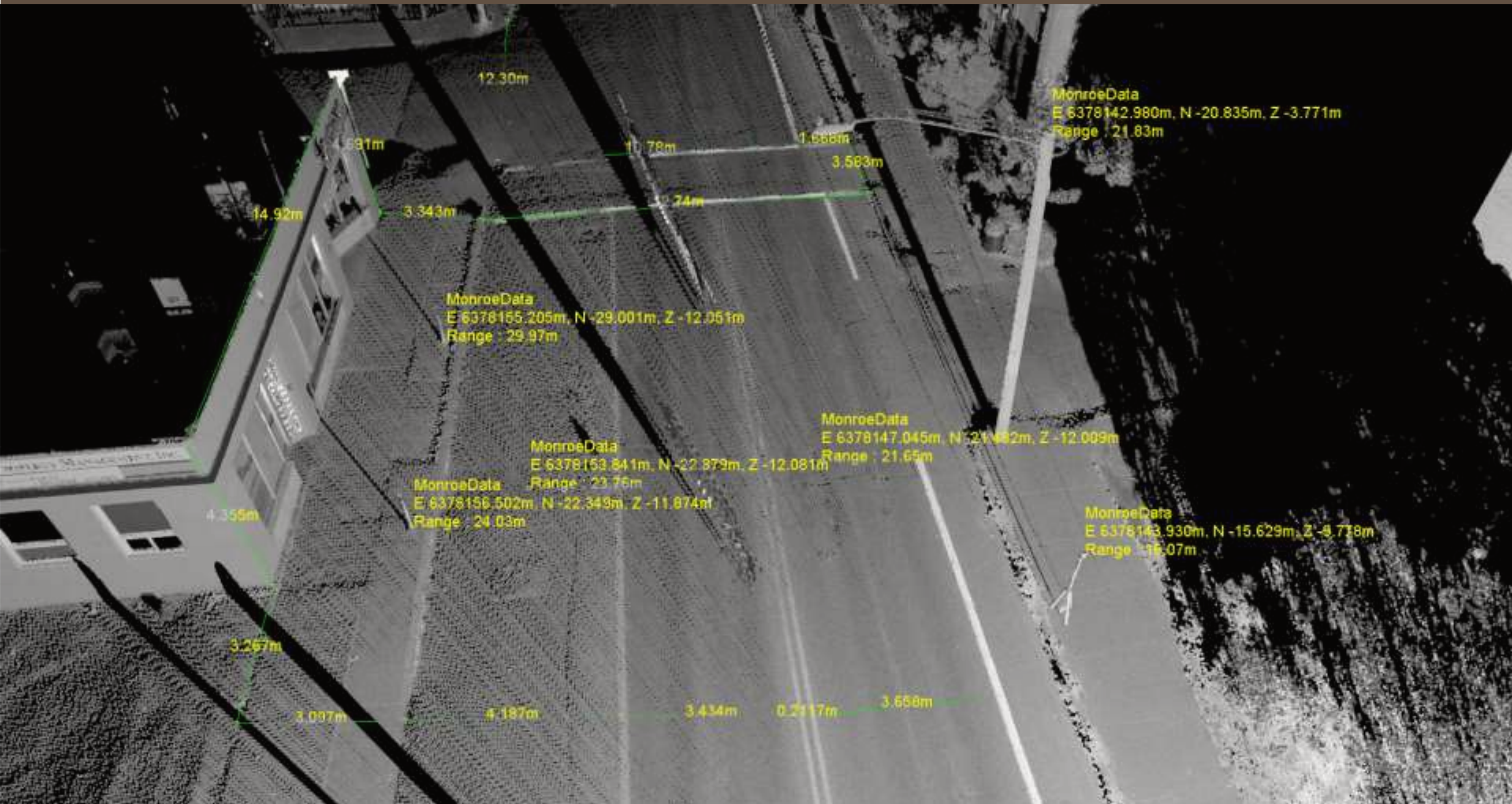
LiDAR relies on Line of Sight
Using pulses of light,
But not too bright,
It calculates the Time of Flight
And can be done in da nite
Works from the ground or during da flight,
Gives you da heightz,
Requires lots of bytes,
Objects in the way give you a blight,
Don’t have fright
We’ll learn you how to avoid plight,
So it gits da job done right!
With data dat can fit your control nice n tight!

Magic School Bus LIDAR

Oregon State University

Point Cloud

Measurements



Static Scanning Products

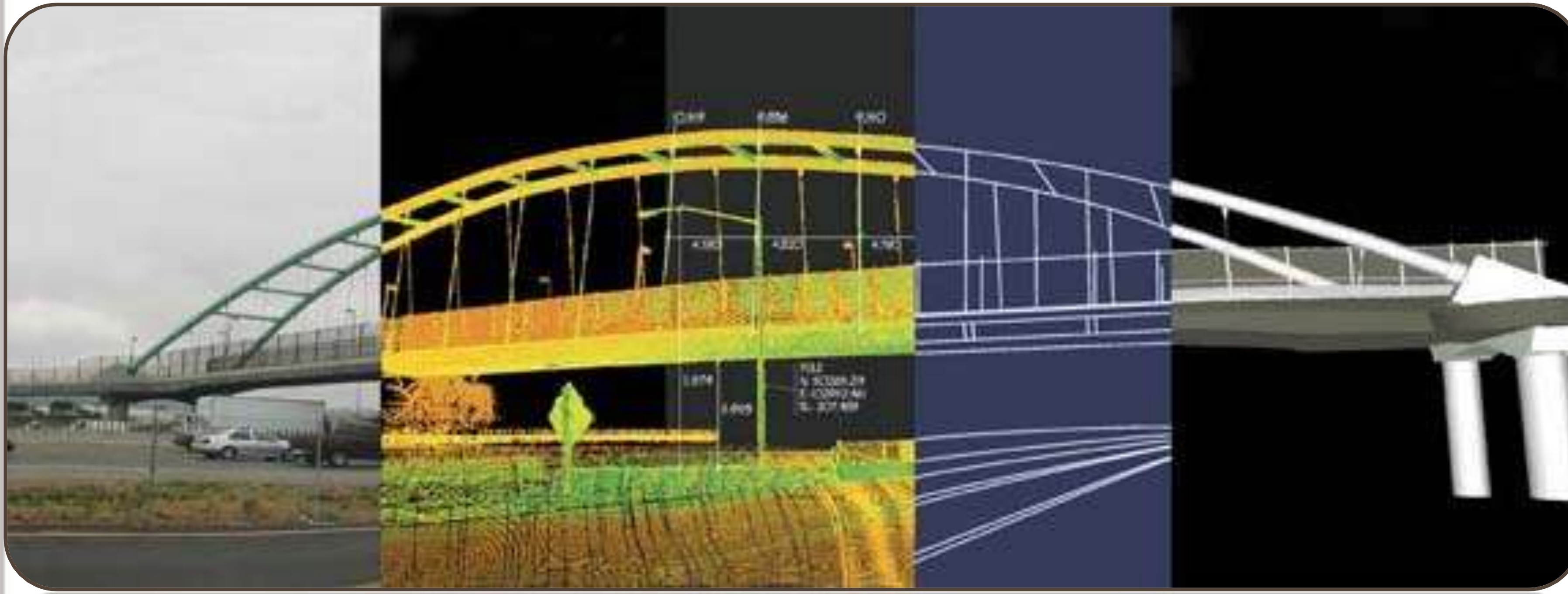
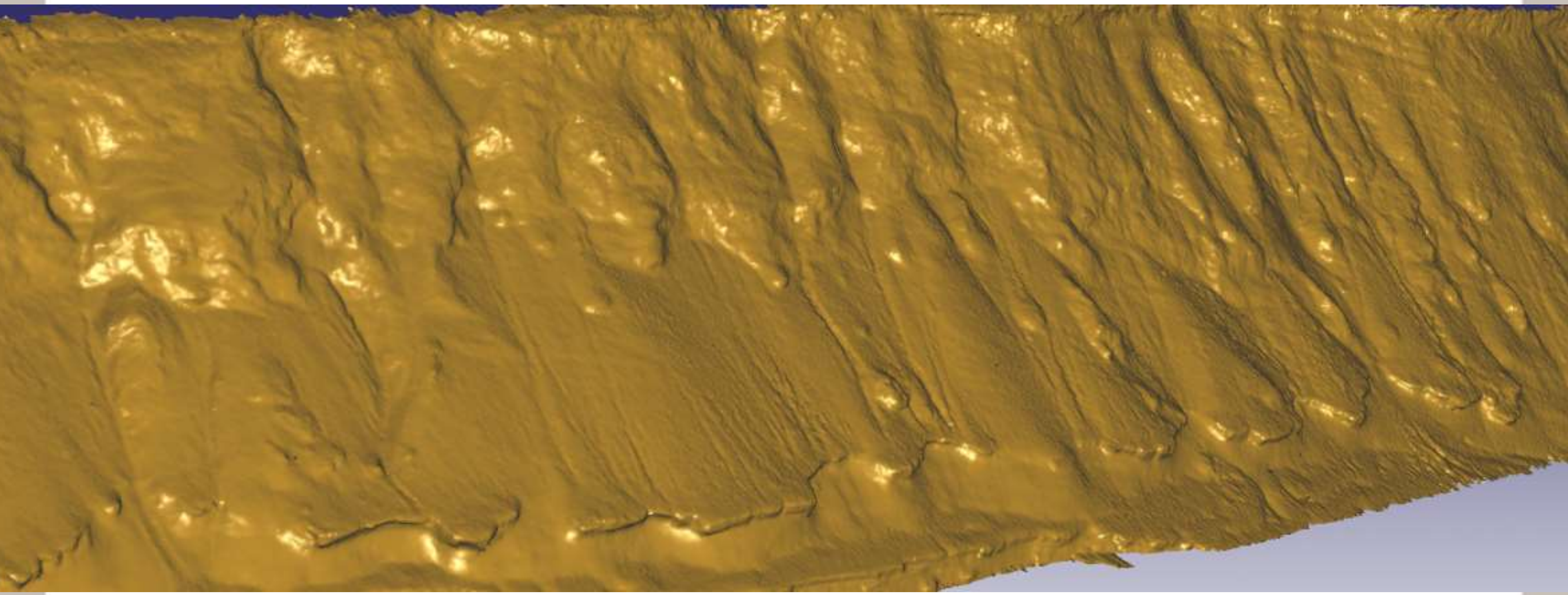


Photo Scan Vector Solid Objects

3D surface modeling



Multiple Returns

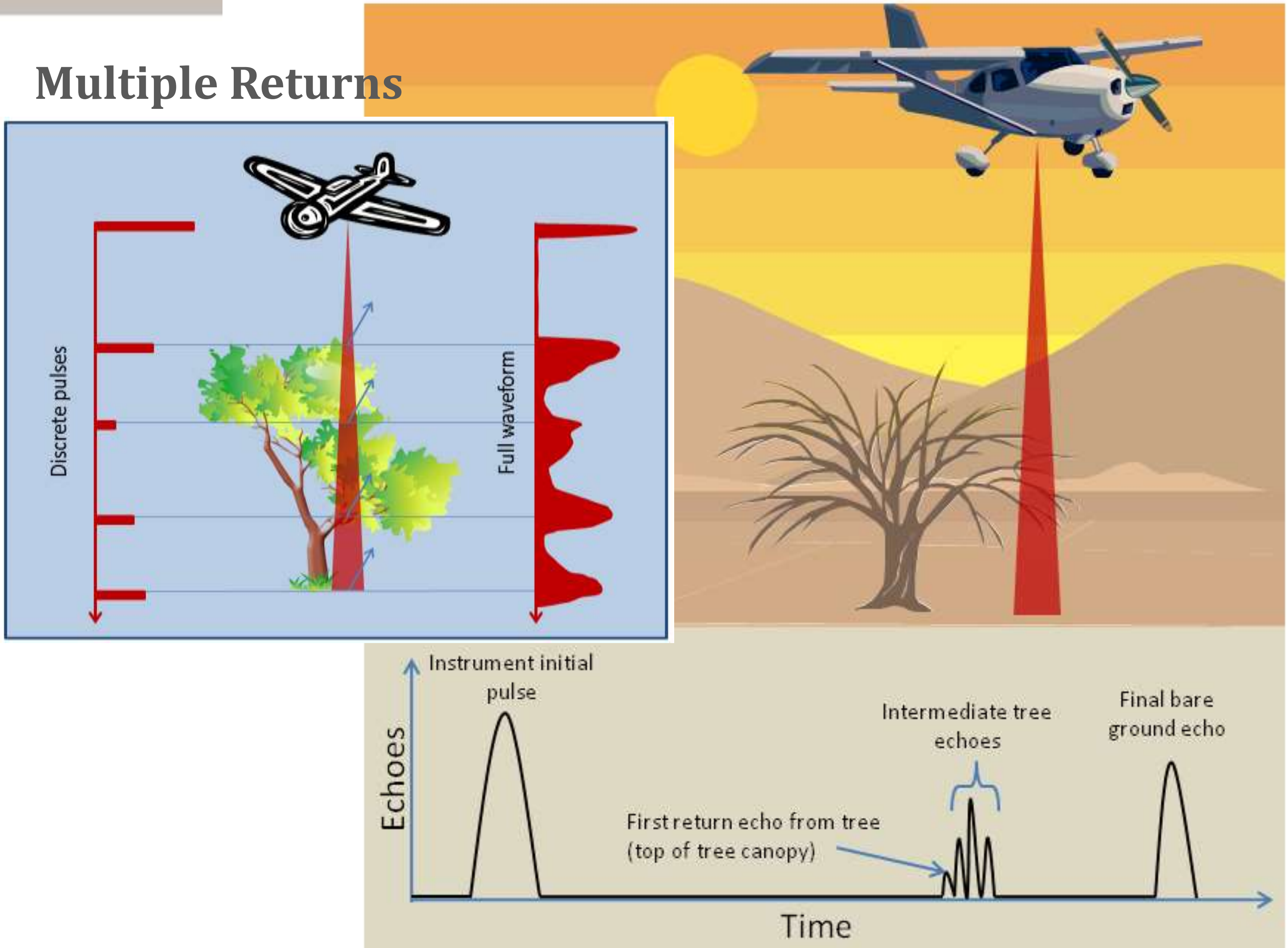
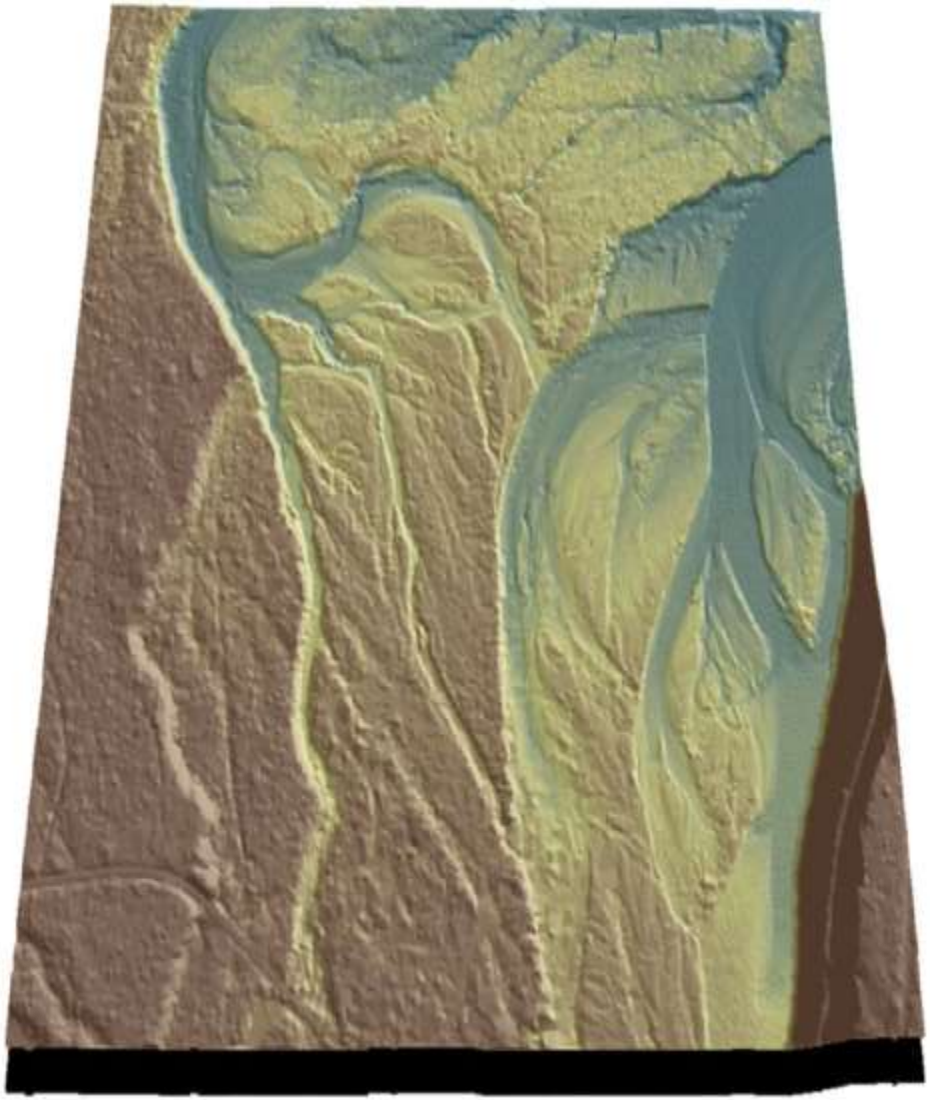
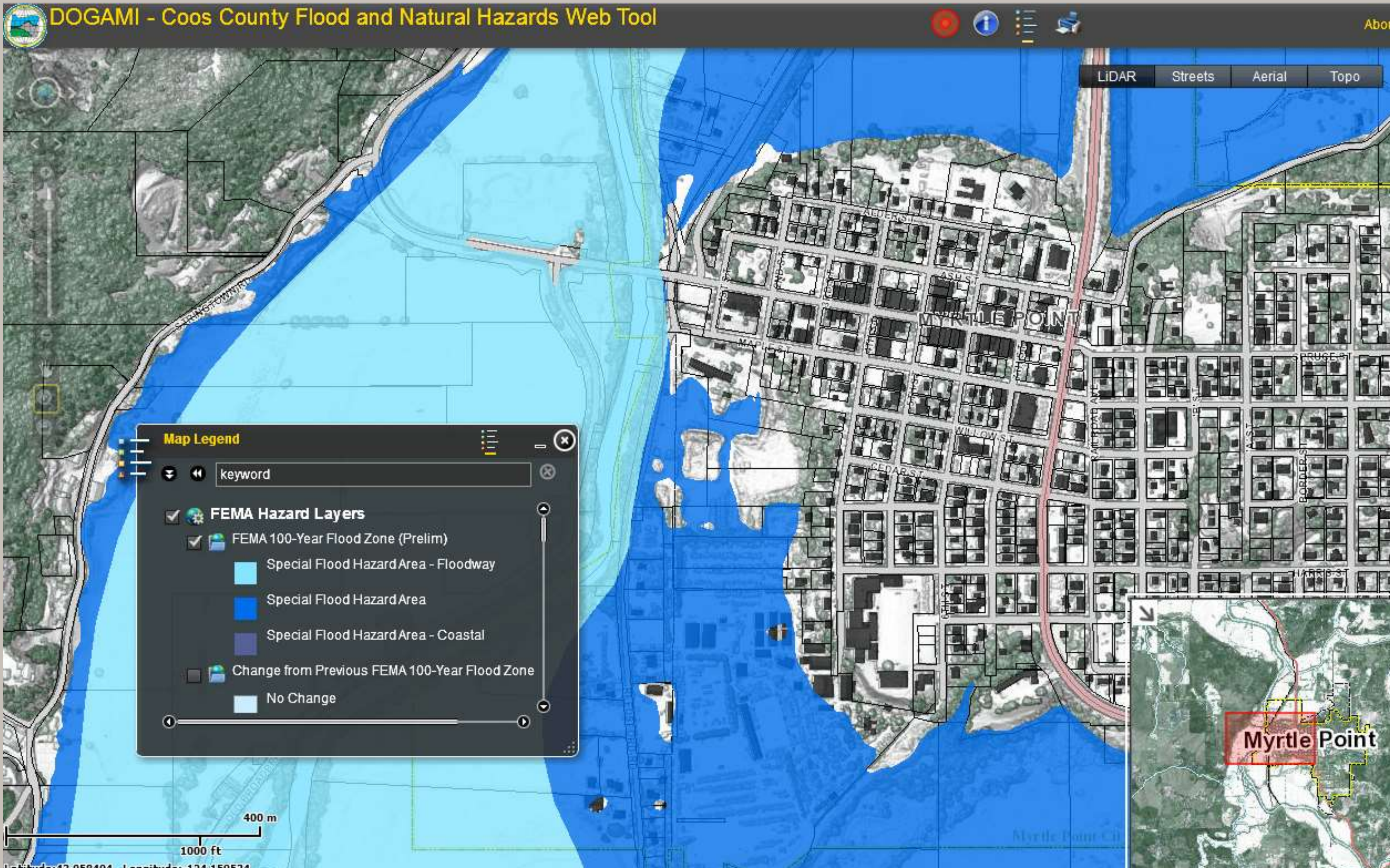


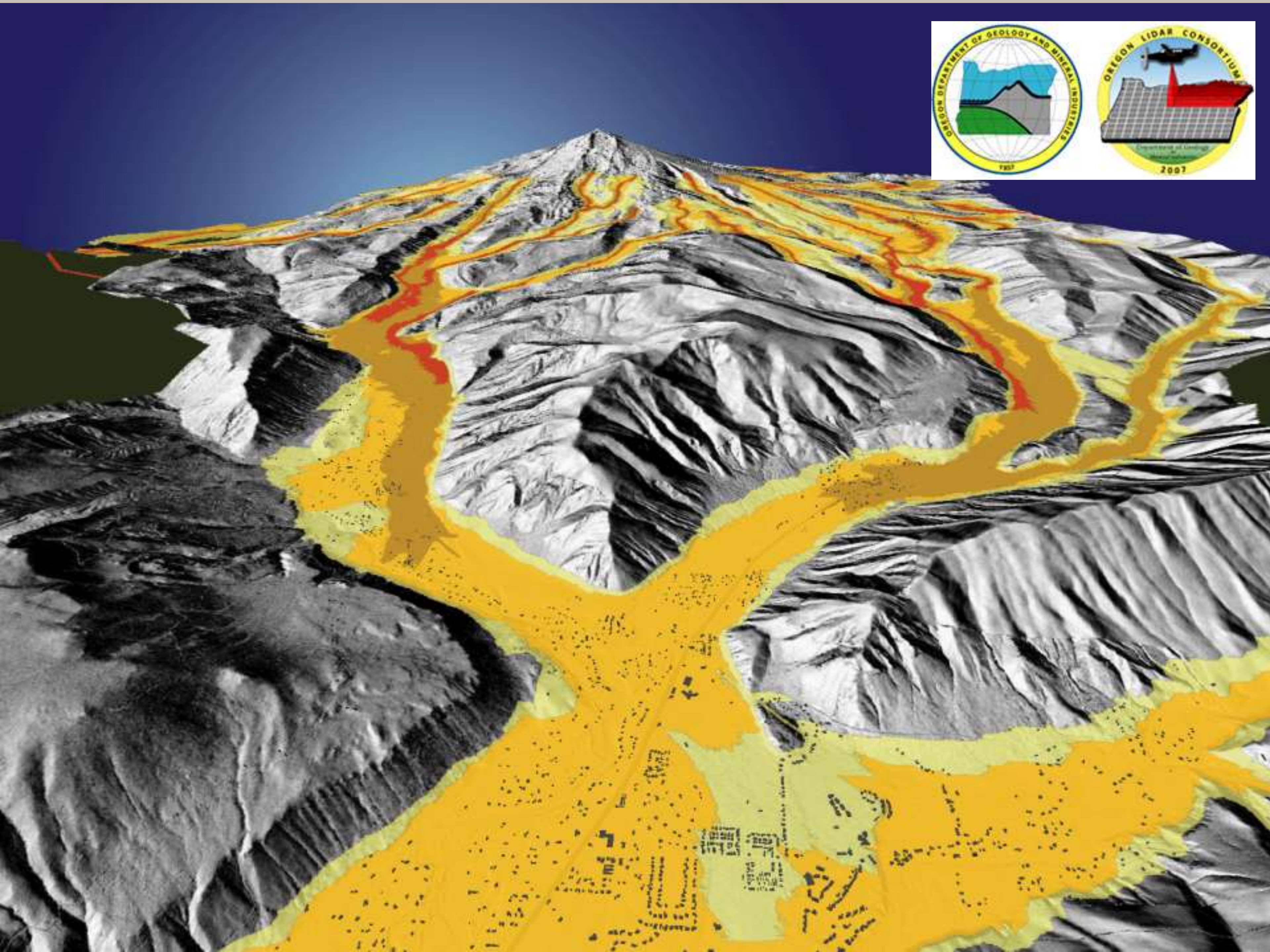
Figure by Keith Williams, Oregon State University

