

CERTAINTY 3D PRESENTS

LIDAR in Roadway Design & Construction

The application of LiDAR across operations

FDOT Design Expo 2013

Presented by: Ted Knaak, President Certainty 3D

Certainty 3D, Orlando, FL - (407) 248-0160 - info@certainty3d.com - www.certainty3d.com

About, . . .





The Certainty 3D Team



***Decades of LiDAR technology experience
ready to support your success!!***

Certainty 3D Products

*LiDAR/Point Cloud
Processing Software*



*Project Planning
Web Applications:
www.certainty3d.com*

FREE!!



FREE!!



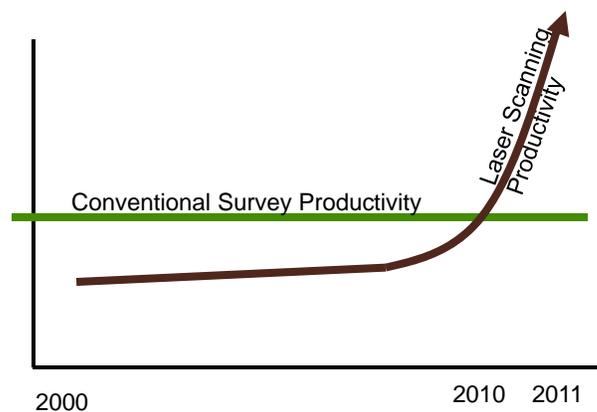
*Innovative Laser
Scanning Platform*



Why LiDAR?? . . .