DATA COURTESY OF WATERSHED SCIENCES AND DOGAMI



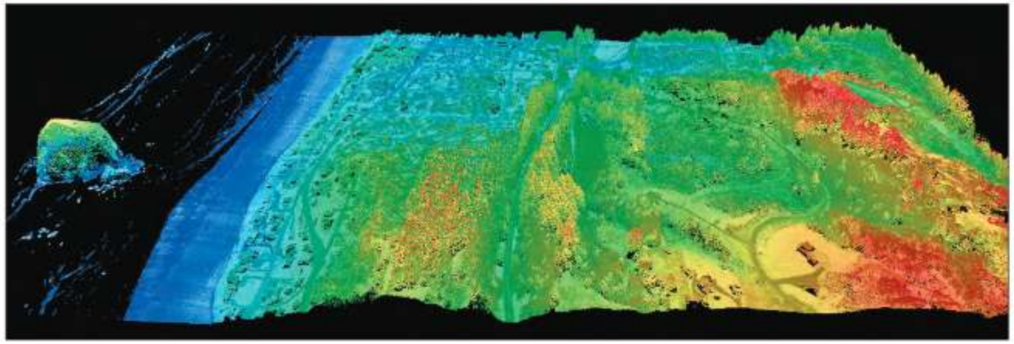


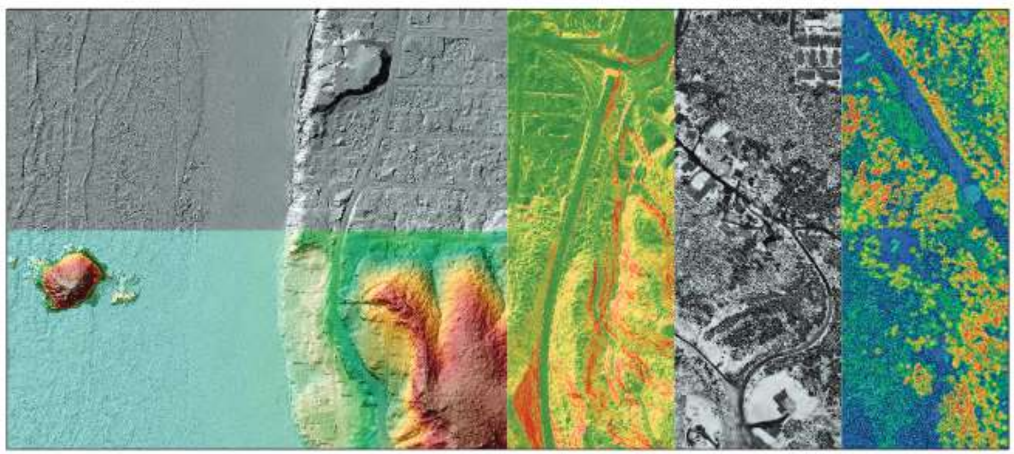
Oregon State University


OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
OREGON LIDAR CONSORTIUM
2007

USGS science for a changing world http://nationalmap.gov/3DEP/

The 3D Elevation Program Initiative—A Call for Action



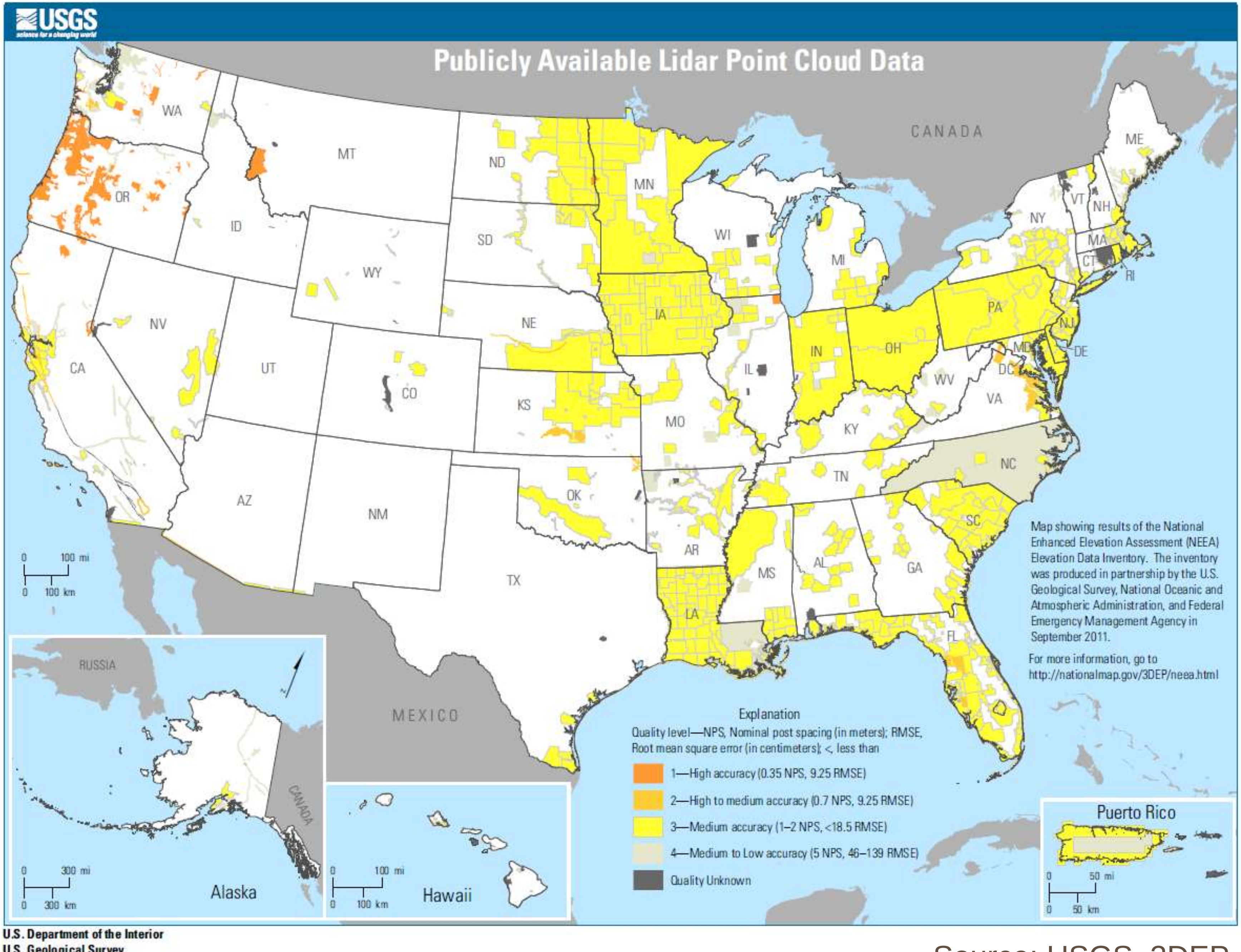


Sugarbaker, L.J., Constance, E.W., Heidemann, H.K., Jason, A.L., Lukas, Vicki, Saghy, D.L., and Stoker, J.M., 2014, The 3D Elevation Program initiative—A call for action: U.S. Geological Survey Circular 1399, 35 p., http://dx.doi.org/10.3133/cir1399

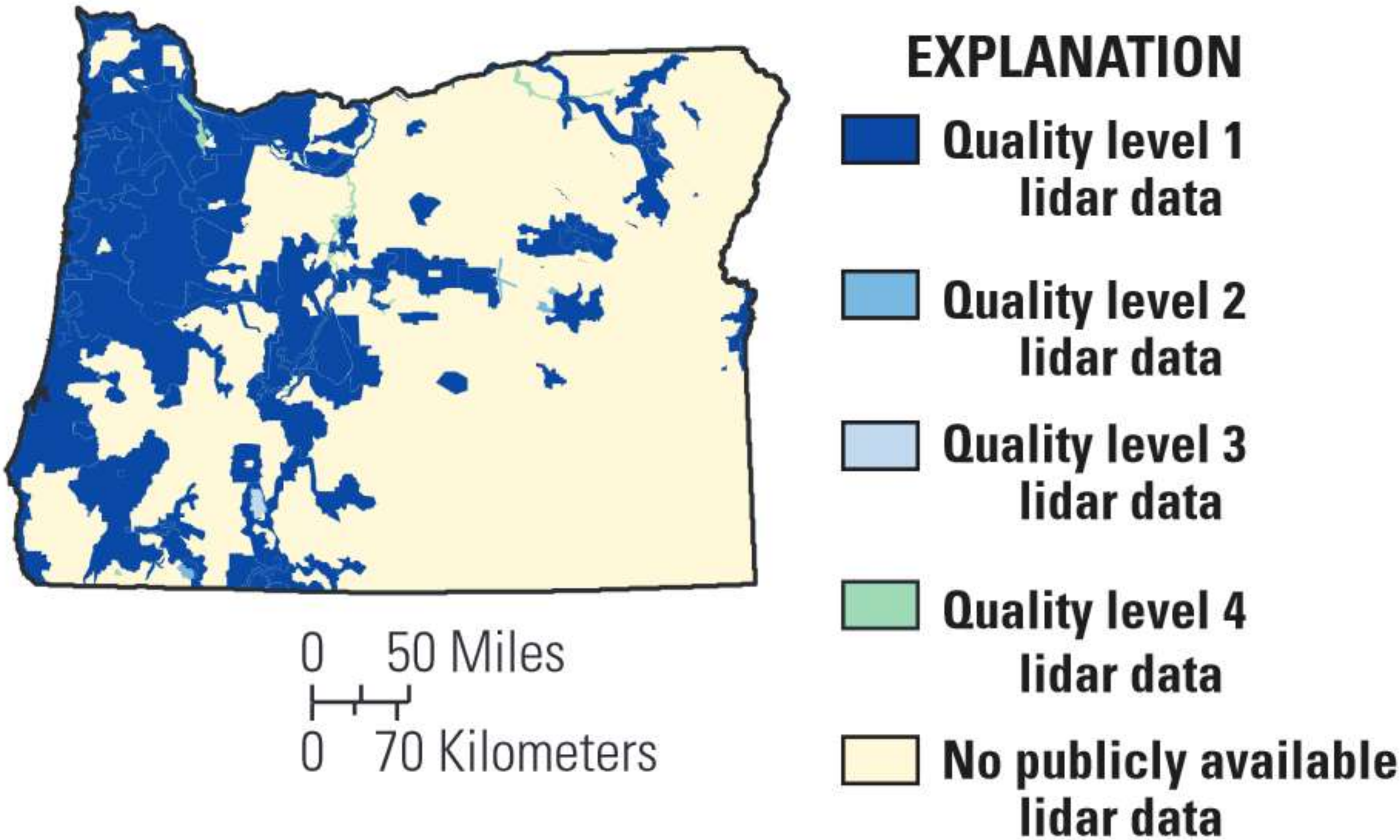
3DEP highlights

- >$690 million annually in new benefits to private sector
- Estimated 5:1 return on investment
- Save lives
- Help economy
- Improve environment
- Collaboration within government
- Prepared for natural disasters (floods, landslides, earthquakes, etc.)
- Multiple agencies\disciplines benefit

Oregon State University



Source: USGS, 3DEP

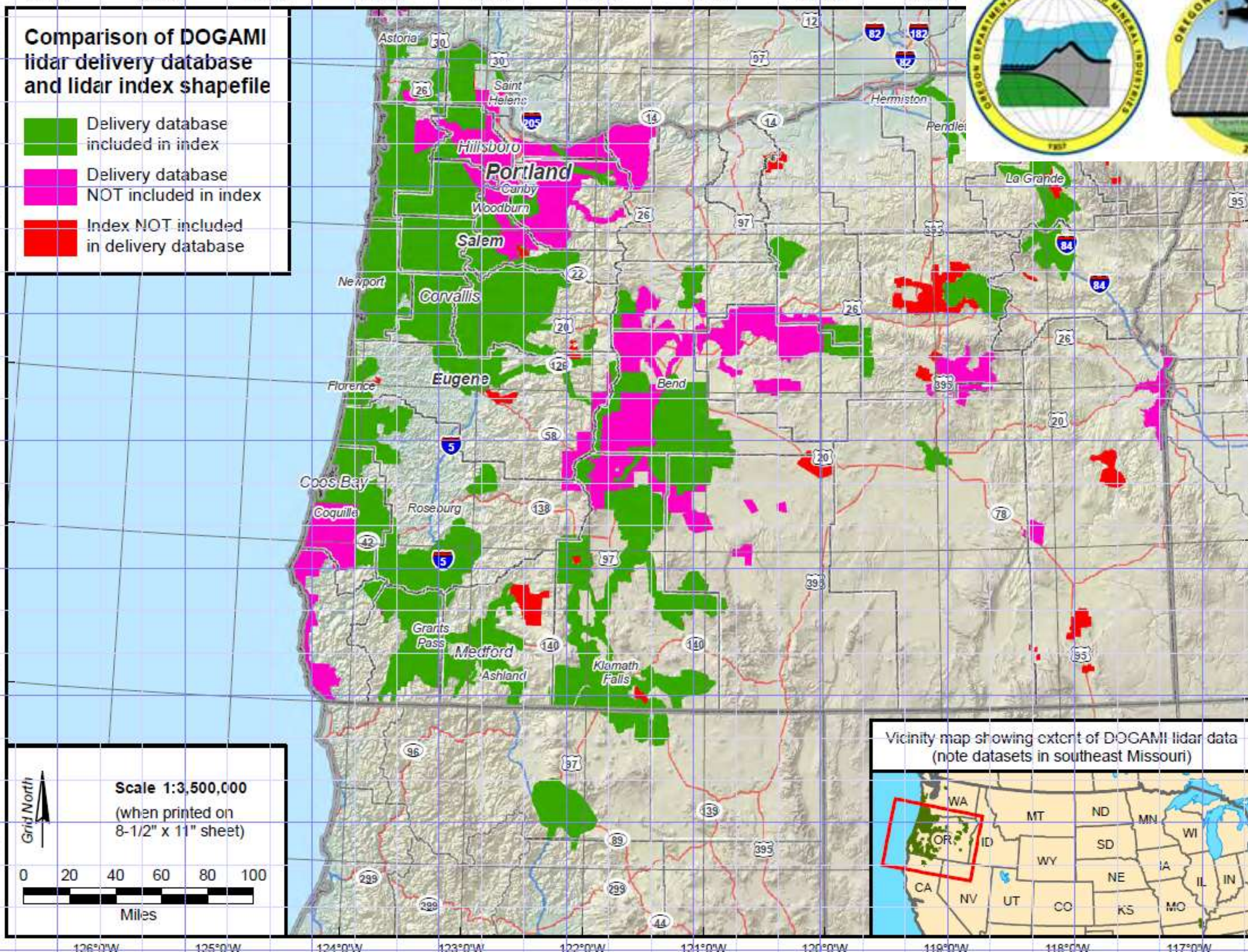

EXPLANATION
Quality level 1 lidar data
Quality level 2 lidar data
Quality level 3 lidar data
Quality level 4 lidar data
No publicly available lidar data
0 50 Miles
0 70 Kilometers

Results of 3DEP inventory

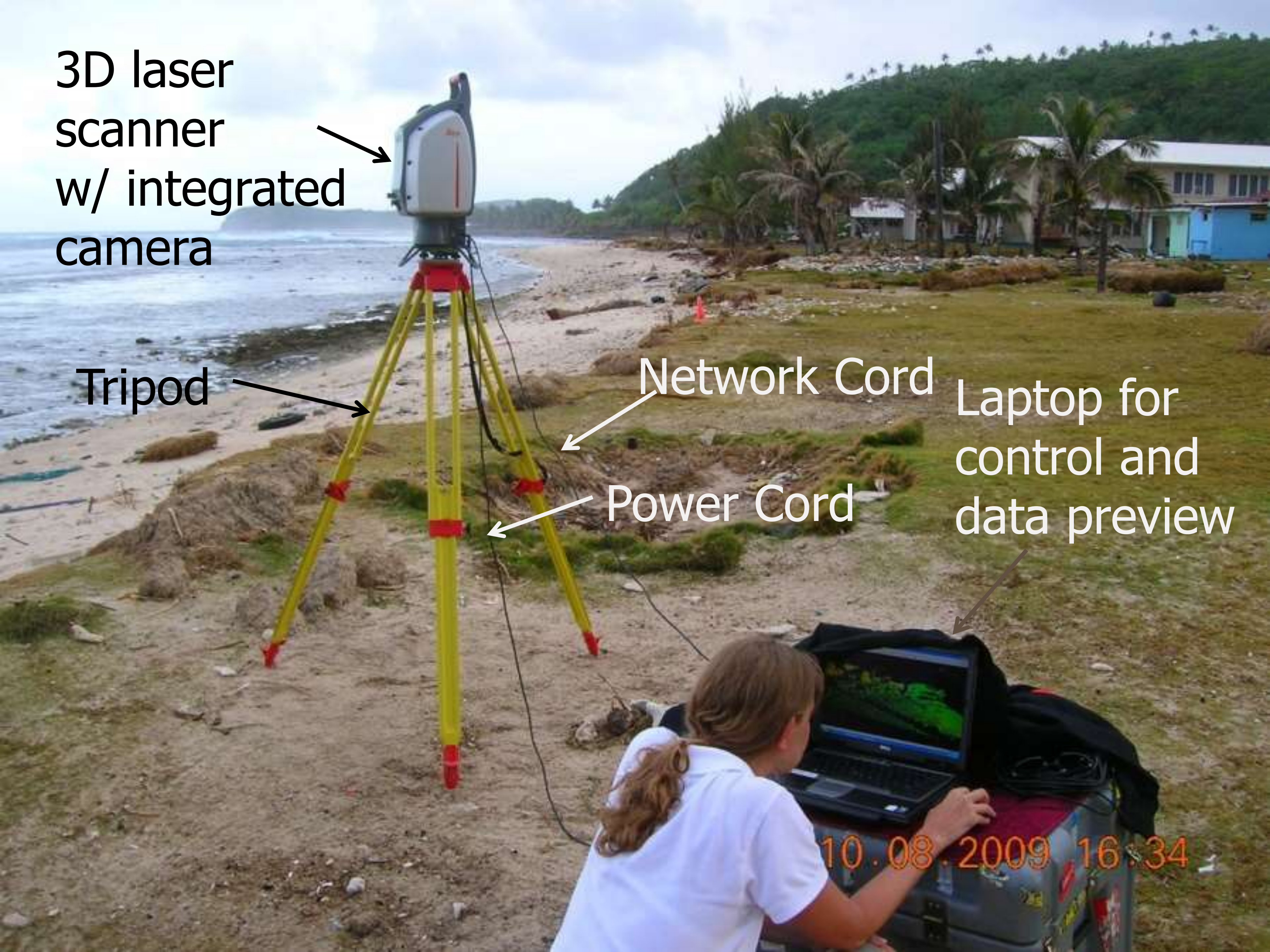
- Lidar data have been collected over 28 percent of the conterminous United States and Hawaii.
- Enhanced elevation data (primarily ifsar data) have been collected over approximately 15 percent of Alaska.
- Elevation data was collected at an average annual rate of 4 to 5 percent from 2009-2011.
- The level of overlapping coverage is less than 10 percent.
- The quality of the data varies from project to project.

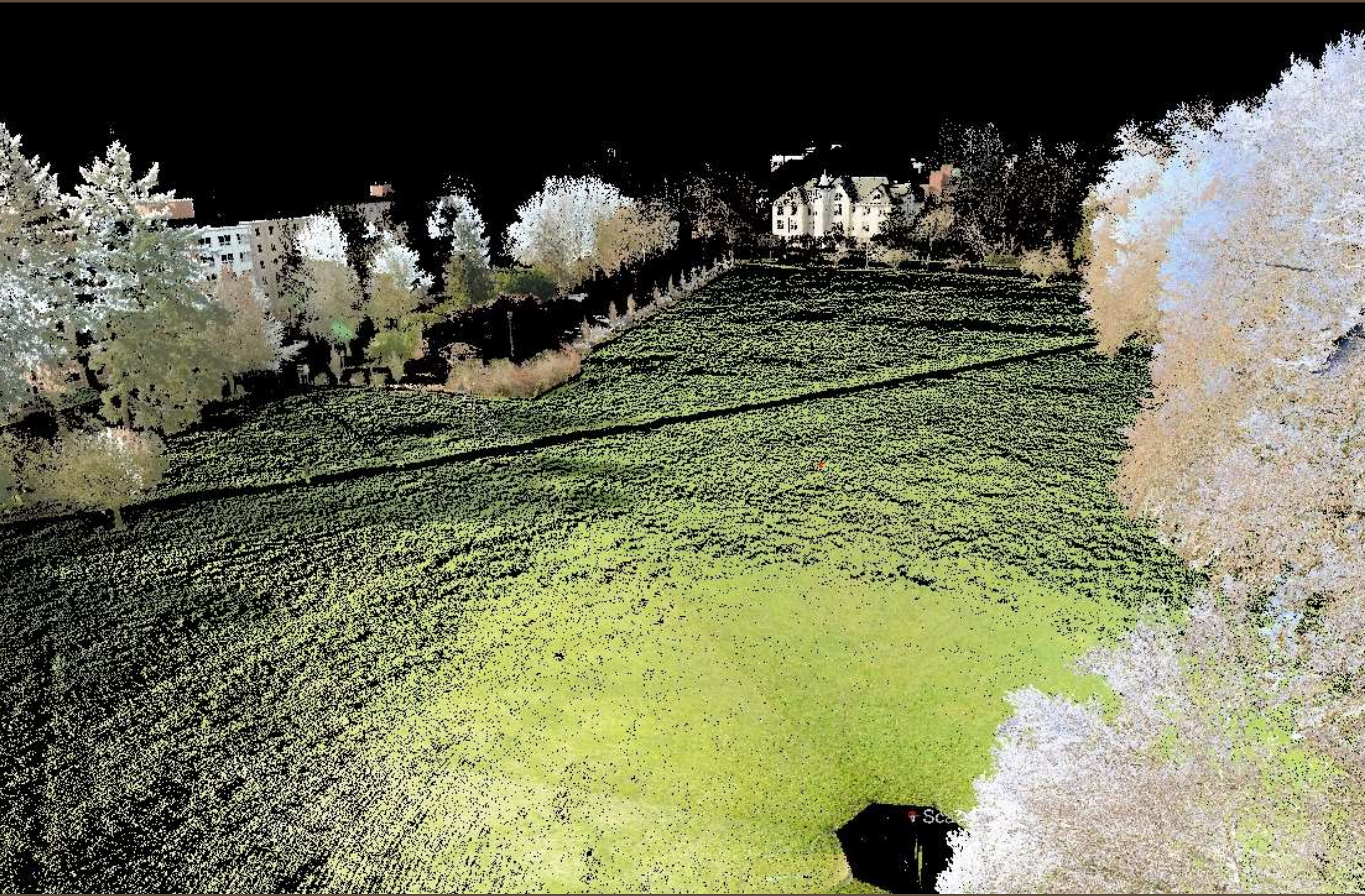
Oregon State University

Oregon LIDAR Consortium



Slide by Michael Denis, OSU CCE Geomatics \\lidar.engr.oregonstate.edu\lds

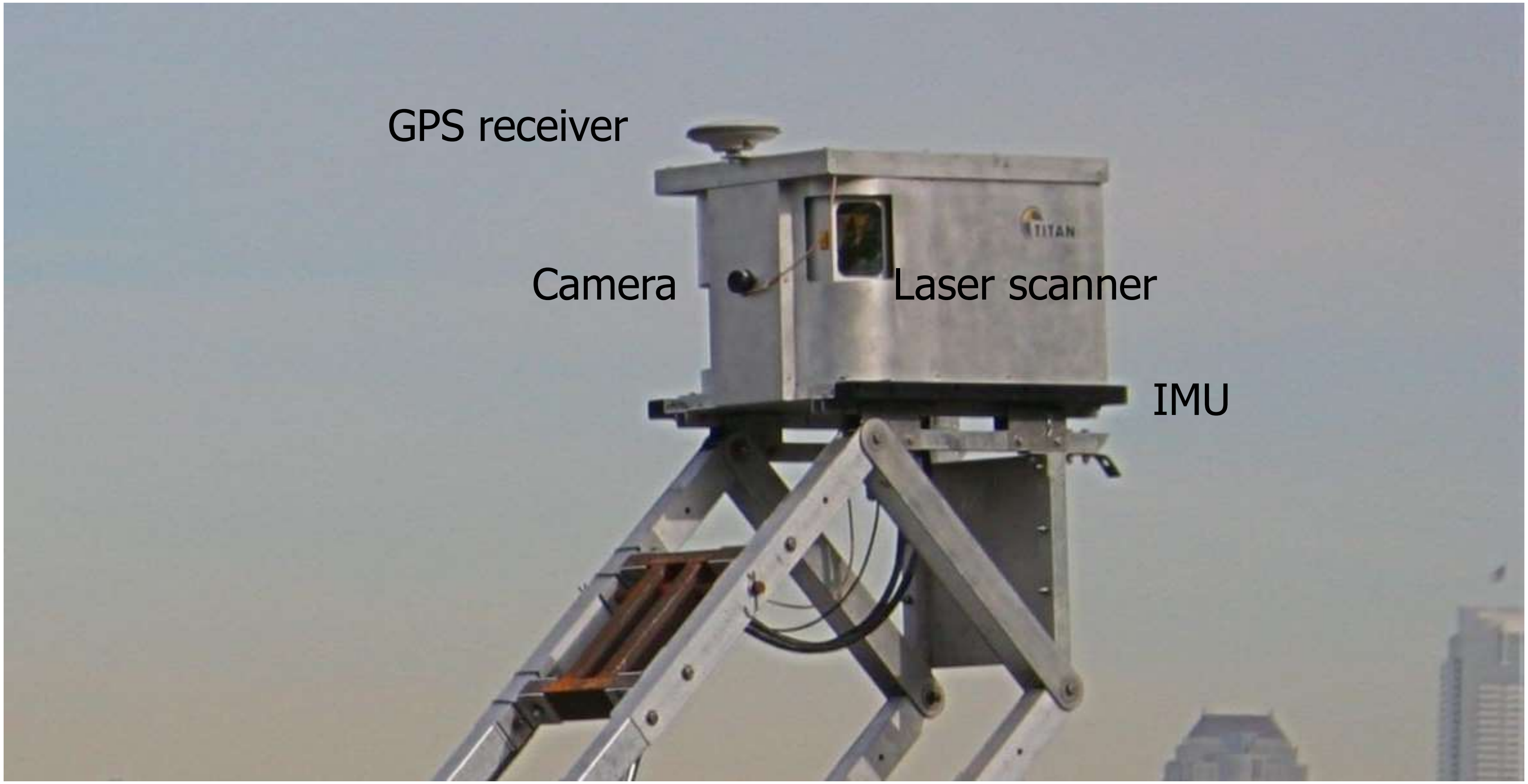

3D laser scanner w/ integrated camera
Tripod
Network Cord
Power Cord
Laptop for control and data preview
10.08.2009 16:34

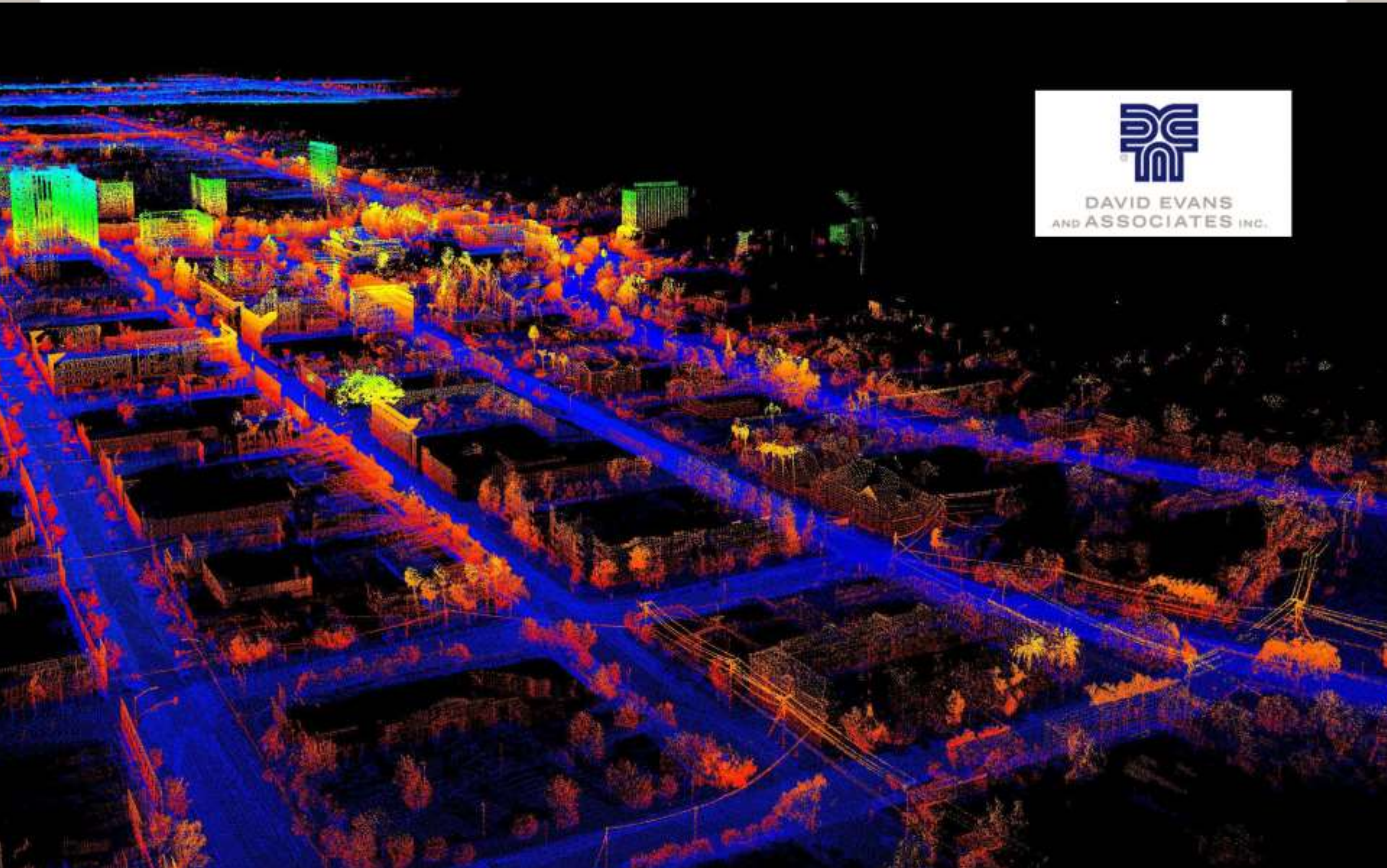


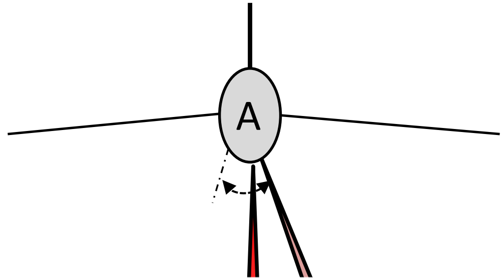

RTK GPS Receiver
3D Laser Scanner
RTK GPS Controller
Cell Phone
Laptop Controller

Mobile Laser scan system

Components




DAVID EVANS
AND ASSOCIATES INC.

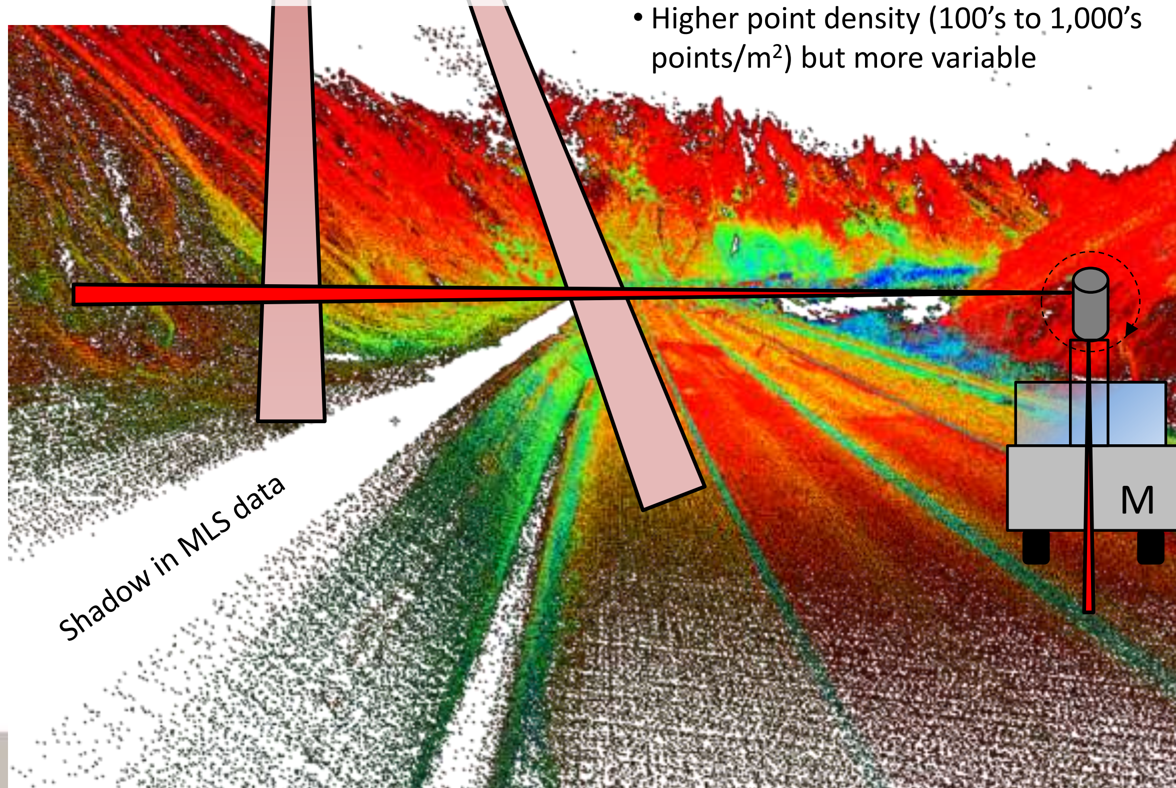


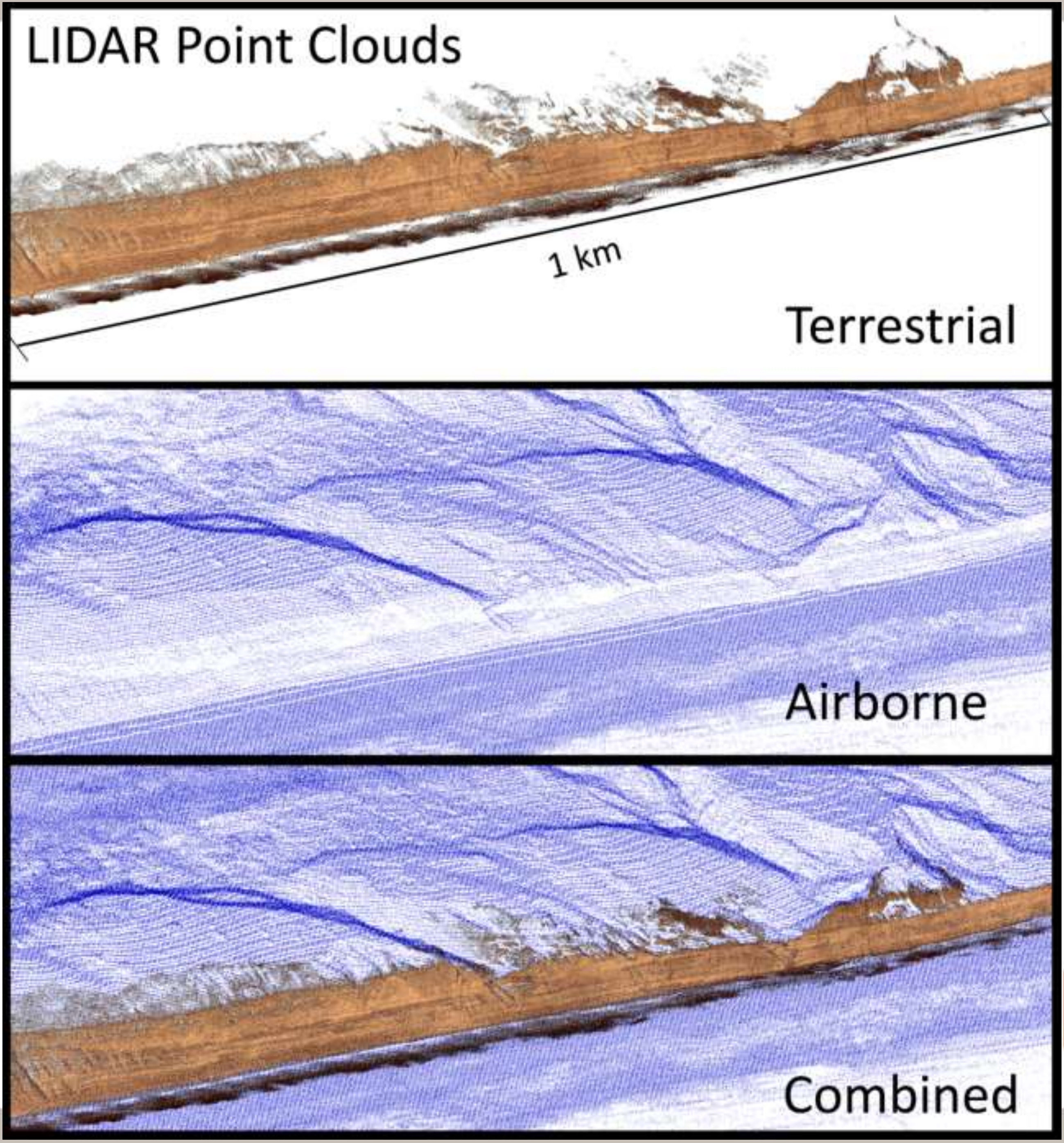
Airborne LIDAR

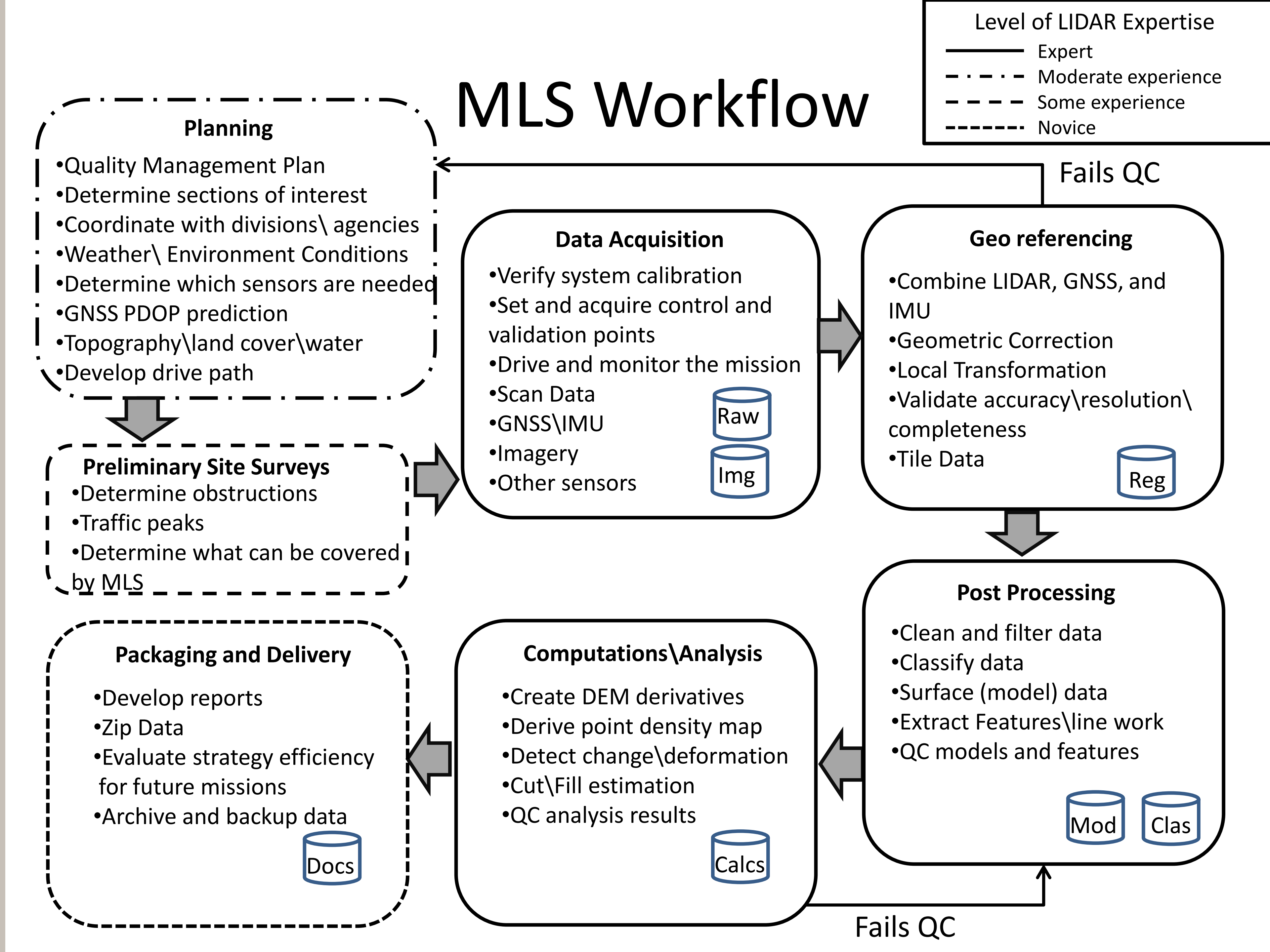
- Direct view of pavement & cliff tops
- Poor (oblique) view of vertical faces and cannot capture overhangs
- Faster coverage
- Larger footprint (>0.5m)
- Laser travels much farther
- Not limited to area visible from roadway
- Lower point density (1-80 points/m^2)

Mobile LIDAR

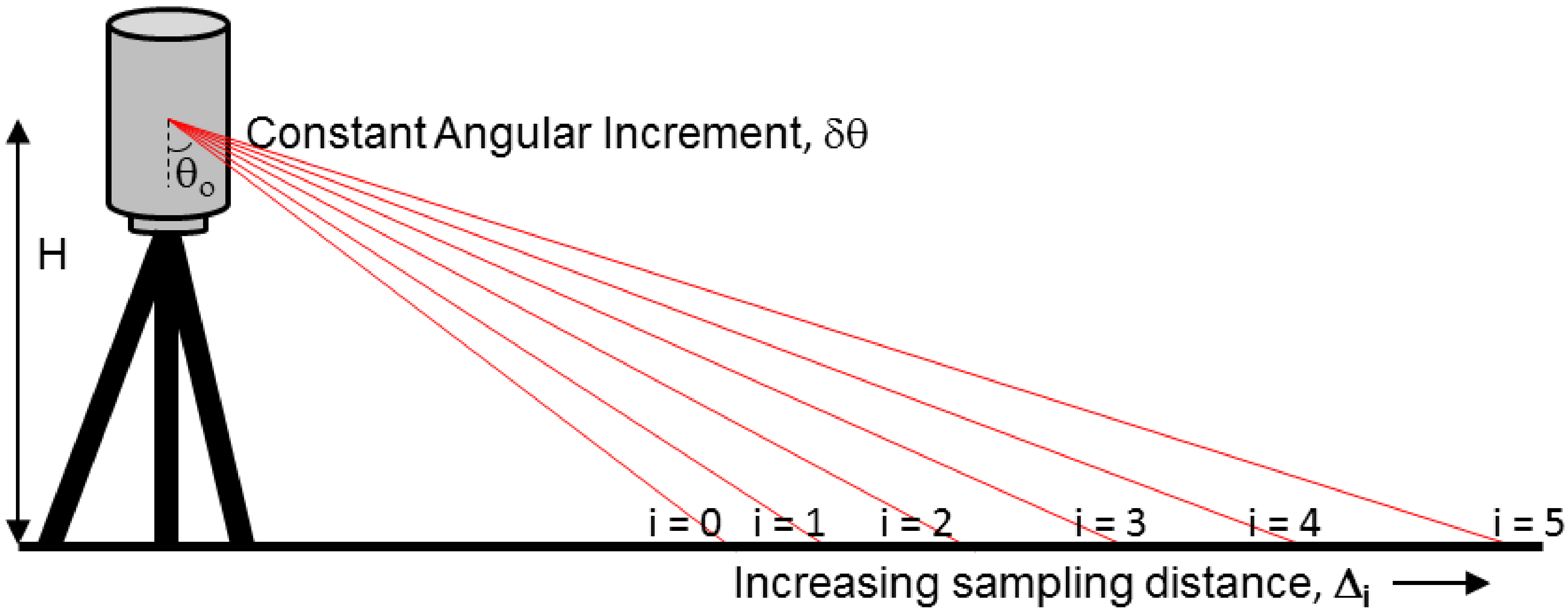
- Good view of pavement
- Direct view of vertical faces
- Cannot capture cliff tops
- Slower coverage
- Smaller footprint (1-3 cm, typical)
- Closer to ground\objects
- Limited to objects close and visible from the roadway (<100m, typical)
- Higher point density (100's to 1,000's points/m^2) but more variable




LIDAR Point Clouds
1 km
Terrestrial
Airborne
Combined


MLS Workflow
Level of LIDAR Expertise
Expert
Moderate experience
Some experience
Novice
Planning
•Quality Management Plan
•Determine sections of interest
•Coordinate with divisions\ agencies
•Weather\ Environment Conditions
•Determine which sensors are needed
•GNSS PDOP prediction
•Topography\land cover\water
•Develop drive path
Preliminary Site Surveys
•Determine obstructions
•Traffic peaks
•Determine what can be covered by MLS
Data Acquisition
•Verify system calibration
•Set and acquire control and validation points
•Drive and monitor the mission
•Scan Data
•GNSS\IMU
•Imagery
•Other sensors
Raw
Img
Geo referencing
•Combine LIDAR, GNSS, and IMU
•Geometric Correction
•Local Transformation
•Validate accuracy\resolution\ completeness
•Tile Data
Reg
Fails QC
Post Processing
•Clean and filter data
•Classify data
•Surface (model) data
•Extract Features\line work
•QC models and features
Mod
Clas
Computations\Analysis
•Create DEM derivatives
•Derive point density map
•Detect change\deformation
•Cut\Fill estimation
•QC analysis results
Calcs
Fails QC
Packaging and Delivery
•Develop reports
•Zip Data
•Evaluate strategy efficiency for future missions
•Archive and backup data
Docs

Scanning geometry



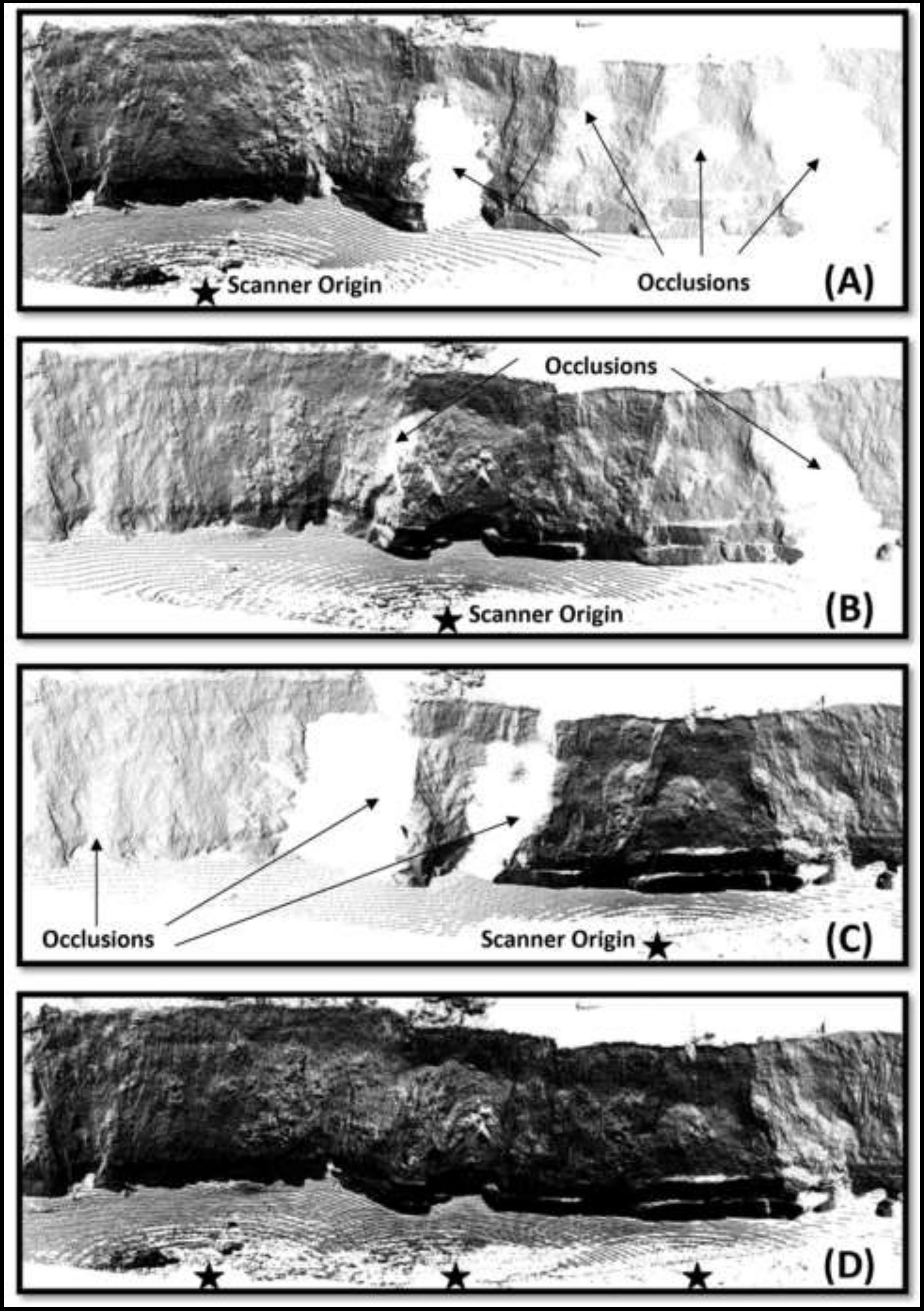
$$\Delta_i = H * [\tan(\theta_o + i*\delta\theta) - \tan(\theta_o + (i-1)*\delta\theta)]$$