- *Reduce Costs*
- *Accelerate Schedule*
- *Improve Quality*
- *Increase Safety*

LiDAR Field Productivity



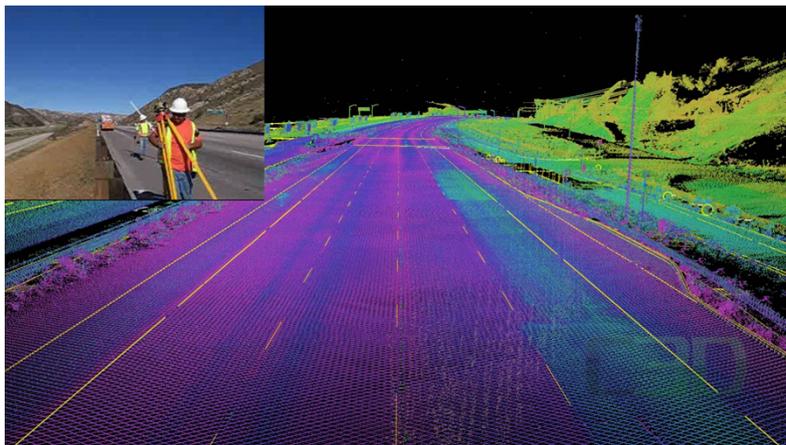
Productivity



Static Stop-n-Go



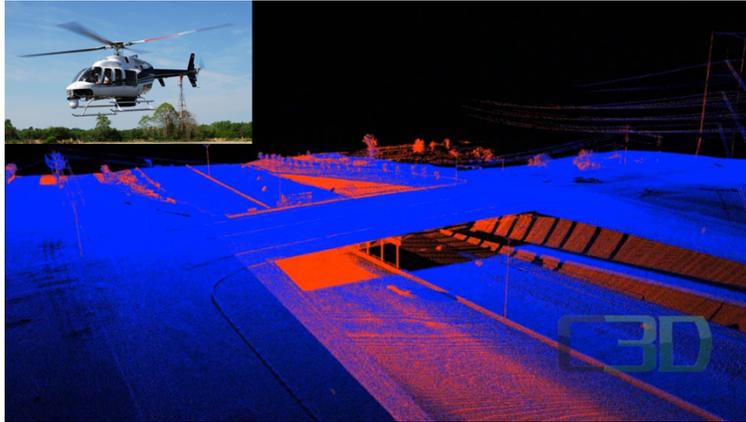
Safety



Mobile



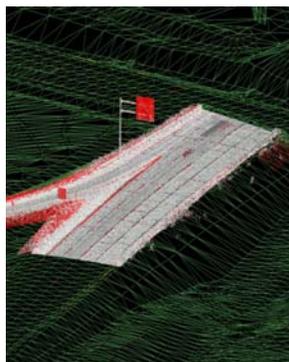
Accuracy



Airborne



Survey/Mapping Savings Using SSI's Moli™



I-96/US 23 Interchange in Brighton, MI

- MDOT's first Mobile LiDAR project
- Consisted
 - 1.) Mobile LiDAR
 - 2.) Photogrammetry
 - 3.) Conventional Survey
- Full topographic survey for use in design
- Approximately 8 miles
- Timeline from collection to deliverables of less than six (6) weeks

Information courtesy of:



Economic Performance: Brighton Interchange

Information courtesy of:  **SSI**
surveying solutions, inc.

	Conventional	MoLi™
Project Timeline	3 Months Minimum	6 Weeks
Safety for Field Crews	Exposure to high traffic volumes for 90 days	2 Days of exposure for control + 1 Day of MoLi™
Cost of Services	\$300k+	\$185k
Accuracy	0.03'	0.03'
Deliverables	Microstation DGN 50 ft cross-sections	Microstation DGN 10 ft cross-sections

Customer: Michigan Department of Transportation

Savings \$115K (40%) !!!

Economic Performance: Bridge Clearance

Information courtesy of:  **SSI**
surveying solutions, inc.

	Conventional	MoLi™
Project Timeline	1-2 Months	1 Day
Safety for Field Crews	Exposure to high traffic volumes for 60 days	1 Day of MoLi™
Cost of Services	\$78k+	\$17K
Accuracy	0.03'	0.03'
Deliverables	32 Bridge Clearances for Detroit Metro Area	32 Bridge Clearances

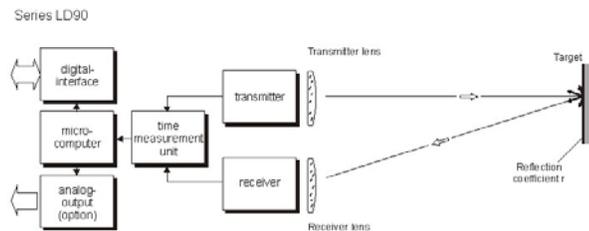
Customer: Parsons Contact: Pat Gibbons, PE

Savings \$61K (78%) !!!

An Overview of LiDAR Technology

- *Basic Function*
- *Data uncertainty*
- *Lineage to survey control*

Understanding LiDAR Technology

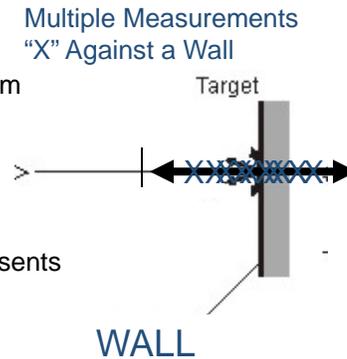


- Pulse-time-of-flight type systems (PTF) typically used in Civil-Transportation applications
- A short laser pulse is emitted and reflected from a surface back to receiver
- Knowing the speed of light, the distance of the LiDAR to the surface is measured



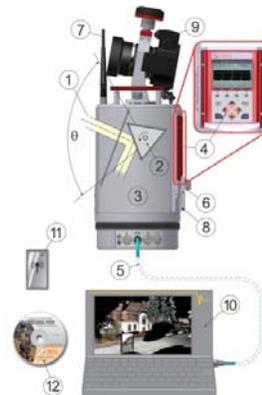
Basic LiDAR Measurement Uncertainty

- Distance of averaged measurement from true wall position is “Systematic”
 - Data “Shift”
 - Not easily removed
- Distribution of measurements “X” represents the “Random” uncertainty
 - Data “Fuzziness”
 - Removed by filtering