Scan A

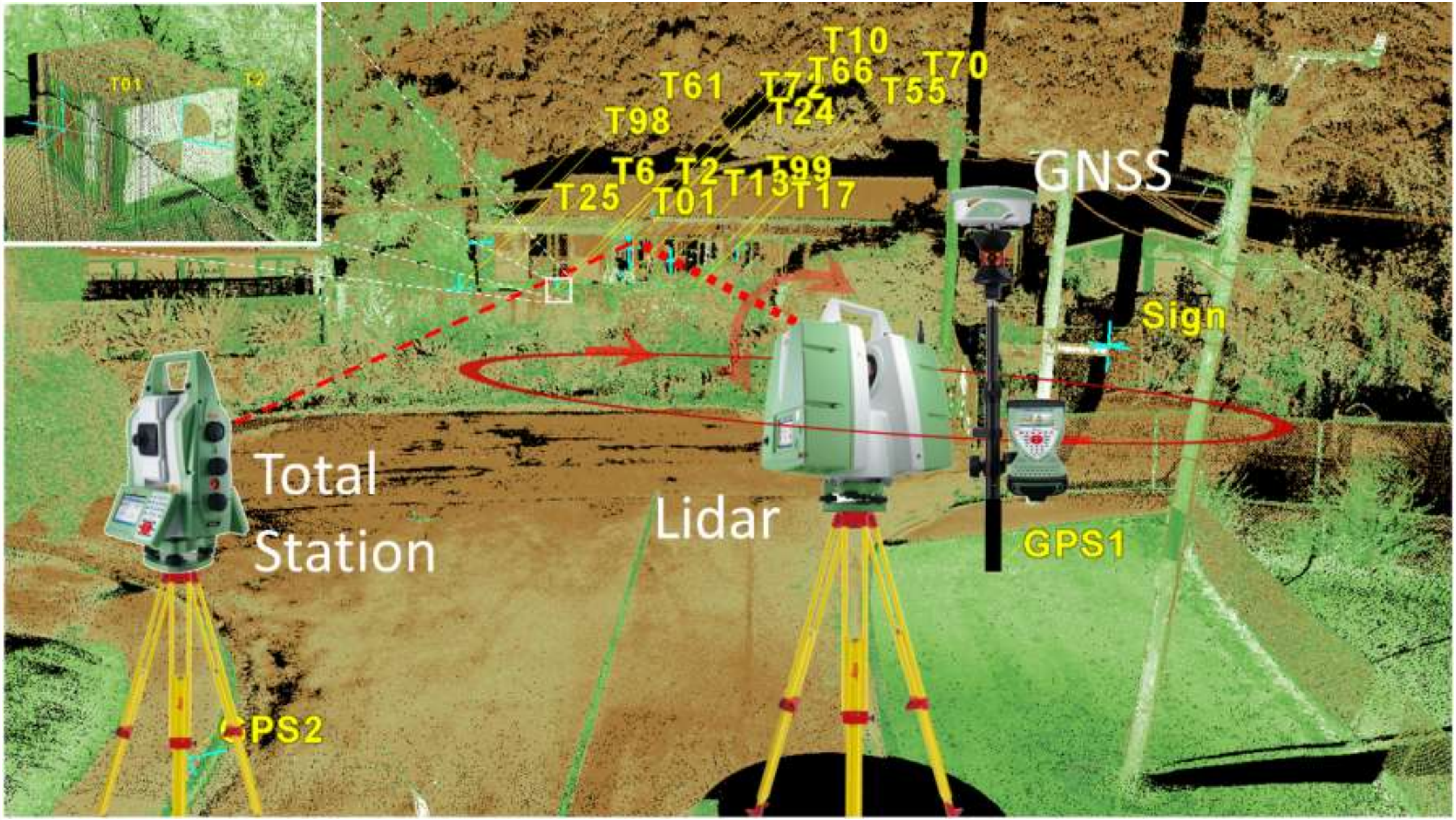
B

C

A+B+C

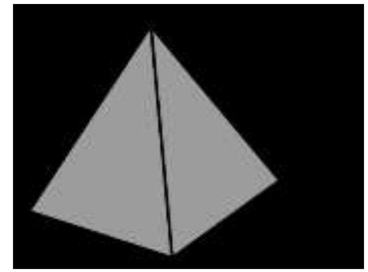
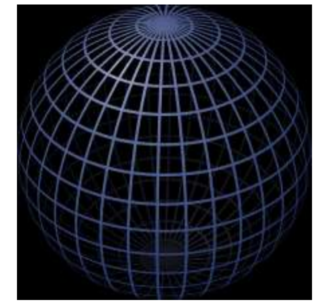
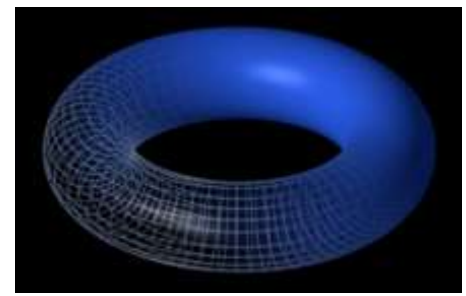
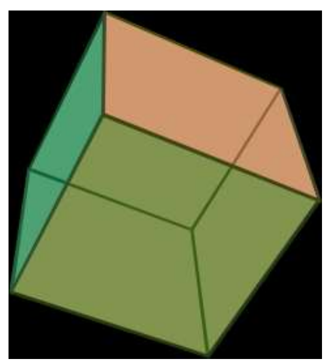
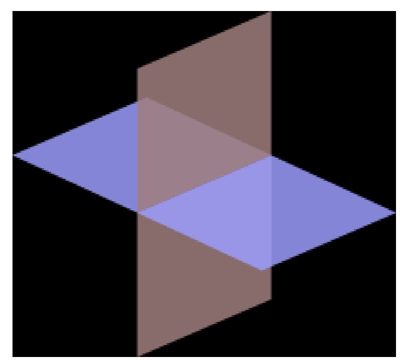
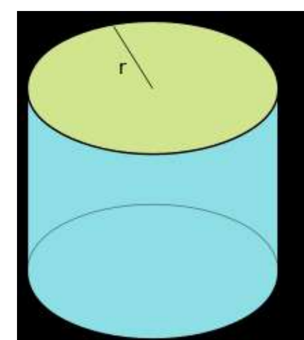

Scanner Origin
Occlusions
(A)
Occlusions
Scanner Origin
(B)
Occlusions
Scanner Origin
(C)
(D)

Integration of Geomatics Technologies

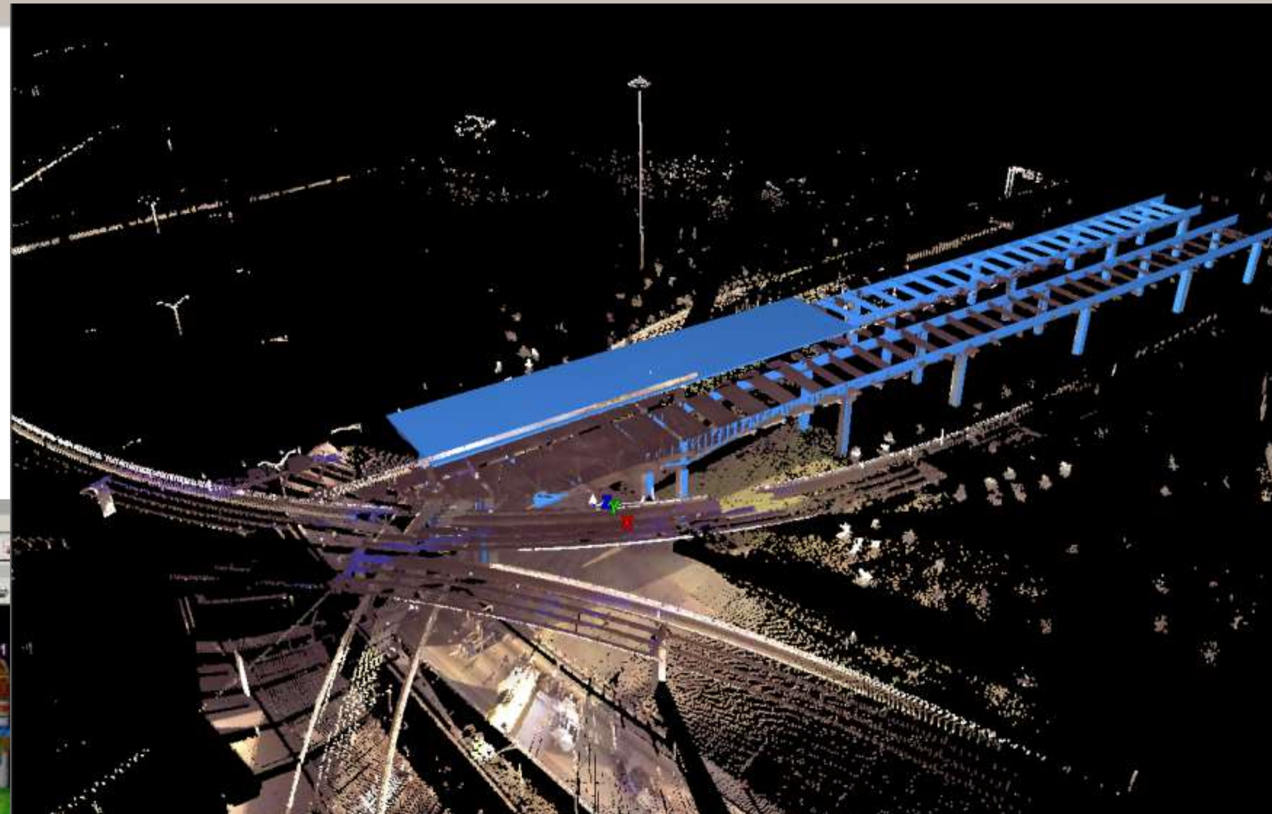


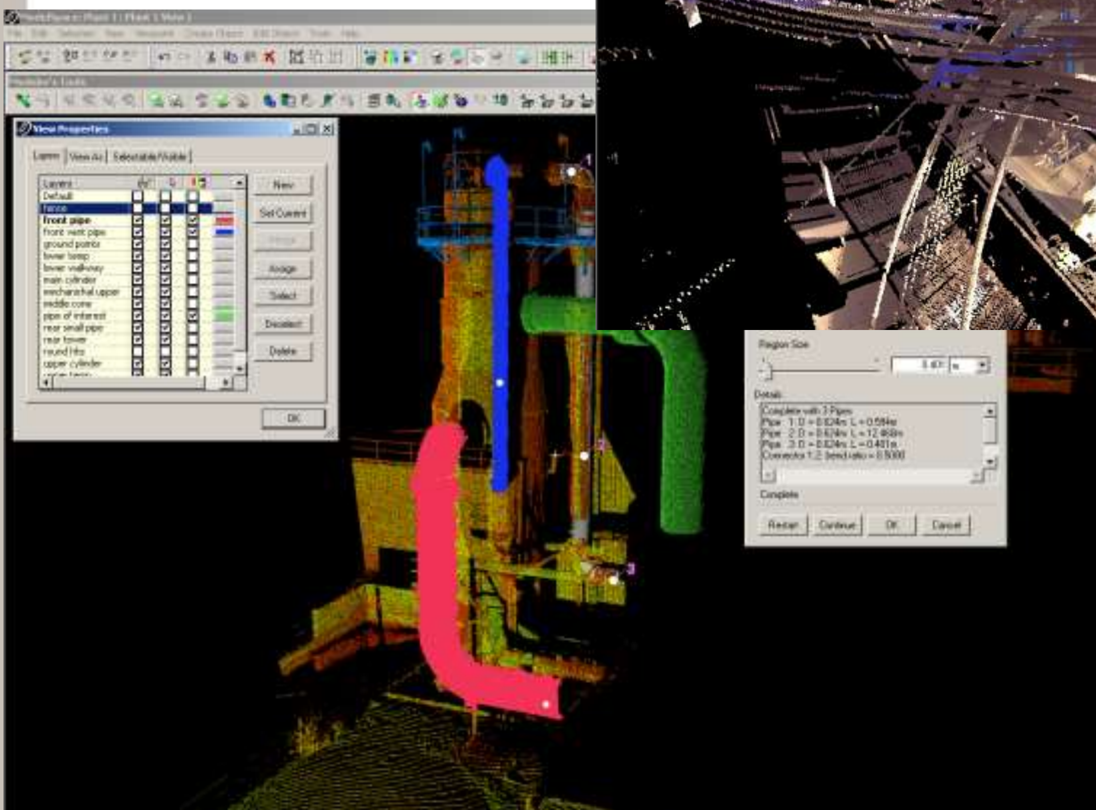
Mathematically defined, Geometric Primitives

points
lines and line segments
planes
circles and ellipses
triangles and other polygons
spline curves
spheres
cubes or boxes
toroids
cylinders
pyramids
teapot

Modeling in Leica Cyclone





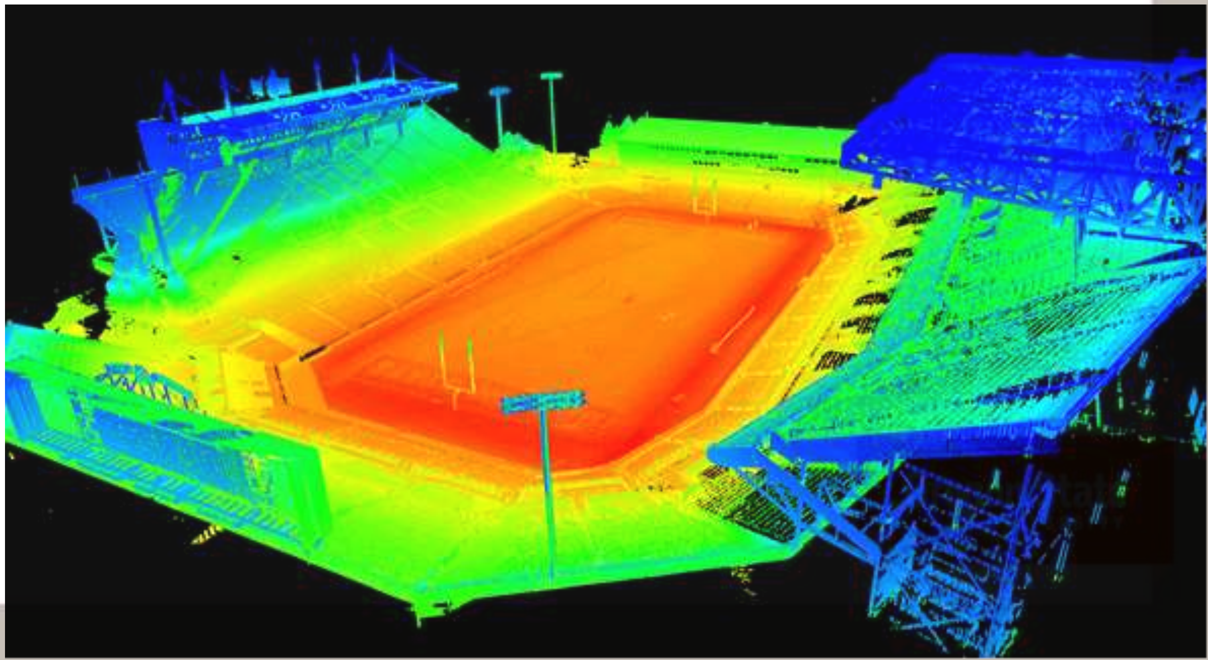
By:
Logan Allendar
Torger Torgerson

Oregon State University

School of Civil and Construction Engineering

Example Applications

- Transportation
- Coastal Erosion
- Landslide Assessment
- Earthquake and Tsunami damage assessment
- Wireless signal mapping
- Cultural Heritage
- Laboratory Testing



TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NCHRP 15-44 (Report #748) Guidelines for the use of mobile lidar in transportation applications

MPN Components

Persi Consulting

Martha Hales Design

Alisa Bolander Consulting

DAVID EVANS AND ASSOCIATES INC.

Innovative Data, LLC

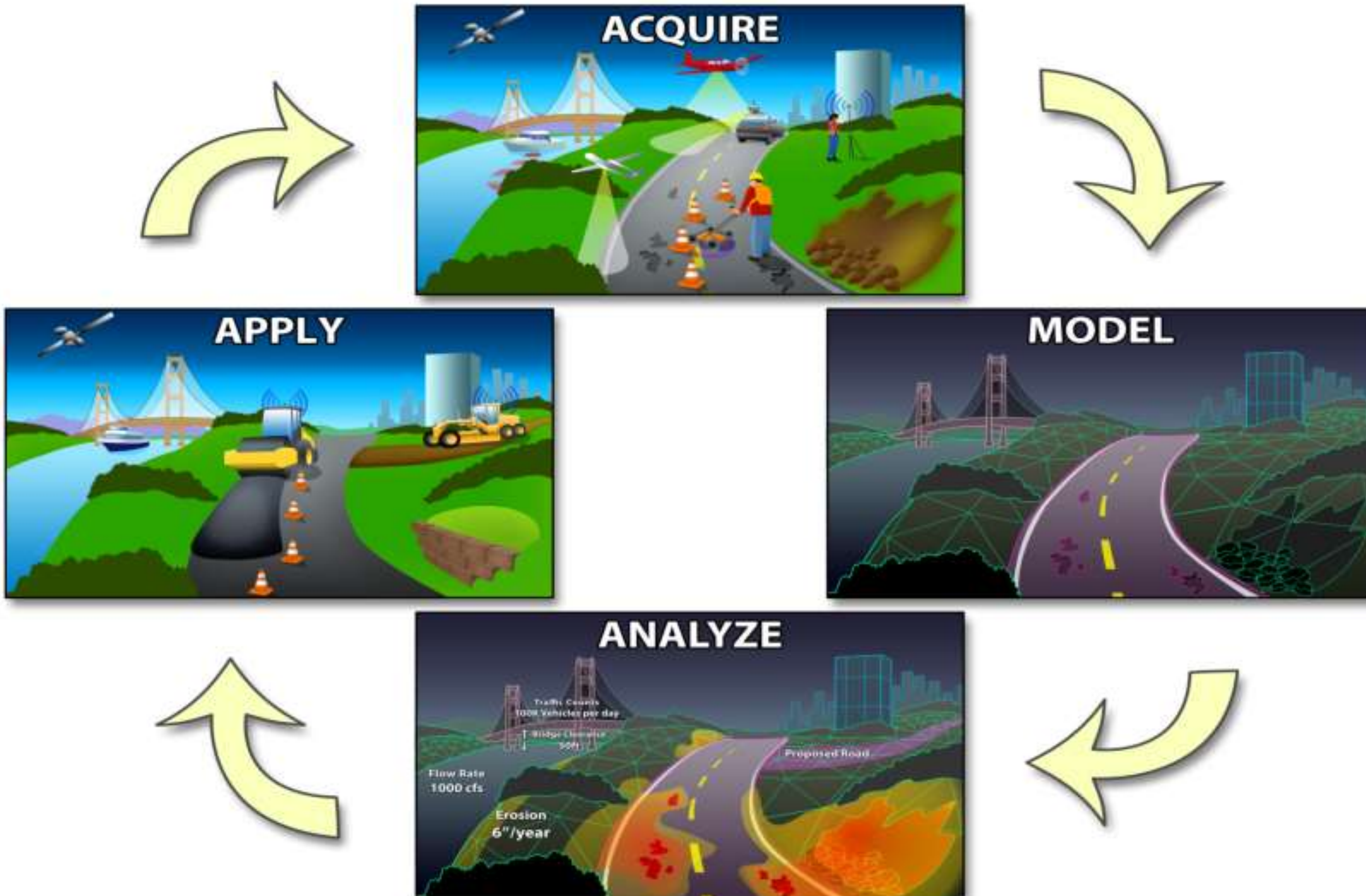
Oregon State UNIVERSITY OSU

UNIVERSITY of HOUSTON

Graduate Students: Keith Williams, Matt O'Banion

Oregon State UNIVERSITY

Transportation Asset Lifecycle



eLearning Resources

Mobile LIDAR
Guidelines for Use in Transportation Applications

Search this website... | Search

http://learnmobilelidar.com

GUIDELINES FOR THE USE OF MOBILE LIDAR IN TRANSPORTATION

Welcome to the online resource for the NCHRP 15-44 Guidelines for the use of Mobile LIDAR in Transportation Applications. Mobile LIDAR is one of several new 3D technologies that offer the promise of transforming the way in which transportation agencies plan, design, construct and maintain their highway networks. This website is designed to facilitate the interactive learning of the guidelines document and serve as a central hub for discussion and transmission of knowledge amongst the Mobile LIDAR community.

Getting Started

Review key overview references for Mobile LIDAR.

E-Learning Modules

Learn about mobile LIDAR technology and how to manage it.

Mobile LIDAR Forum

Join others in the discussion of mobile LIDAR.

News Feed

International LiDAR Mapping Forum Launches 2014 Program - GISuser.com (press release)

Literature Database

Welcome to the Literature Database. This database includes all references cited in NCHRP Report 748 as well as other references relevant to mobile LIDAR and geomatics. Most references can be viewed by clicking on the title of the reference. If you know of relevant references which are not included or come across a broken link, please Click Here to let us know.

Print

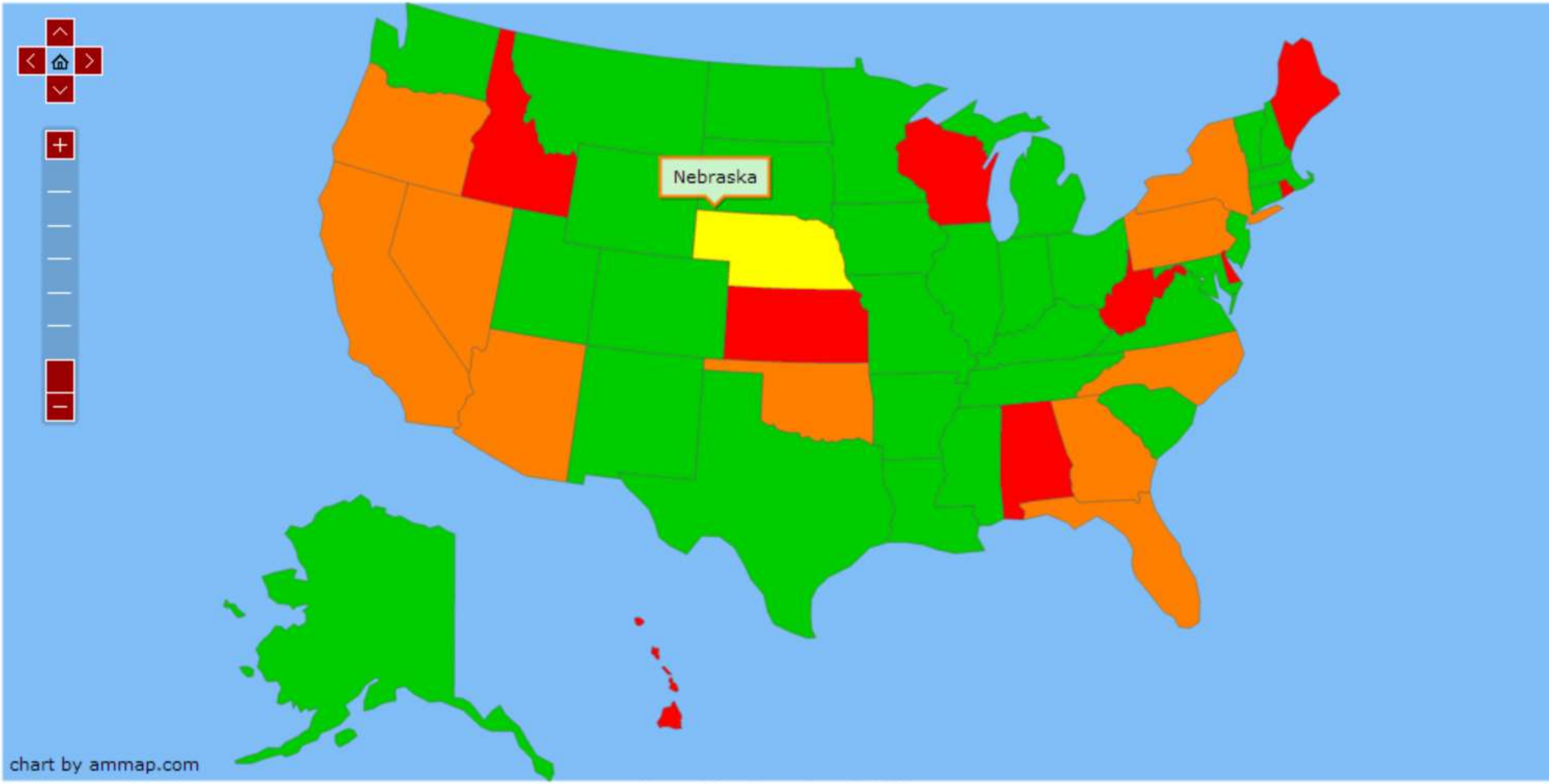
Search:

Title	Date	Author	Key Terms	Source
3DLM Helps Reduce Motorway Congestion	2011	3D laser mapping	Transportation, Traffic, Accident	News
Highway Safety Manual	2010	AASHTO	Transportation	Manual
Guidelines for Procurement of Commercial Geospatial Products (DRAFT)	2011	ASPRS	Geospatial, Mapping	Guidelines
ASPRS Guidelines: Vertical Accuracy Reporting for Lidar Data	2004	ASPRS Lidar Committee	Specifications, Standards	Guidelines
ASPRS LIDAR Guidelines: Horizontal Accuracy Reporting (DRAFT ver. 0.9)	2005	ASPRS Standards Committee	Specifications, Standards	Guidelines
LAS 1.4 Specification Approved by ASPRS Board	2011	ASPRS	File Format	Guidelines
LASer (LAS) Specification, Version 1.4-R11	2011	ASPRS Standards Committee	File Format	Guidelines
Lib E57: Software Tools for Managing E57 Files	2010	ASTM	File Format	Guidelines
Airborne laser scanning: basic relations and formulas	1999	Baltsavias, E.P.	ALS, scan patterns	Journal
Geomeric validation of a ground-based mobile	2008	Barber, D., J. Mills, S. Smith-	Accuracy, Terrestrial, Mobile Mapping, Validation	Journal

photogrammetry, and GPS. If you know of relevant specifications which are not available or need to be updated please Click Here to let us know.

Select a State: --

Last Updated: 04/04/1

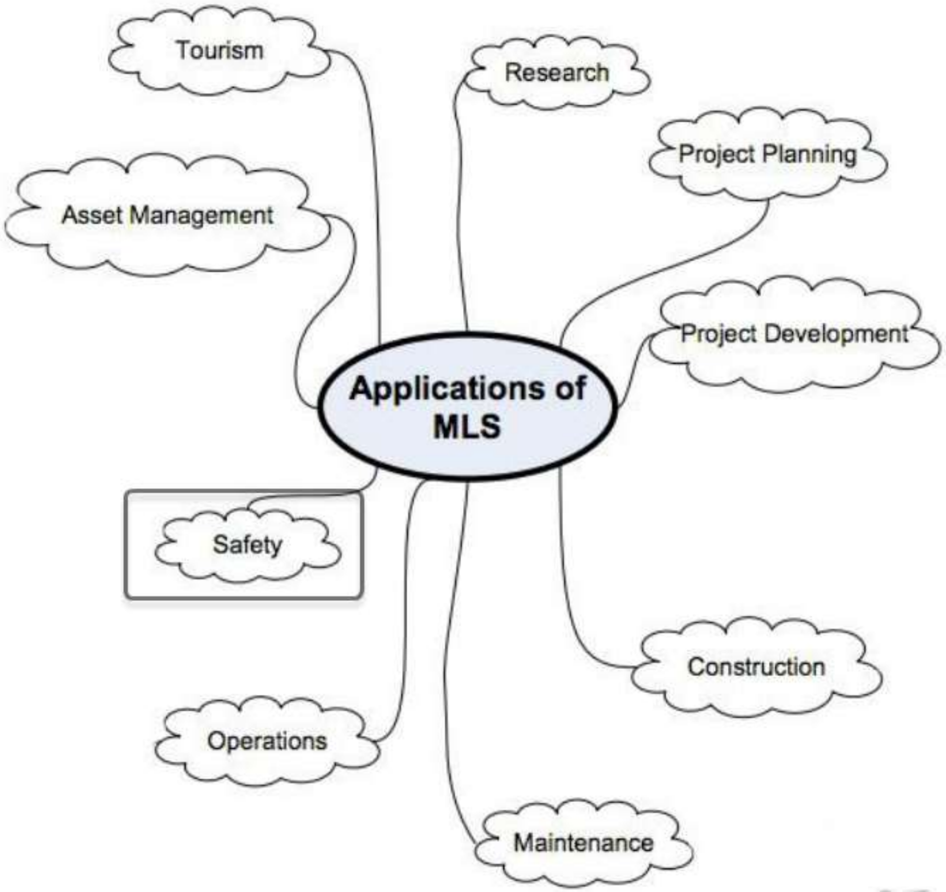


Specification Availabiliy

Surveying LIDAR None

Potential applications

Click on each of the applications shown at right to learn more about how Mobile LIDAR may be used in that context.



Potential applications

Tourism applications

Tourism is an emerging mobile LIDAR application. As tools to visualize point clouds from LIDAR systems become available, mobile LIDAR can provide a new generation of 3D, digital maps for navigation and exploration.

A 2009 report describes the efficiency gains possible with the acquisition of mobile LIDAR in the historic peninsula of Istanbul.

- Only 80 ha of the required 1500 ha were completed using static scanning in 6 months
- The remaining 1420 ha were completed in 3 months using mobile LIDAR.

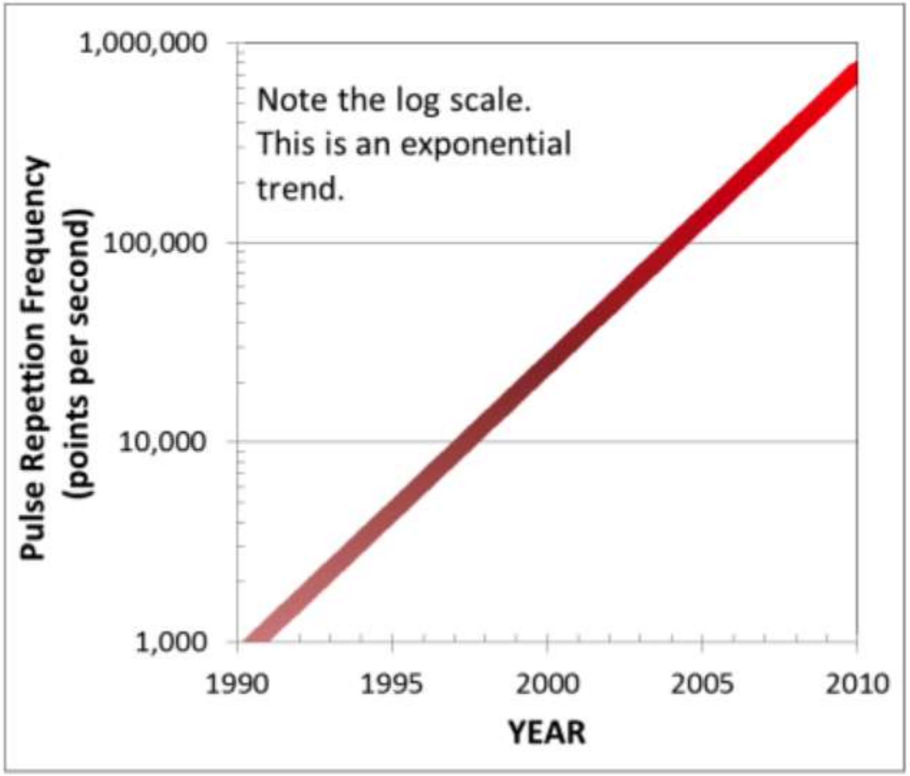
Stop-and-go LIDAR point cloud of Balboa Park, San Diego, CA

Guidelines, A.6.8.

Return

LIDAR point sampling

Over the 20 year period from 1990 to 2010, the point sampling capability of laser scanners has increased from 1,000 points/second to over 1 million. This impressive improvement in the ability to collect data faster also results in increased challenges when it comes to managing that data.

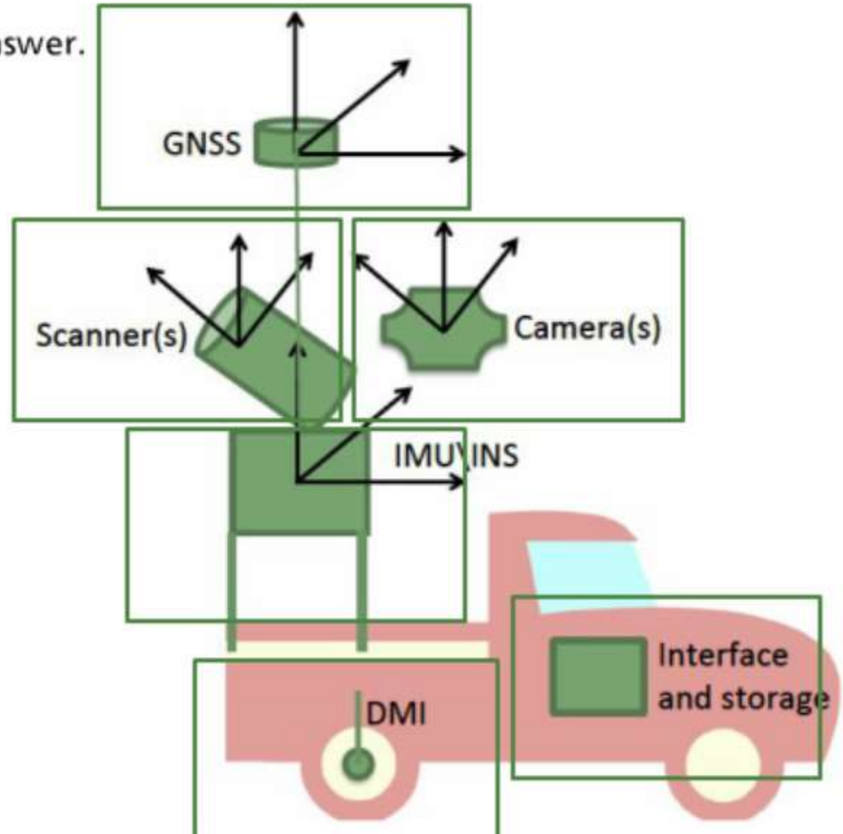


Knowledge check: How MLS technology works

Below is an image of an MLS system and with descriptions of the components. Drag each description to place it on top of the correct component.

Click SUBMIT to lock in your answer.

- Provides additional detail that allows color to be added to point clouds
- Provides time, position, and velocity measurements
- Provides orientation and attitude information and position estimation
- Fires pulses or continuous waves that determine the range to objects
- Provides an estimate of distance traveled



Knowledge check: How MLS technology works

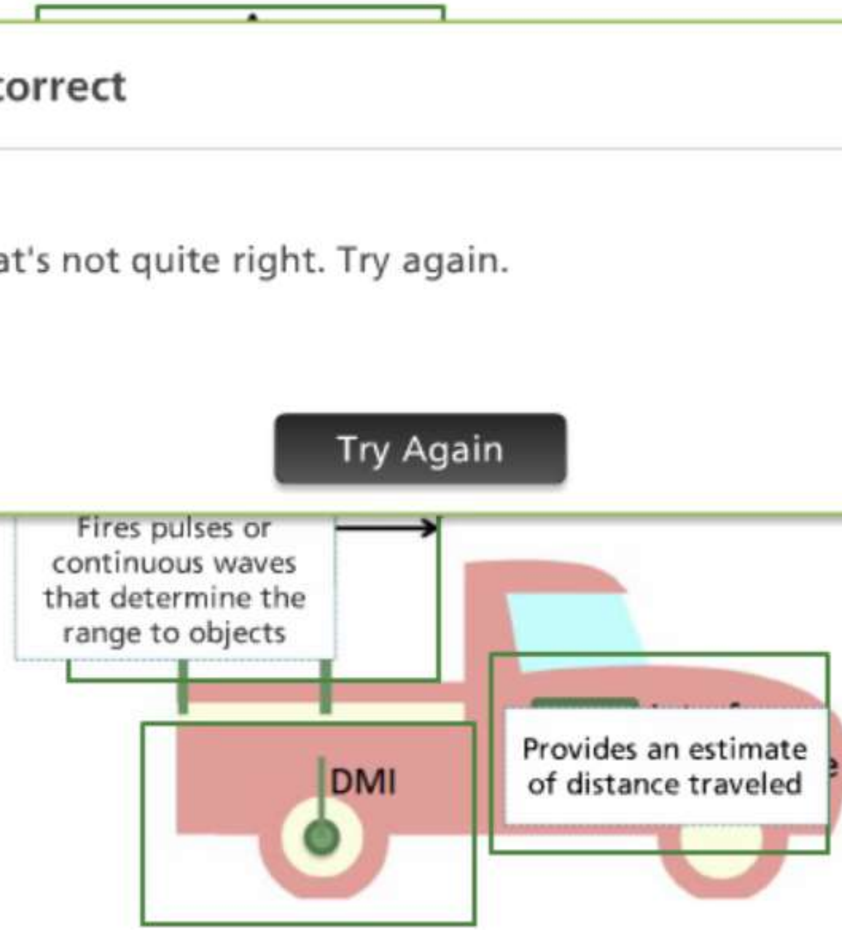
Below is an image of an MLS system and with descriptions of the components.
Drag each description to place it on top of the correct component.

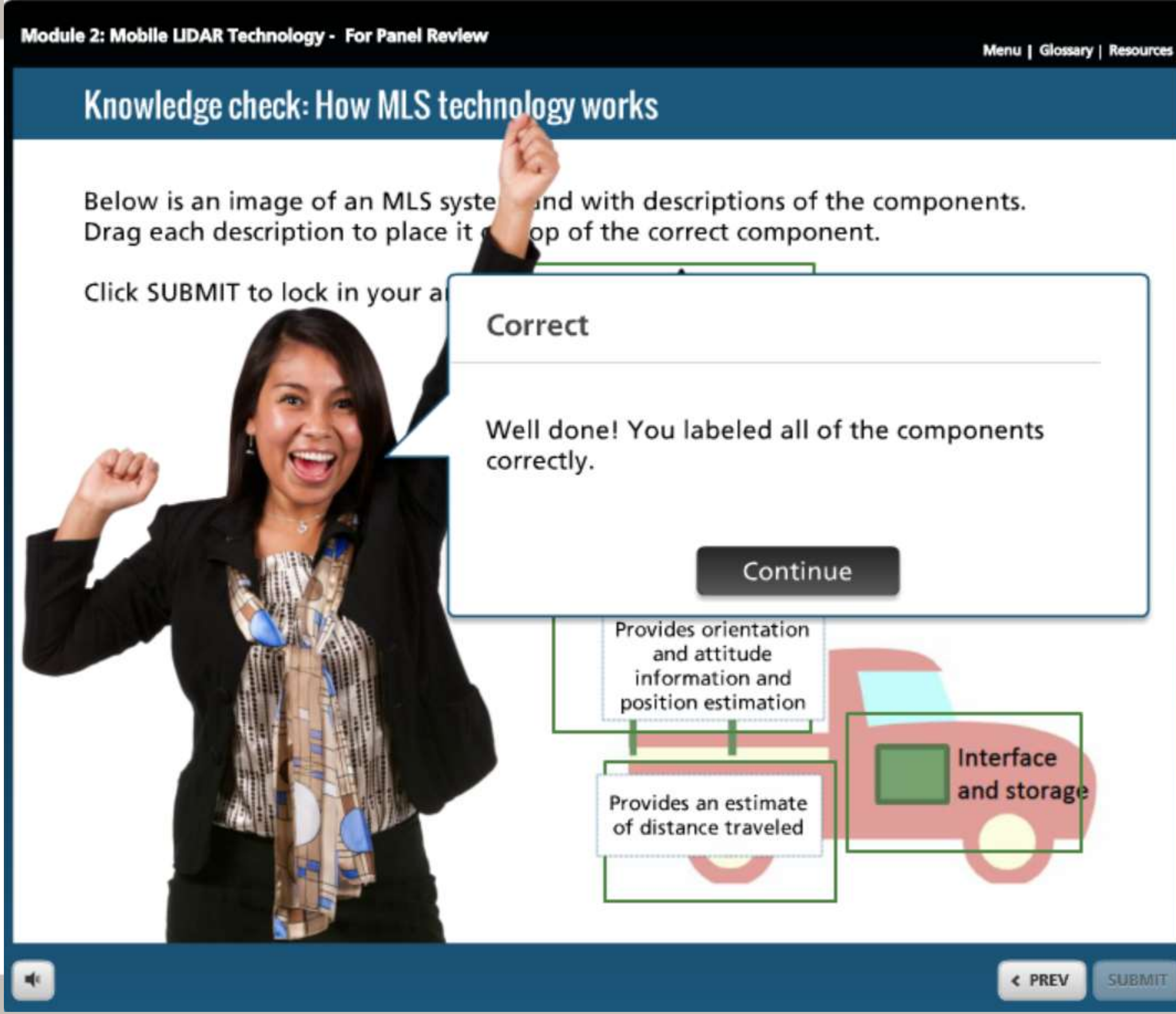
Click SUBMIT to lock in your a

Incorrect

That's not quite right. Try again.

Try Again





Module 2: Mobile LIDAR Technology - For Panel Review
Menu | Glossary | Resources
Knowledge check: How MLS technology works
Below is an image of an MLS syste and with descriptions of the components.
Drag each description to place it op of the correct component.
Click SUBMIT to lock in your a
Correct
Well done! You labeled all of the components correctly.
Continue
Provides orientation and attitude information and position estimation
Provides an estimate of distance traveled
Interface and storage
PREV
SUBMIT


Module 2: Mobile LIDAR Technology - For Panel Review
Menu | Glossary | Resources
Knowledge check: How MLS technology works
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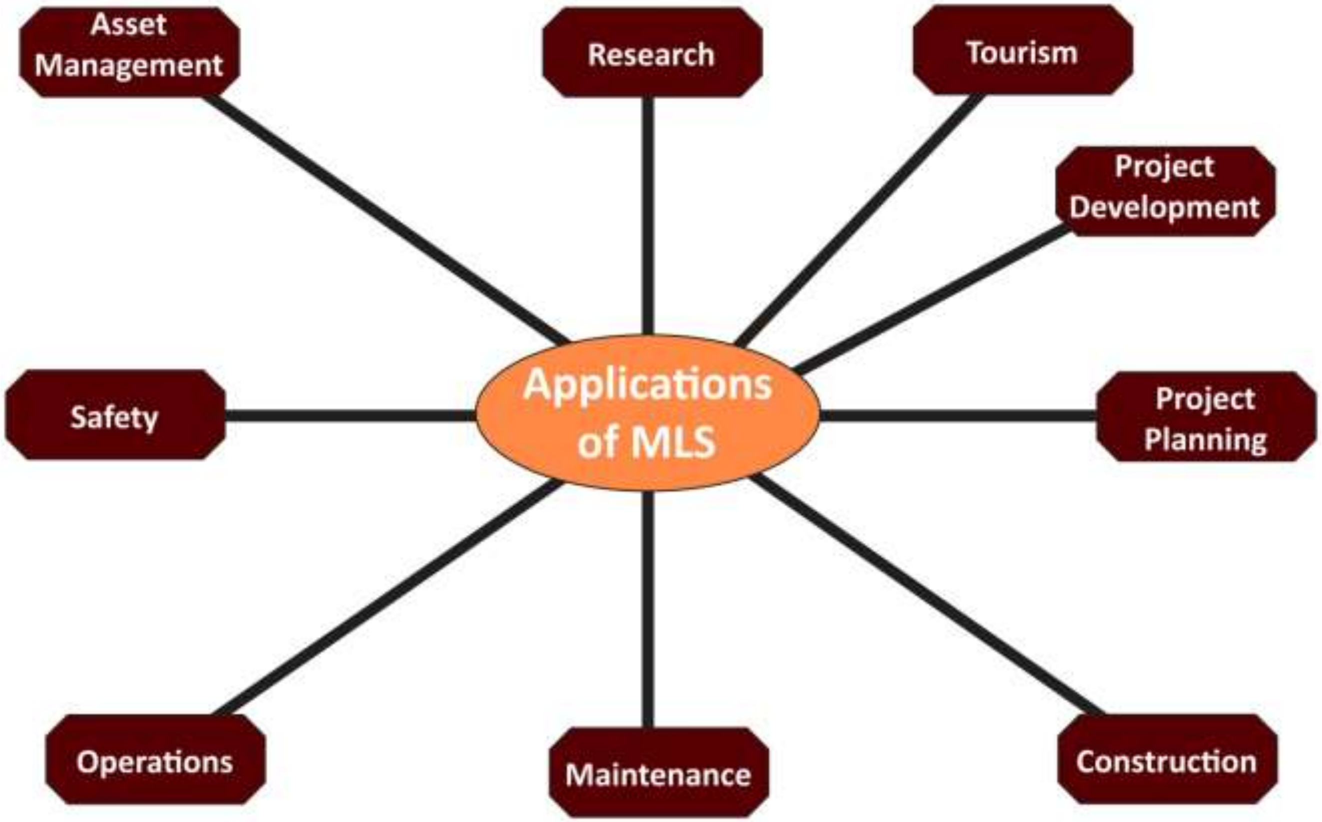
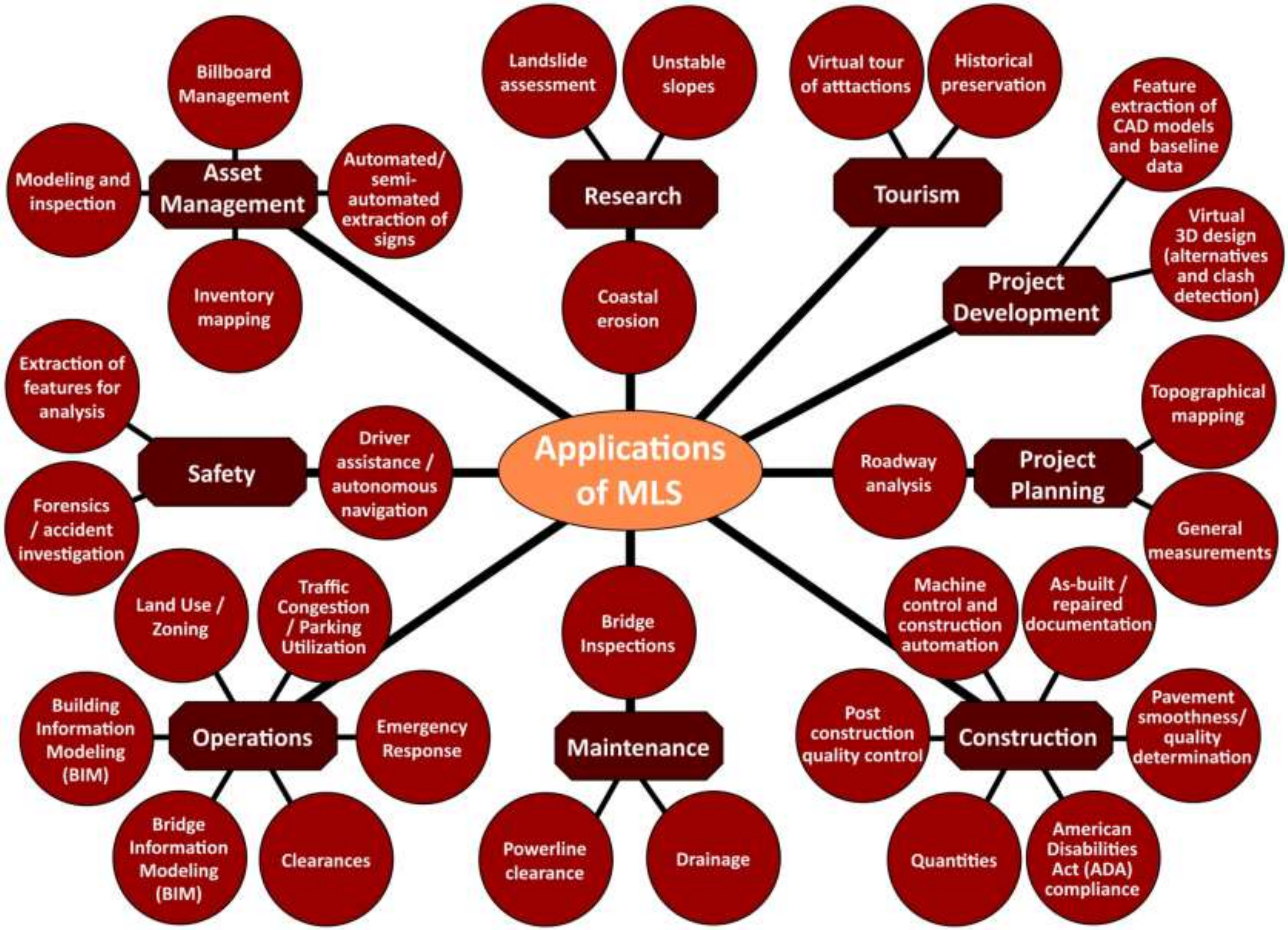
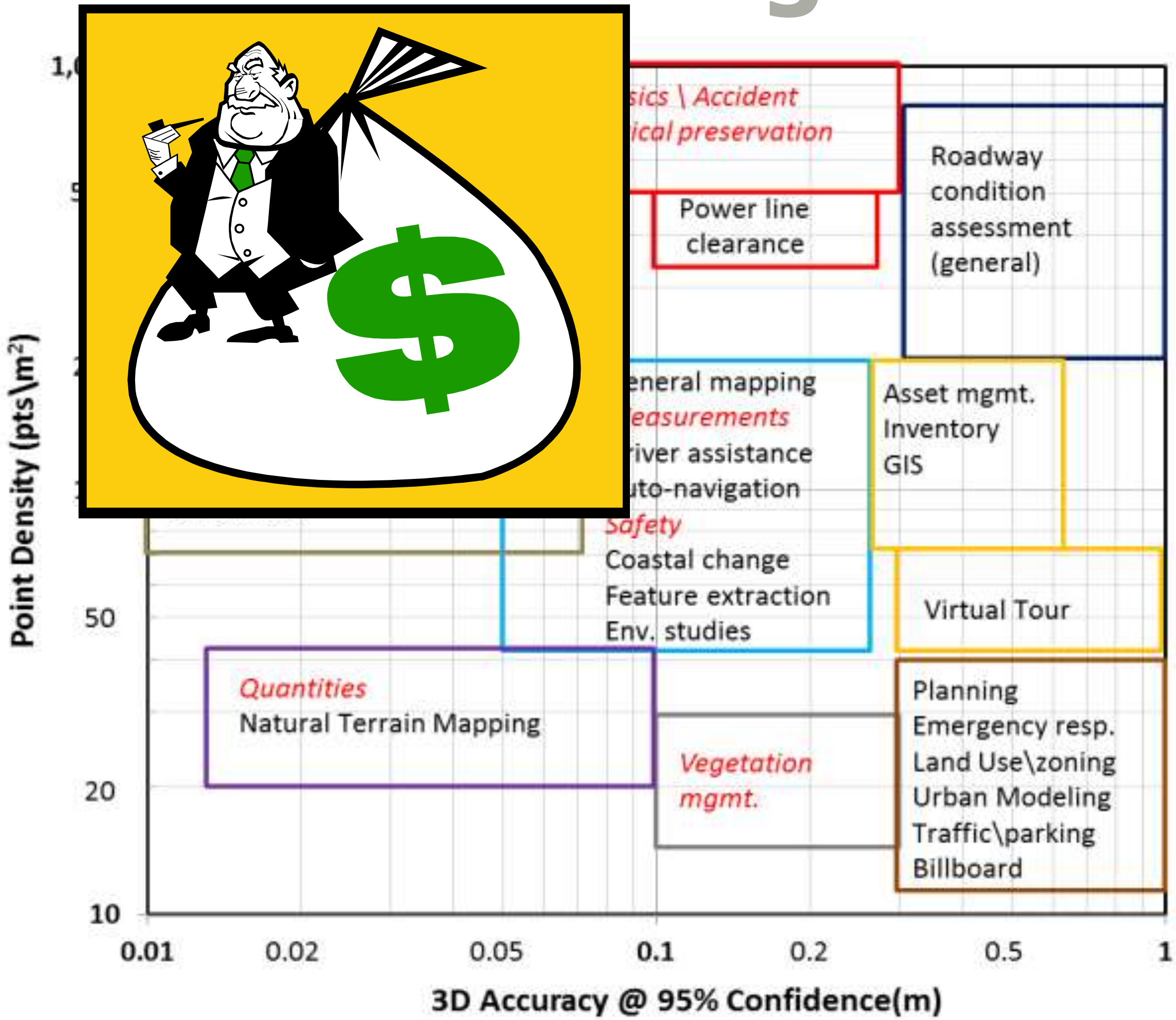

Asset Management
Research
Tourism
Project Development
Safety
Applications of MLS
Project Planning
Operations
Maintenance
Construction



Applications of MLS
Asset Management
Billboard Management
Modeling and inspection
Automated/ semi-automated extraction of signs
Inventory mapping
Research
Landslide assessment
Unstable slopes
Coastal erosion
Tourism
Virtual tour of atttactions
Historical preservation
Project Development
Feature extraction of CAD models and baseline data
Virtual 3D design (alternatives and clash detection)
Project Planning
Topographical mapping
Roadway analysis
General measurements
Safety
Extraction of features for analysis
Driver assistance / autonomous navigation
Forensics / accident investigation
Operations
Land Use / Zoning
Traffic Congestion / Parking Utilization
Building Information Modeling (BIM)
Emergency Response
Bridge Information Modeling (BIM)
Clearances
Maintenance
Bridge Inspections
Powerline clearance
Drainage
Construction
Machine control and construction automation
As-built / repaired documentation
Post construction quality control
Pavement smoothness/ quality determination
Quantities
American Disabilities Act (ADA) compliance

Data Collection Categories



What do you need? What does it cost?

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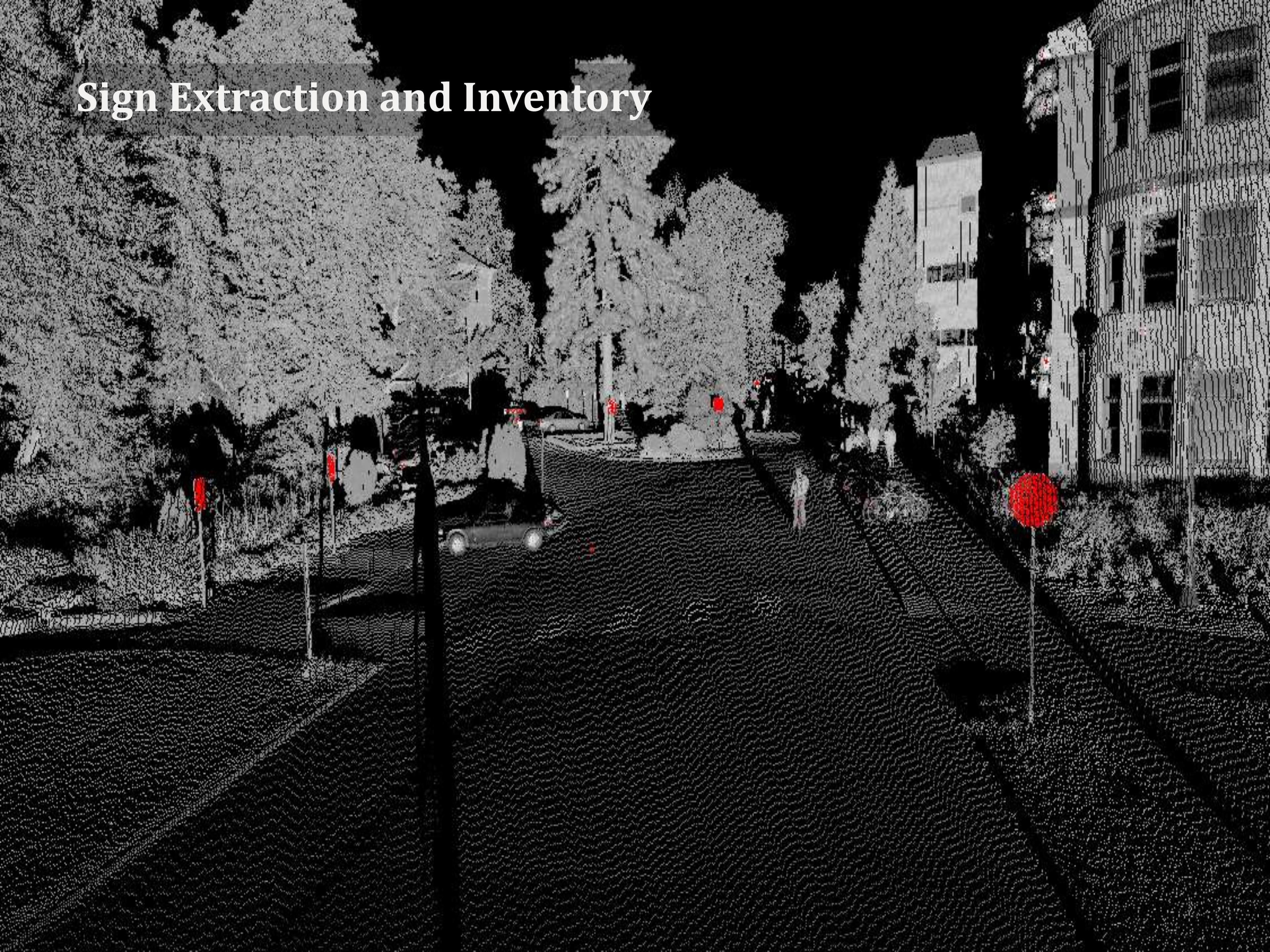
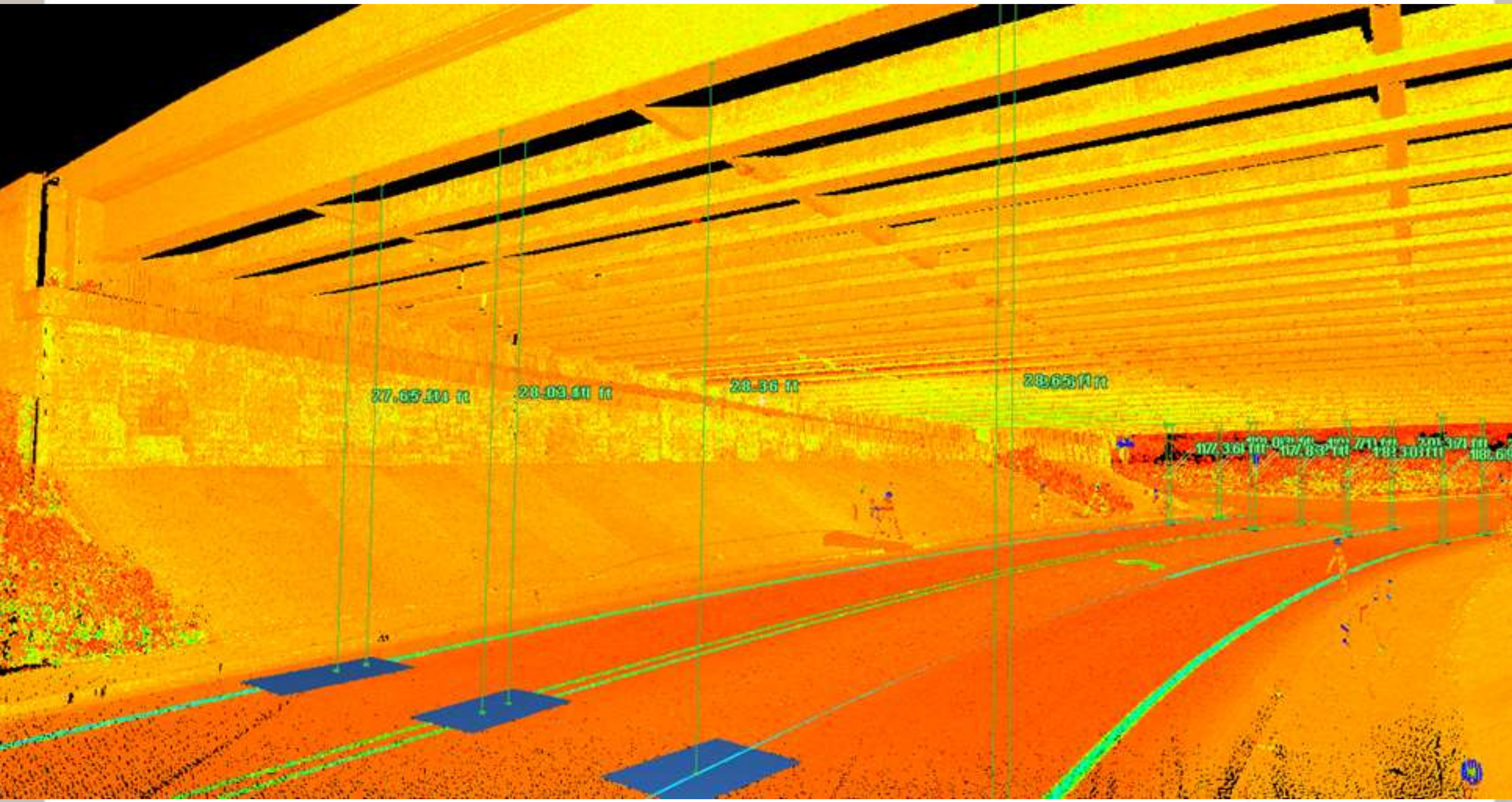
Sign Extraction and Inventory



Bridge Clearances

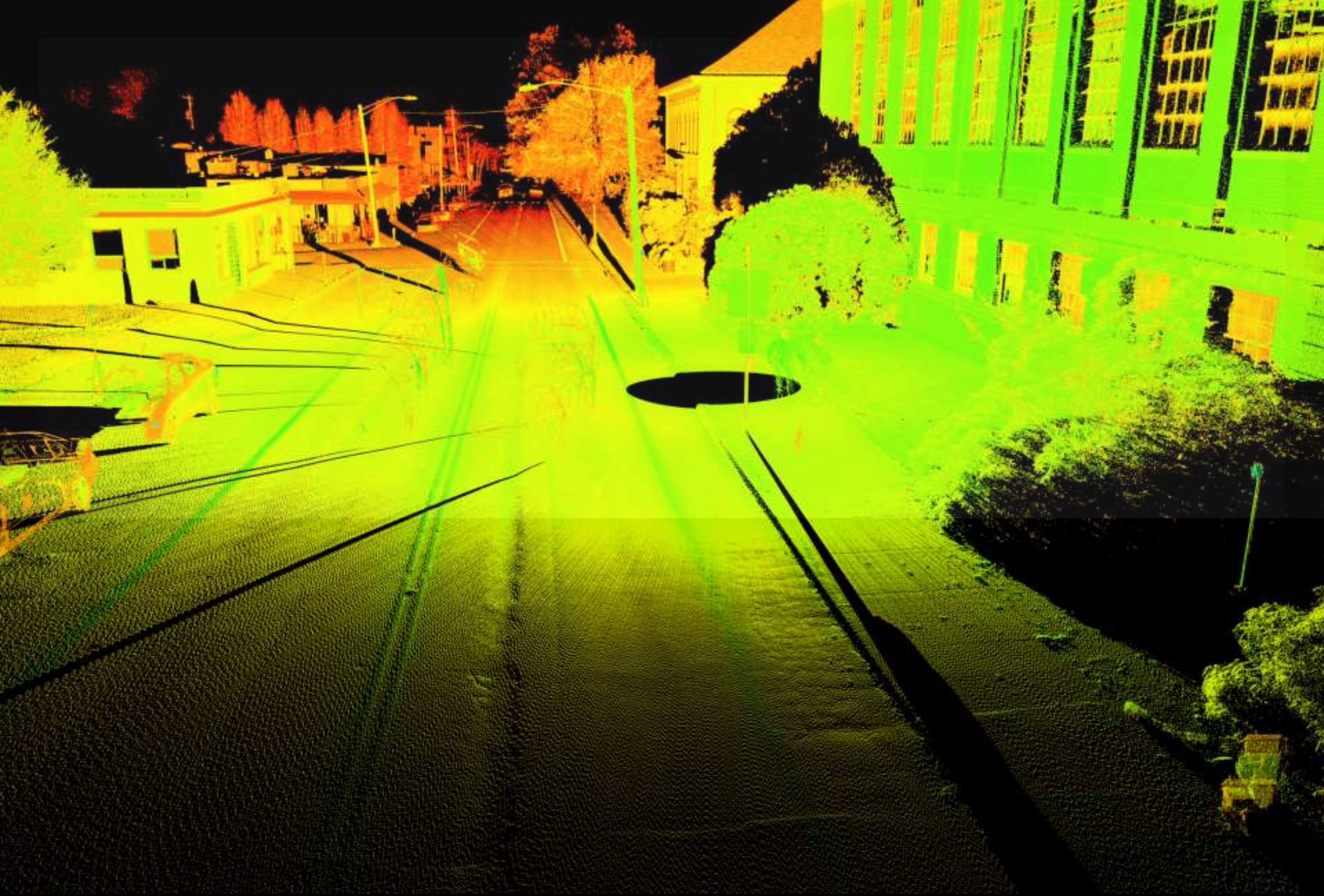


Conflict Analysis - Endeavour

https://www.youtube.com/watch?v=i-aOpGvqMPc

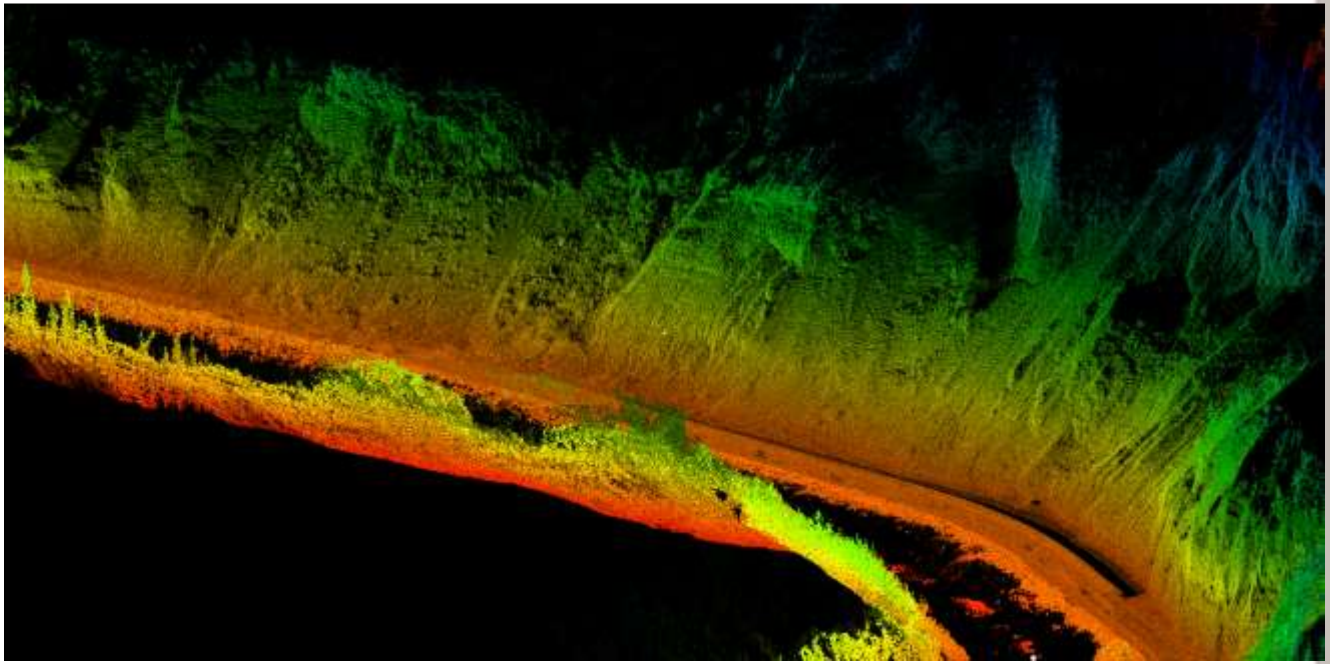
DAVID EVANS AND ASSOCIATES INC.

Pavement Cracking and deterioration



Rutting

A Platform for Proactive Risk-based Slope Asset Management



LIDAR acquisition and processing
Michael Olsen
Oregon State Univ.

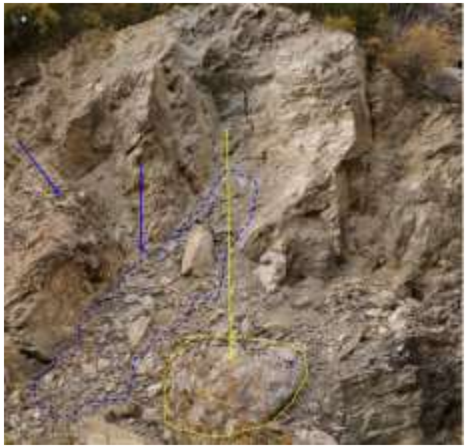
Slope Assessment
Joe Wartman
Lisa Dunham
Univ. of Washington

Risk Assessment
Keith Cunningham
Univ. of Alaska, Fairbanks

Proactive Risk-based Asset Management

Develop a model that identifies and relates high resolution lidar morphological indices to slope hazard categories which can then be related to risk

LiDAR scanning →



Slope Characterization →

Determining Risk

Use emerging technologies to create an automated risk classification system

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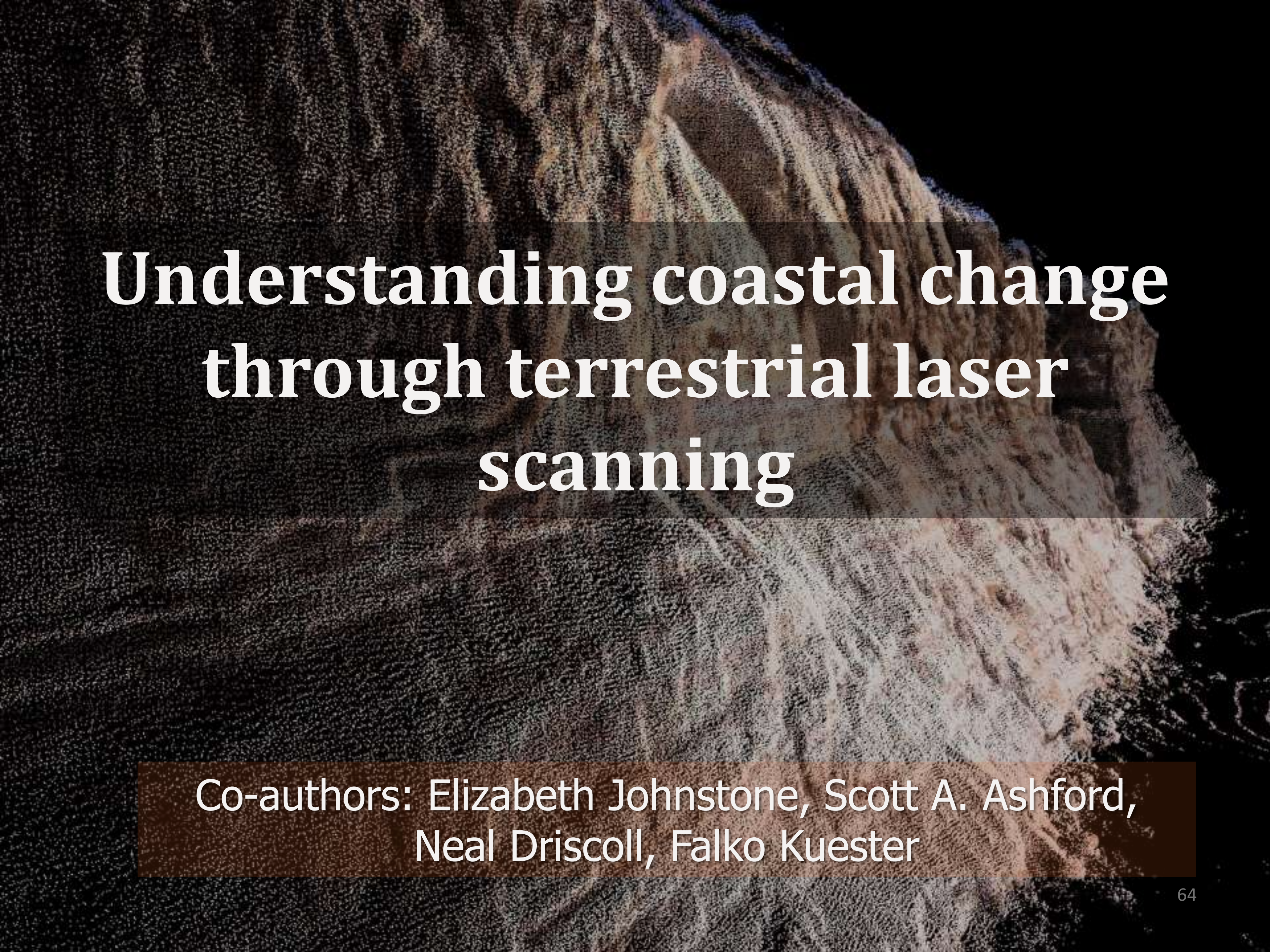
Risk along Highway

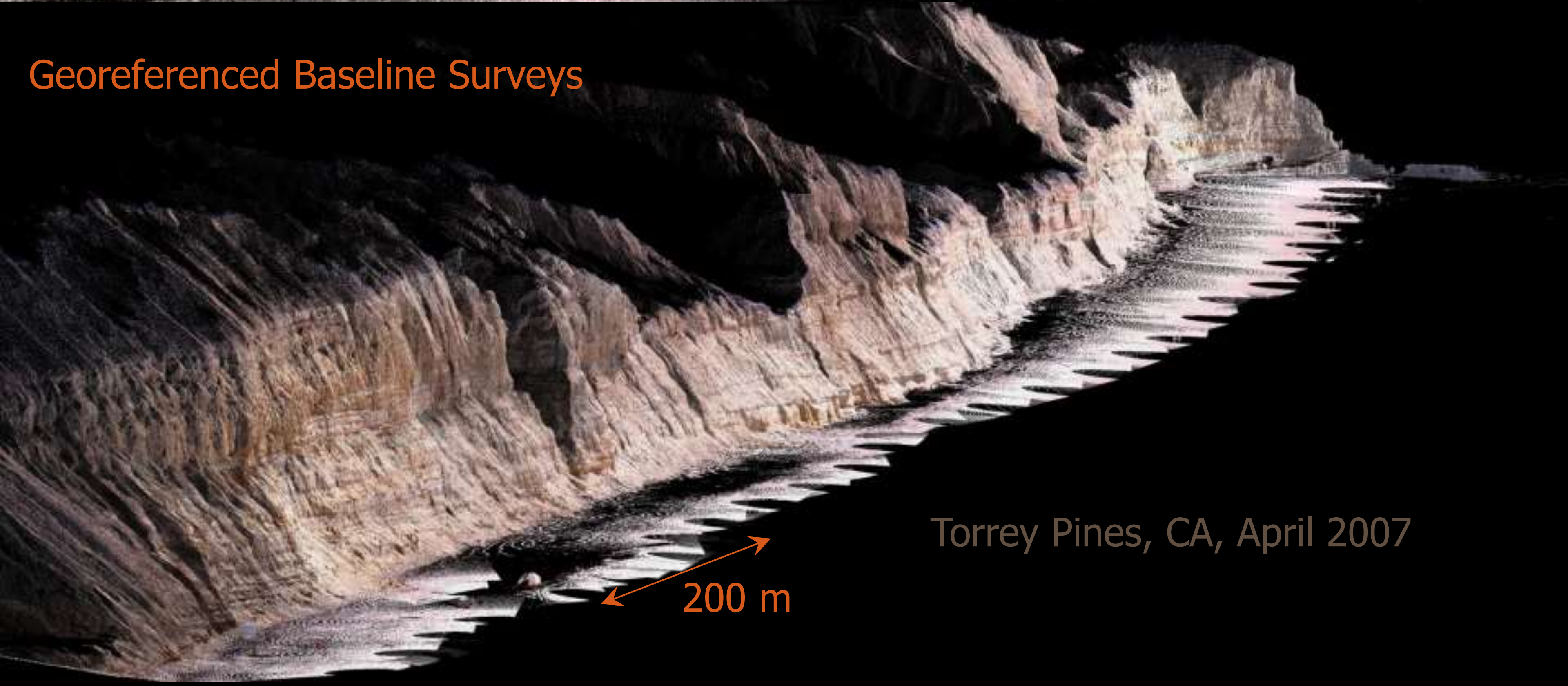
Oregon State University

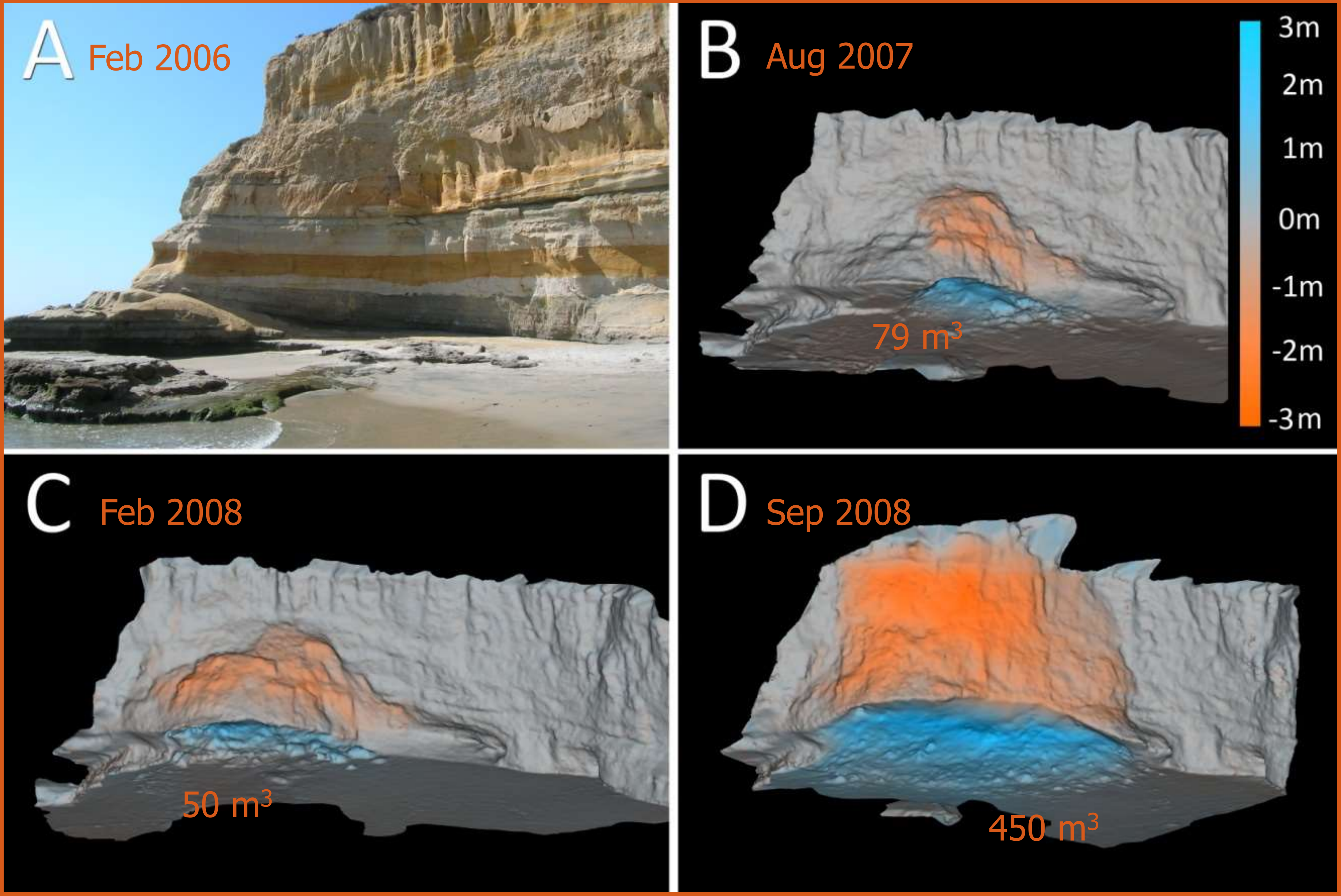


Understanding coastal change through terrestrial laser scanning

Co-authors: Elizabeth Johnstone, Scott A. Ashford, Neal Driscoll, Falko Kuester

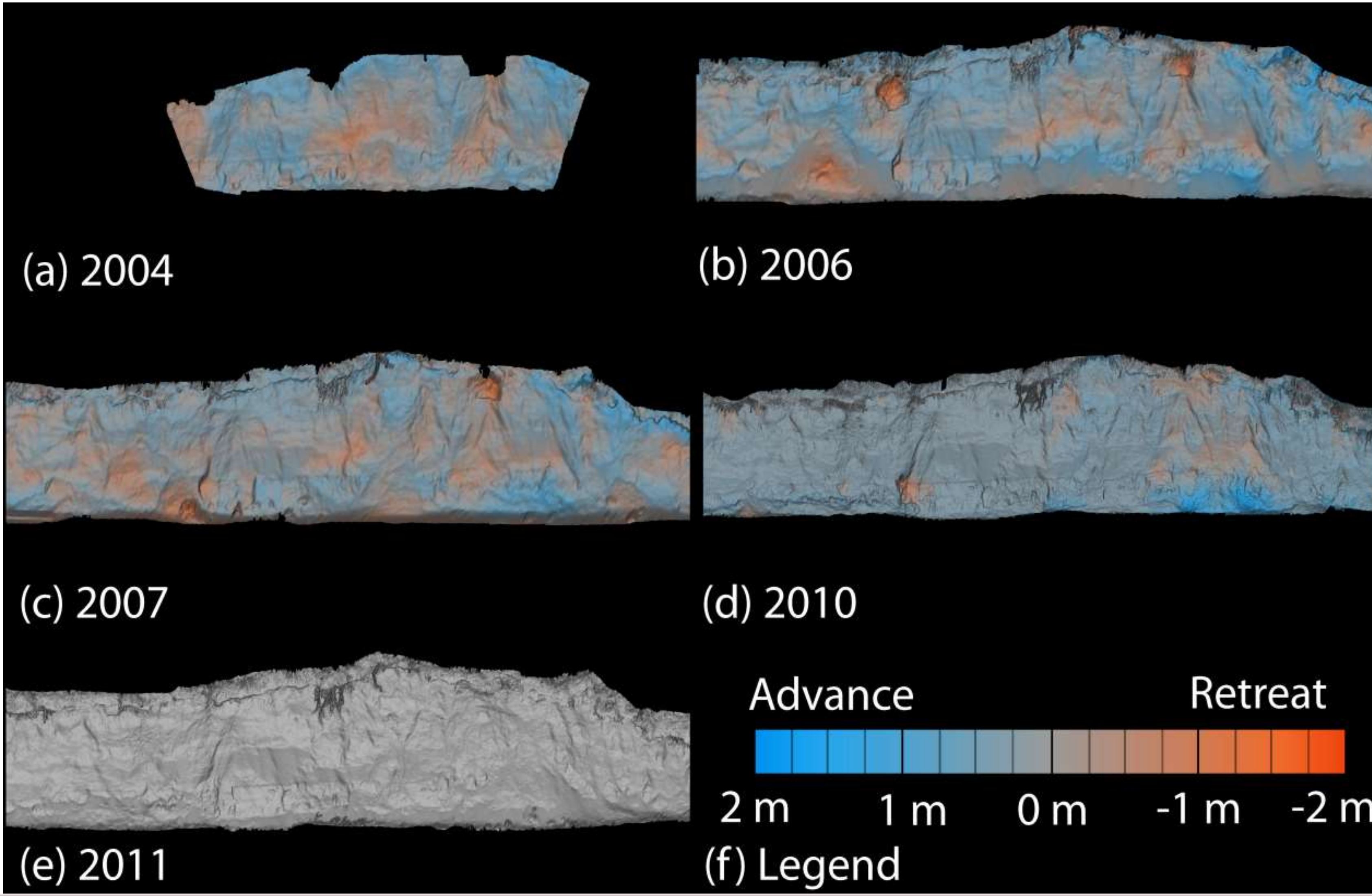
Georeferenced Baseline Surveys





*Change referenced to the November 2006 survey

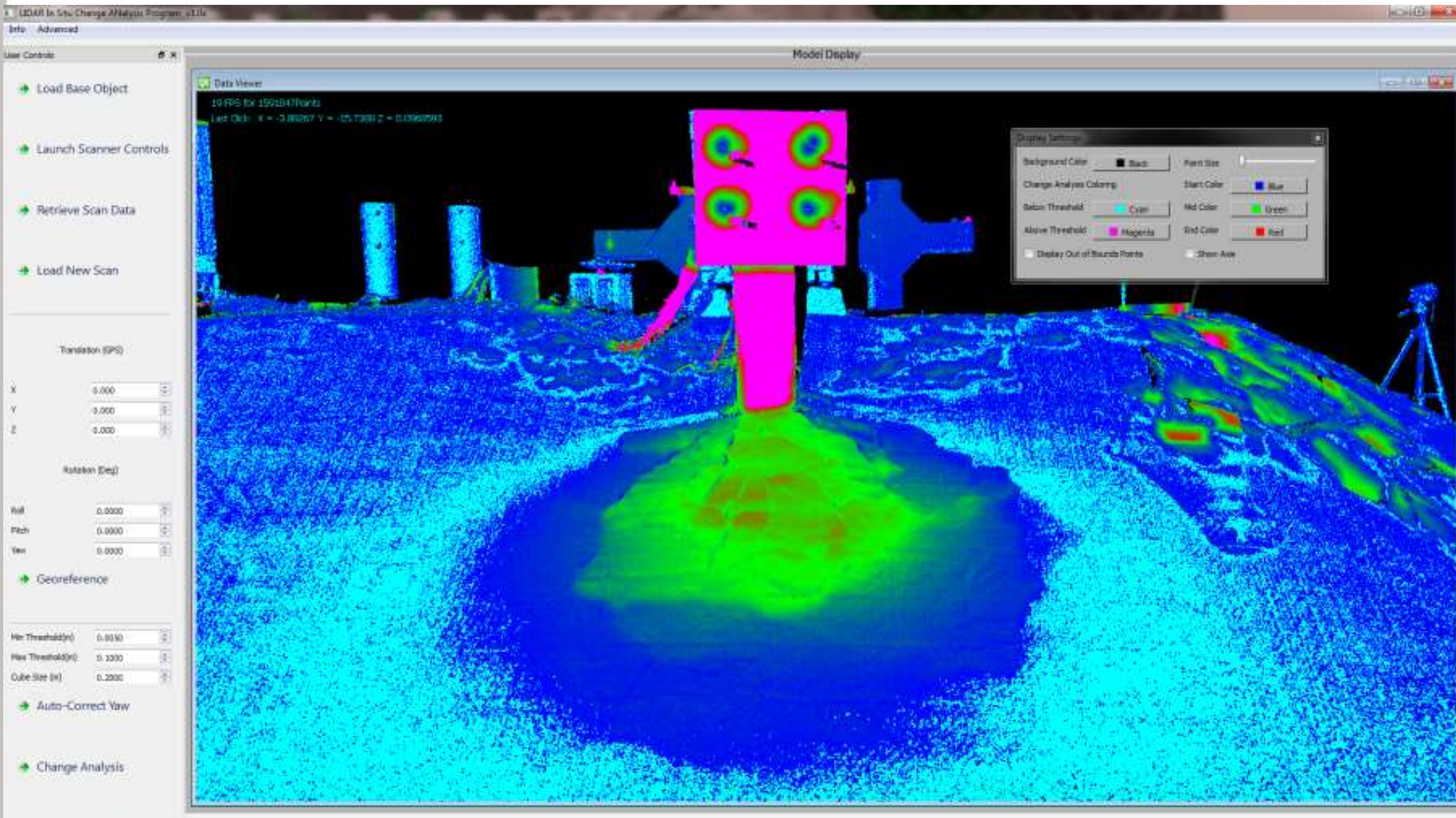
Johnson Creek Landslide, OR



In-Situ Change Detection with lidar

Oregon Department of Transportation

OTREC



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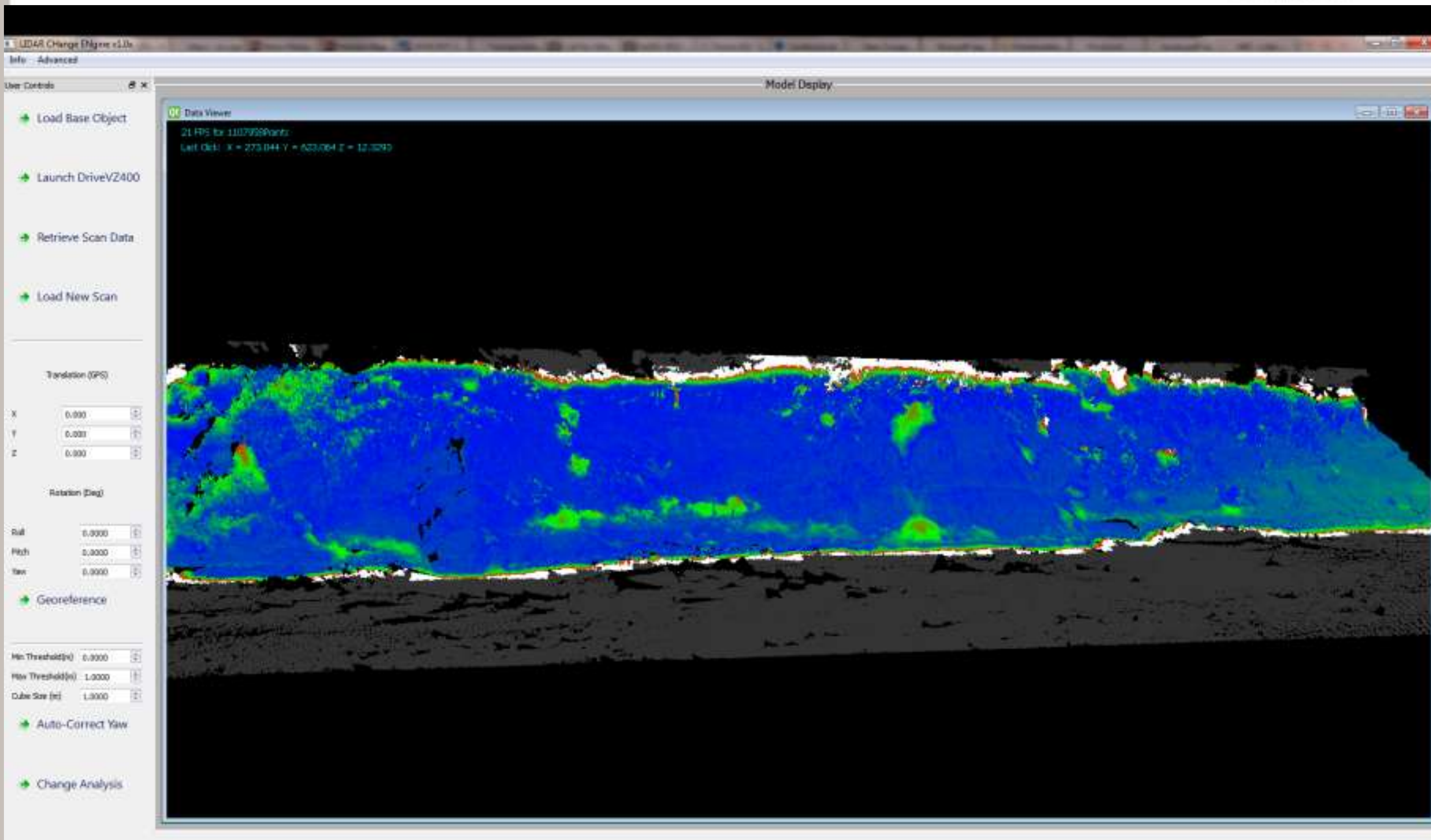
LISCAN (In-Situ Change)

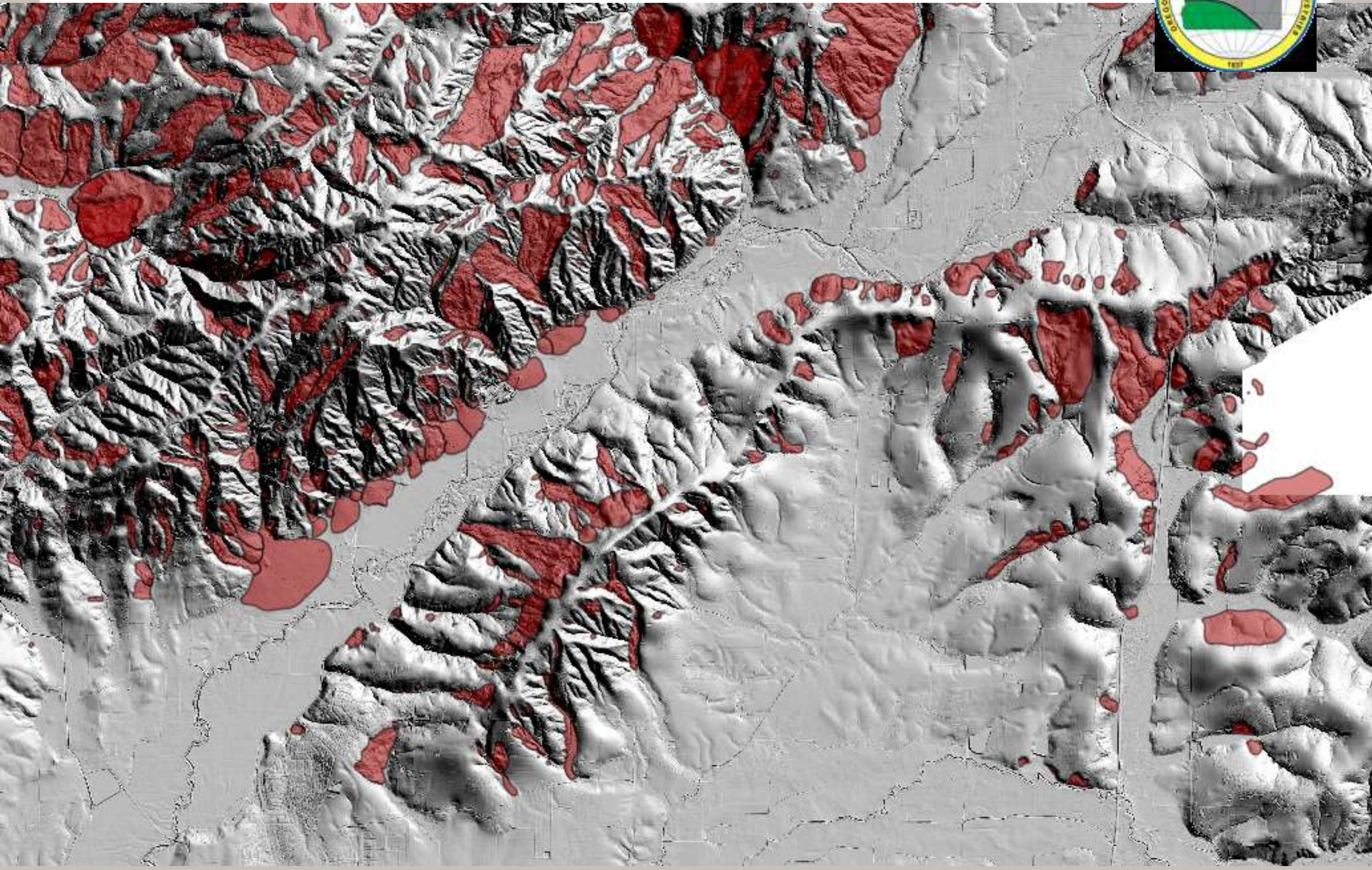
Oregon Department of Transportation

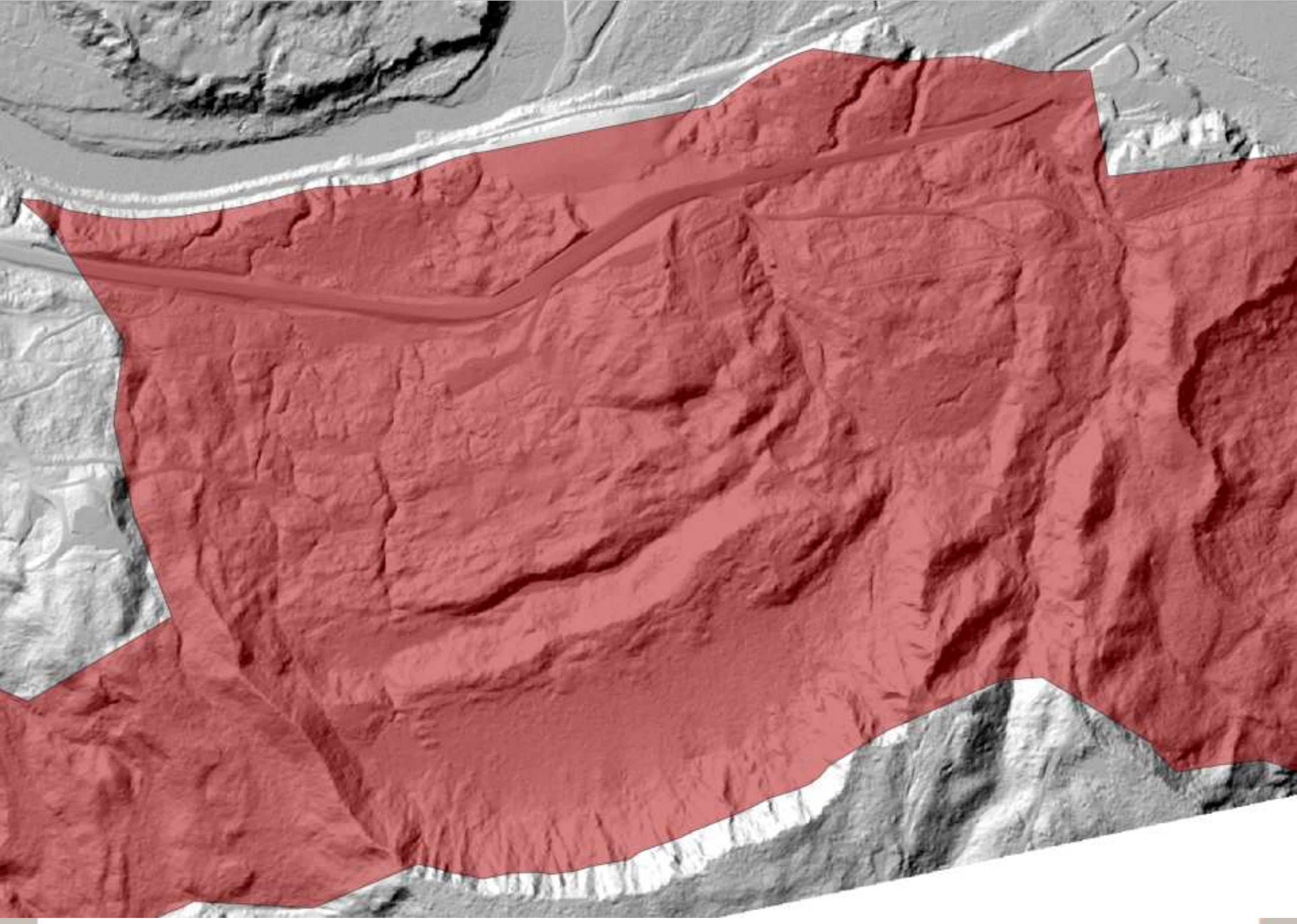
OTREC

OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM



Landslide Inventory- DOGAMI

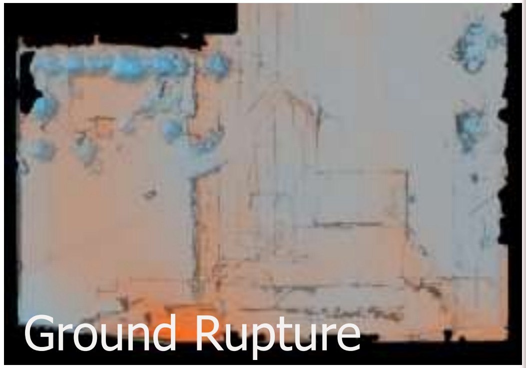


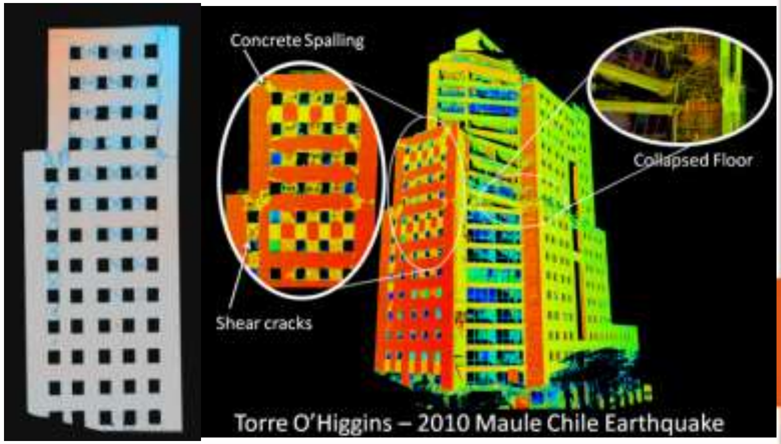


Contour Connection Method

Post EQ/tsunami analyses

- Liquefaction\Lateral spreading
- Landslide\slope stability
- Coastal erosion
- Settlement
- Scour (Depth distribution and volume)
- Bridge Collapse
- Structural Deformations/displacements
- Shear cracking
- Spalled concrete
- Concrete wall blow-out
- Building rotation
- Quay, retaining, sea wall failures
- Surface Rupture

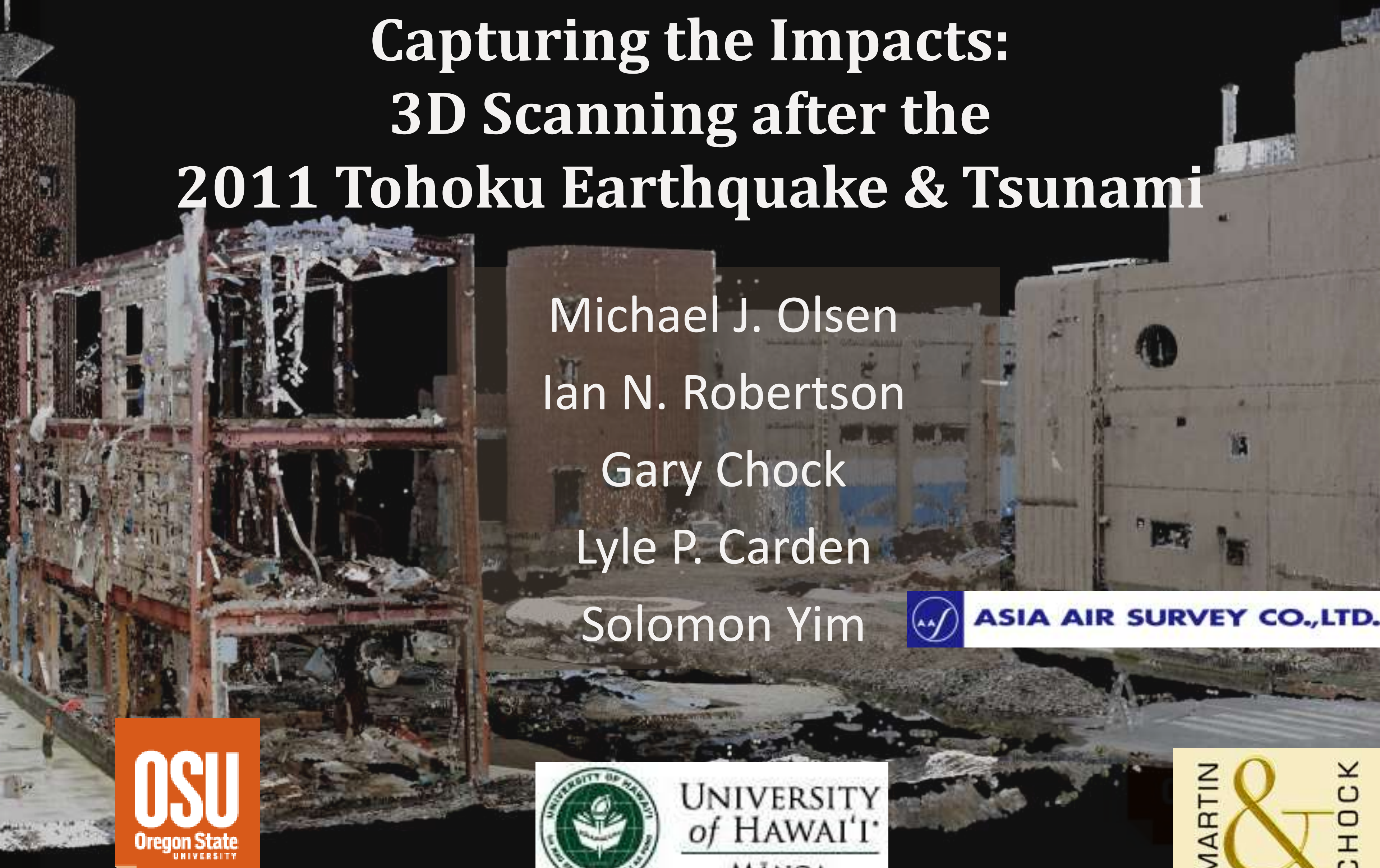




ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

National Science Foundation
WHERE DISCOVERIES BEGIN

Capturing the Impacts: 3D Scanning after the 2011 Tohoku Earthquake & Tsunami



Michael J. Olsen

Ian N. Robertson

Gary Chock

Lyle P. Carden

Solomon Yim

ASIA AIR SURVEY CO.,LTD.

OSU Oregon State UNIVERSITY

UNIVERSITY of HAWAIʻI MĀNOA

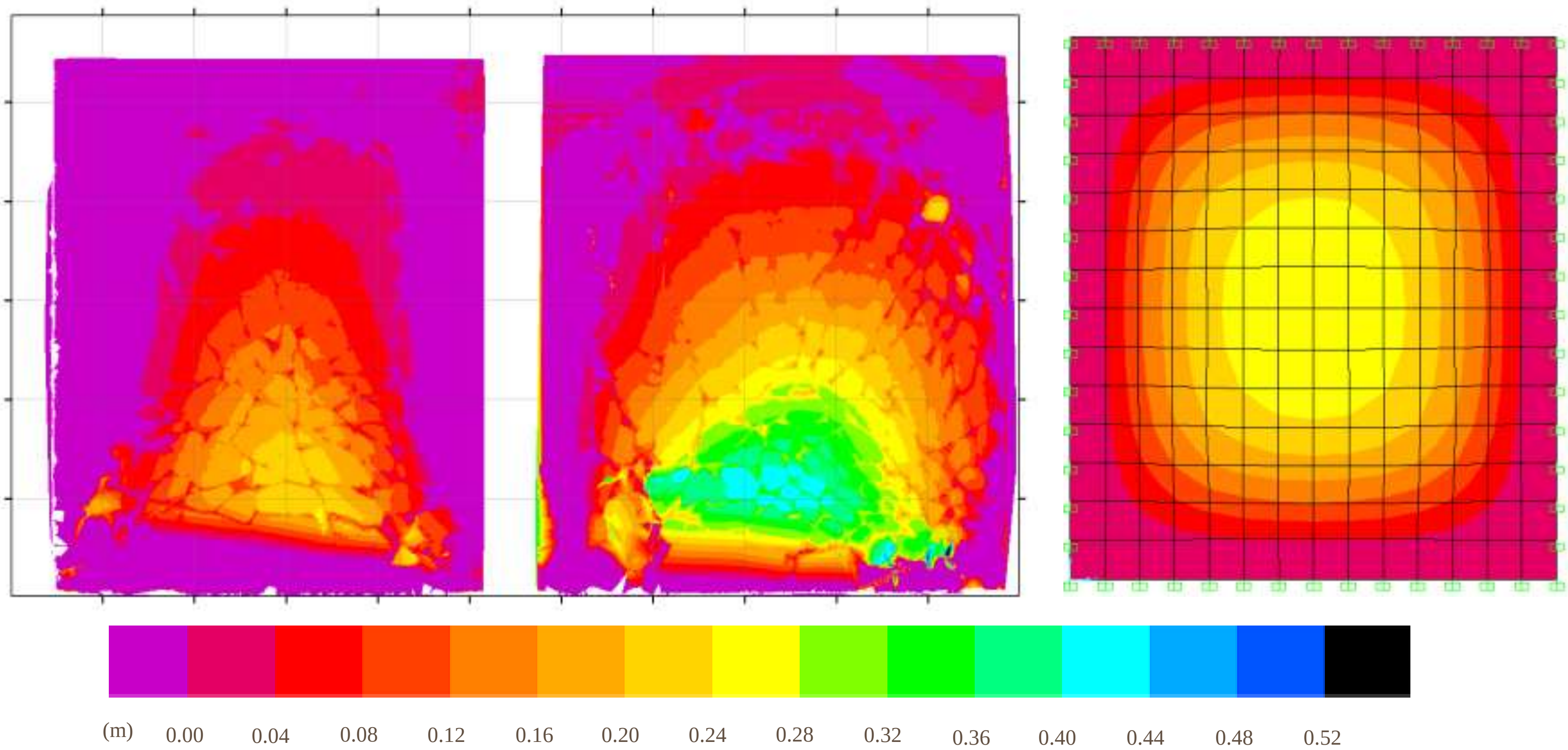
MARTIN & CHOCK

Onagawa Buildings

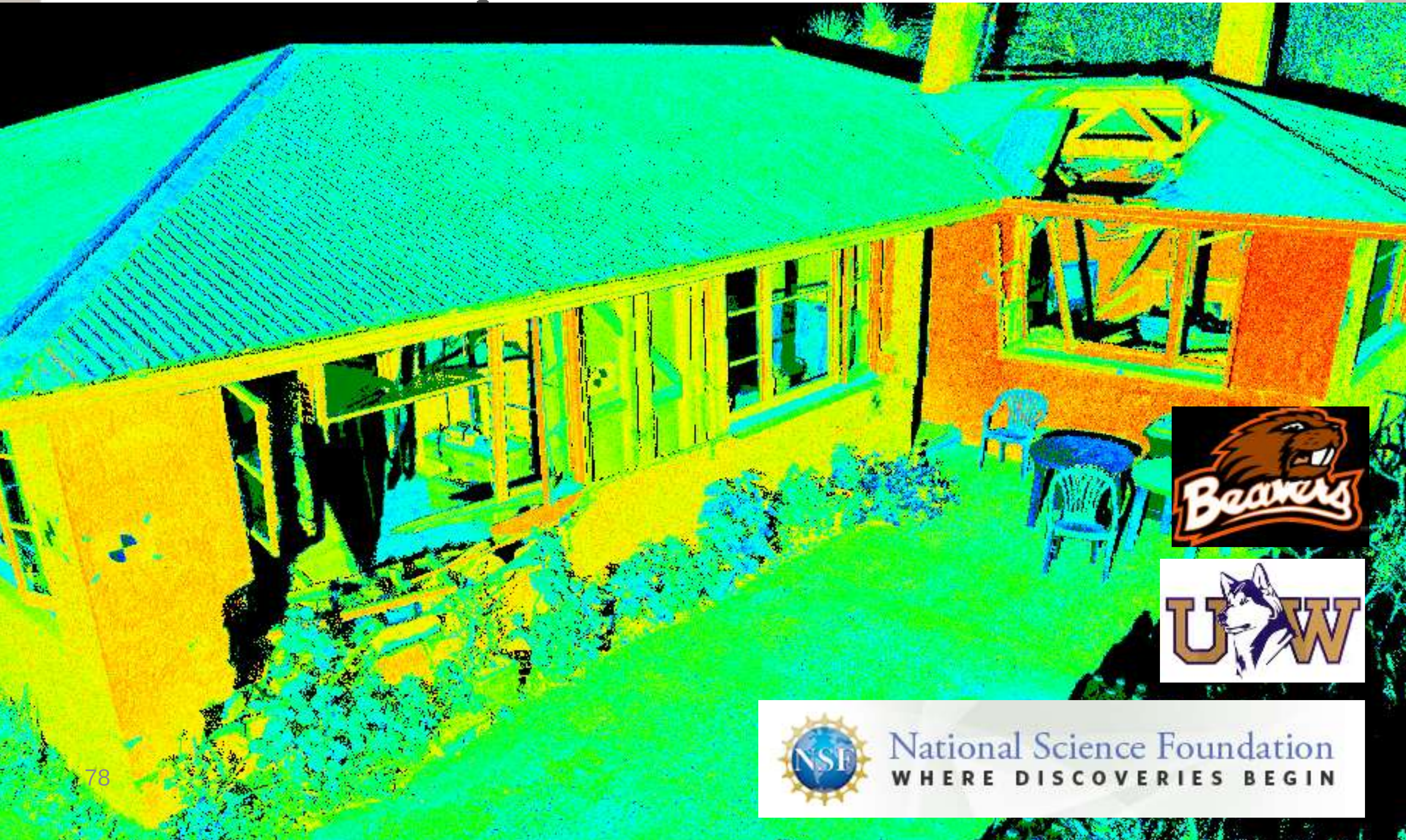
Floor	Lateral Displacement (m)
4 (roof)	0.505
3	0.444
2	0.224
1 ground)	0.000

Concrete Warehouse, Onagawa

Wall blow-outs: LIDAR versus FEM.



NSF- RAPID/Collaborative Research: Investigation of the Effects of Rockfall Impacts on Structures During the Christchurch Earthquake Series



Lessons learned from TLS in disaster environments

- TLS preserves the data virtually, so you can explore anytime and from any location without safety concerns -> Virtual Time Capsule

- TLS provides data to validate and calibrate numerical models

- For structural analysis, TLS provides more information than can be used in current models

- TLS records vital information regarding surrounding terrain and objects -> puts data in context

- TLS maps the location, distribution, and patterns of deformations compared to relatively few traditional measurements and observations

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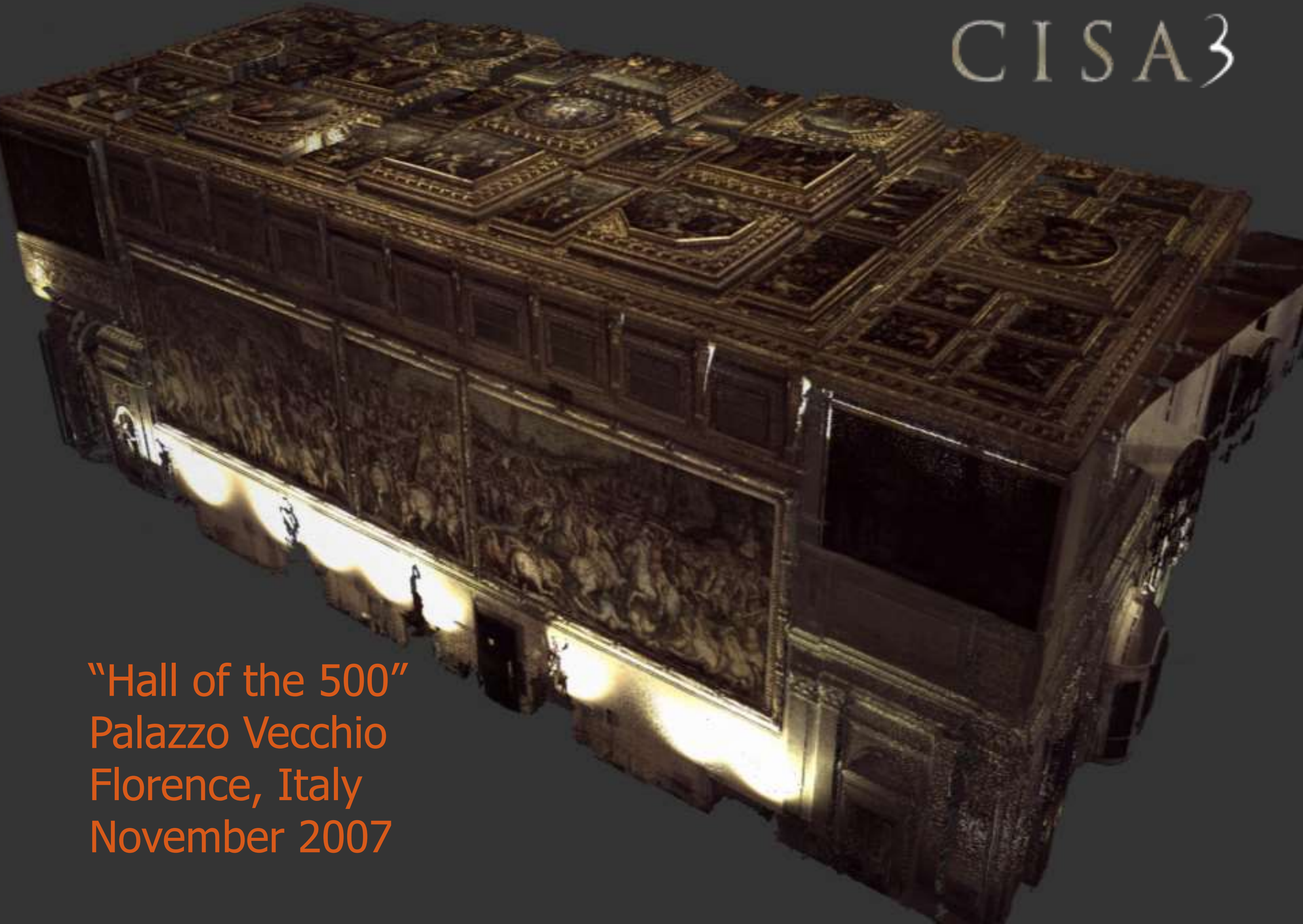
Balboa Park, San Diego, CA
March 26, 2009

CISA3

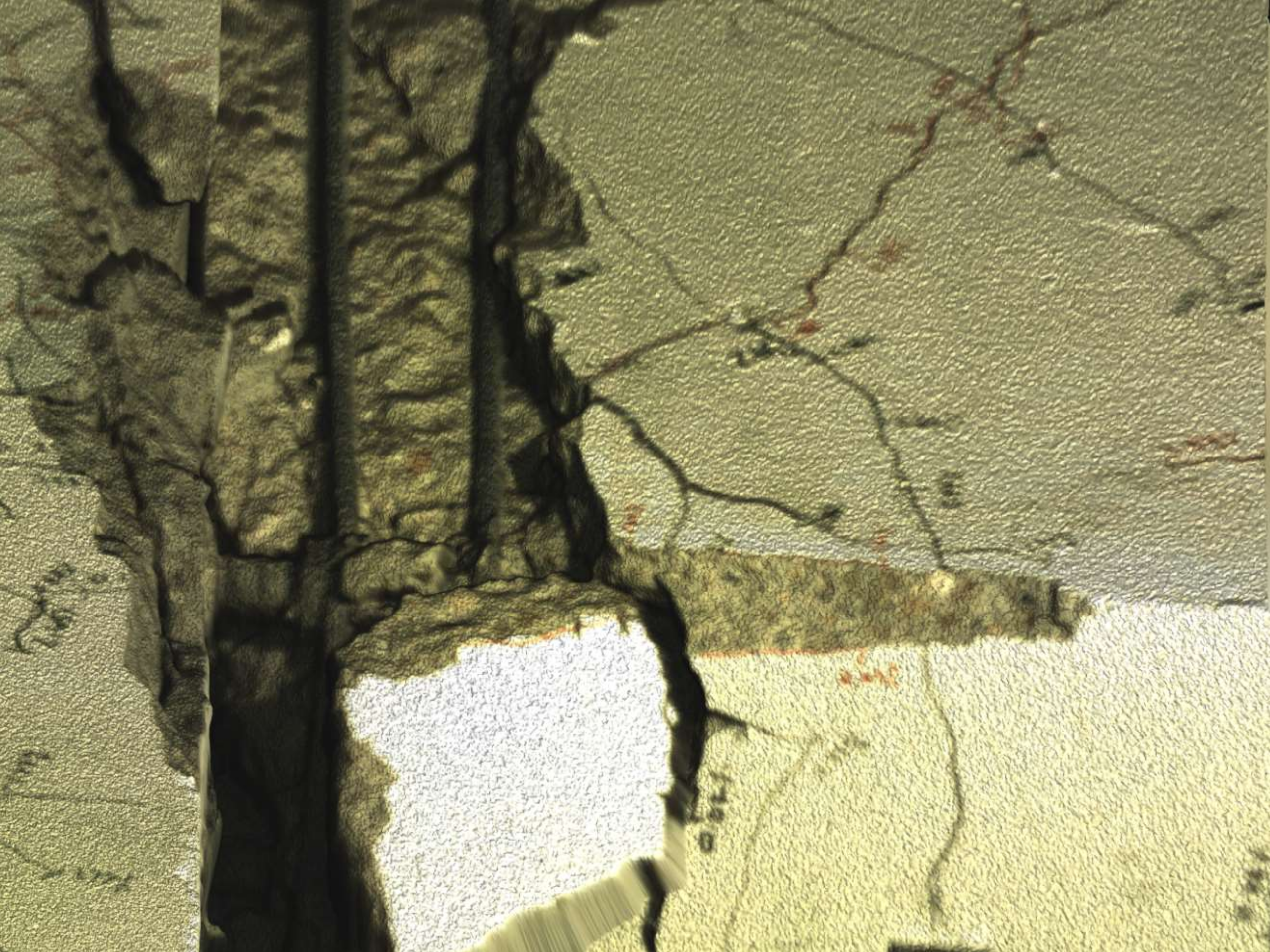


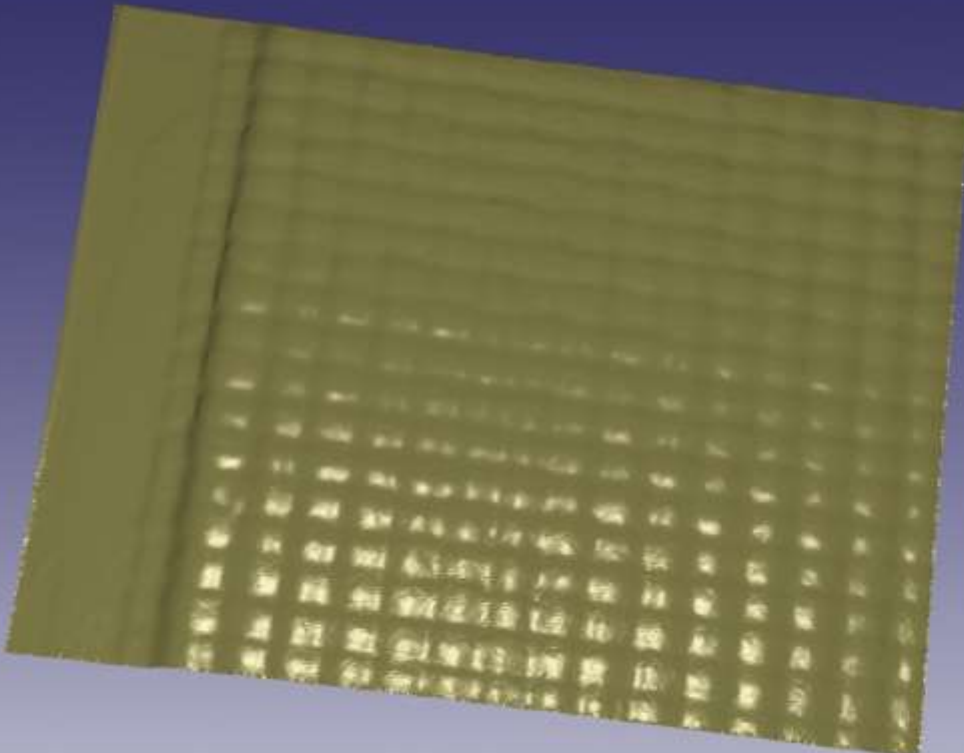
"Hall of the 500"
Palazzo Vecchio
Florence, Italy
November 2007

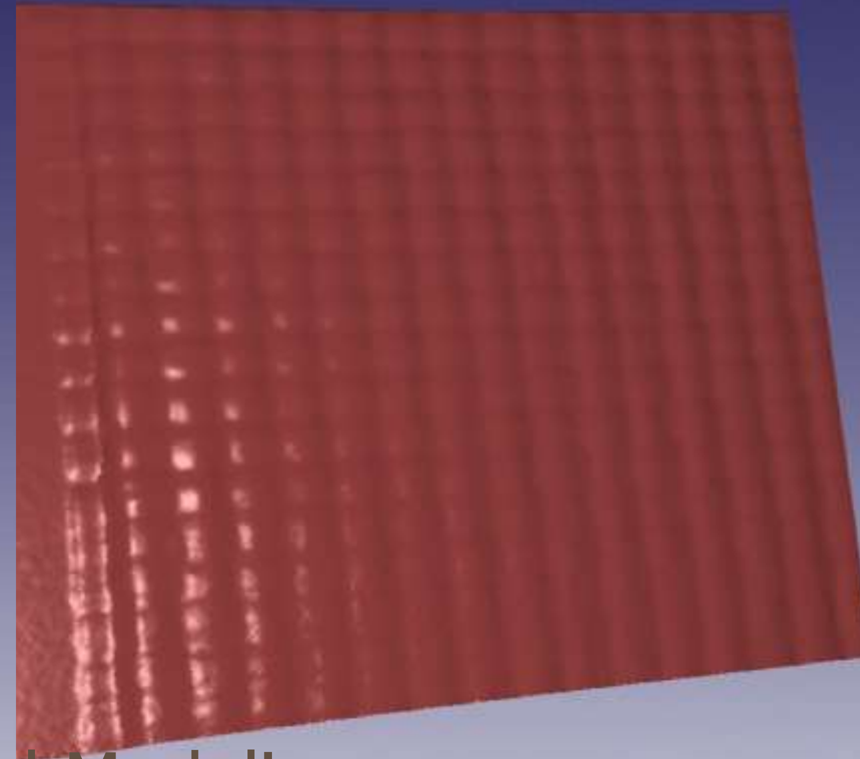
Photograph by David Yoder, National Geographic

CISA3

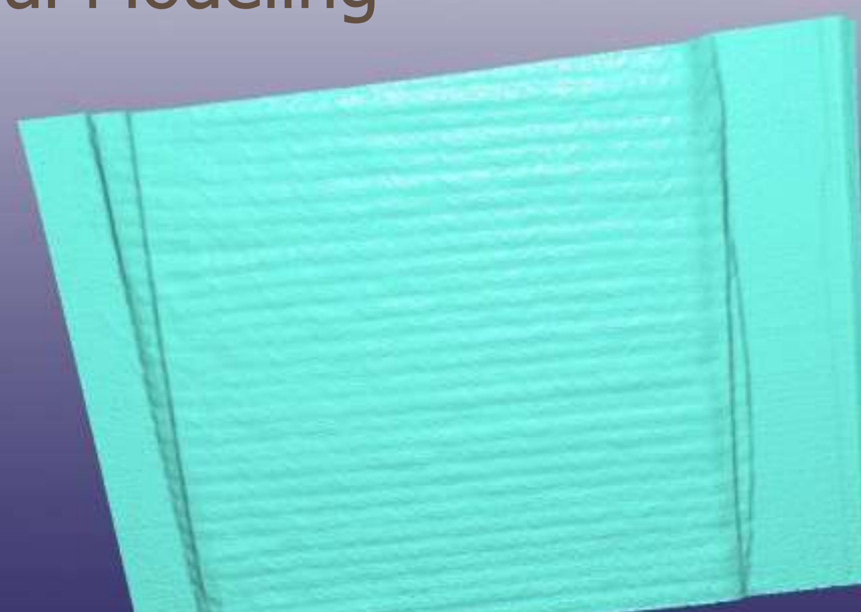
"Hall of the 500"   Palazzo Vecchio   Florence, Italy







Composite Material Modeling



Value of lidar data

- Fast, accurate, safe way to survey
- Allows us to rapidly record time-constrained data
- Can see processes at scales that they occur
- Provides for more accurate quantification of damage
- Useful for input to develop and verify scientific models
- Captures information that can be continually queried without being present on site (New observations that can be missed in the field)

The Future

- Hardware advancements
- Software advancements
- Full 3D planning, design and construction
- New, advanced 3D analysis techniques
- Structural monitoring and control
- Simultaneous Location and Mapping (SLAM)
- LIDAR data across the country
- (1-2m resolution vs 30 m)
- Handheld scanning/UAS

Acknowledgements

Irwin and Joan Jacobs

UCSD Chancellor's
Interdisciplinary Fund

Neal Driscoll's SIO Lab
Falko Kuester's GRAVITY lab

Need more info?

Mobile LIDAR

Guidelines for Use in Transportation Applications

LIDAR news

Questions for discussion?

You know what you guys should get? An ATV!!!!

Is that the Mars Rover?

When will the aliens arrive?

Do you have a concession stand in there? I'll take a taco!!

Hi Wall-E!

How much did that wagon cost?

Can you beam me up, Scotty?

I don't need a computa, I can use my hand as a laser, right?

Well, now I'll go to bed less stupid, right?

Wanna see my geiods?

Are you communicating with the mothership?

Are you sending a satellite around the moon?

That looks suspiciously like a robot….is it?

Is that a submarine?

I was wondering if you were going to travel around the world in that thing, are you?

Do you keep your dollies in there? Can I play with them?

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