LiDAR Scanning System

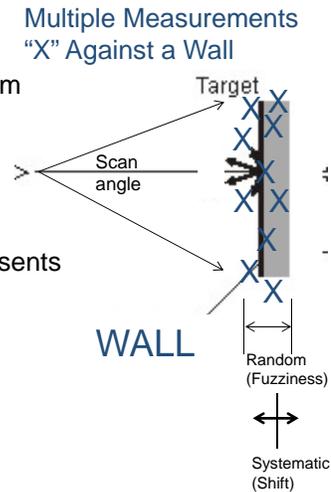
- LiDAR Scanning Systems employ rotating mirrors to direct beam over fixed pattern
- Cameras provide calibrated images mapped to point cloud data
- Systematic and Random uncertainty inherent within each measurement
- LiDAR Scanning System and associated processes introduce additional uncertainty



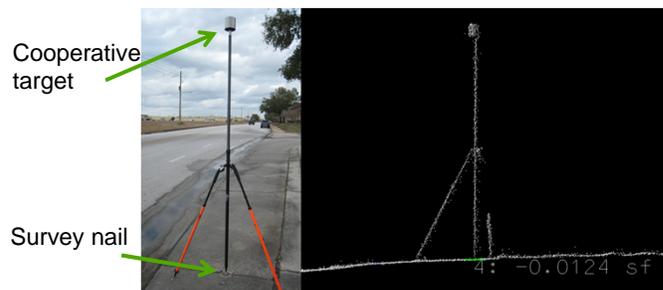


“Scanned” Measurement Uncertainty

- Distance of averaged measurement from true wall position is “Systematic”
 - Data “Shift”
 - Not easily removed
- Distribution of measurements “X” represents the “Random” uncertainty
 - Data “Fuzziness”
 - Removed by filtering



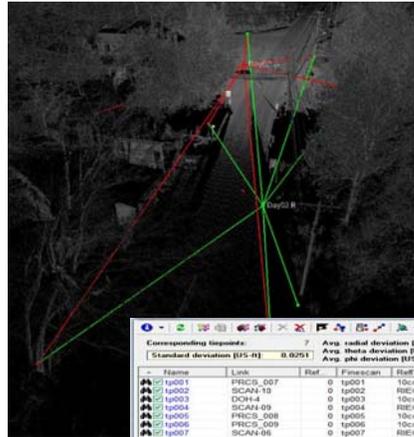
Target Measurement Uncertainty



Identify and locate “cooperative” reference target locations



Static System Uncertainties



Corresponding legends:

Standard deviation [R/S #] 0.0251

Avg radial deviation [R/S #] 7

Avg theta deviation [R/S #] 7

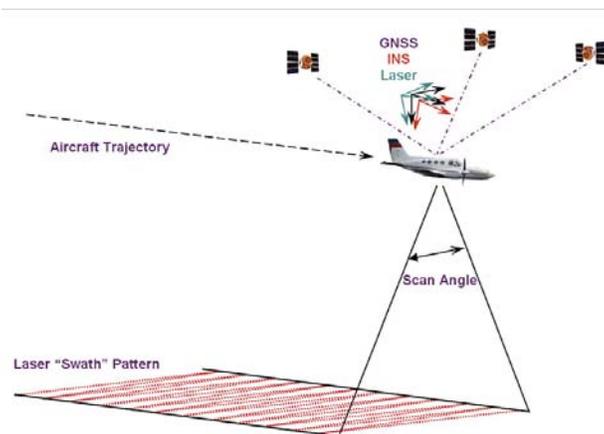
Avg phi deviation [R/S #] 7

Name	Link	Ref	Filename	RefType	X	Y	Z	Range	Δ X	Δ Y	Δ Z
tp001	PRCS_007	0	tp001	10cm CVL	17.229	-88.900	7.910	71.468	-0.001	0.001	0.007
tp002	SCAN1-13	0	tp002	REGI F...	-5.589	-87.689	-3.716	87.937	0.008	0.006	-0.052
tp003	DOH4	0	tp003	10cm CVL	-146.9	-77.903	-2.031	166.351	0.039	-0.029	0.038
tp004	SCAN4-09	0	tp004	REGI F...	-66.889	85.111	-6.549	107.854	0.002	0.023	-0.022
tp005	PRCS_008	0	tp005	10cm CVL	17.564	-35.062	-3.505	38.372	-0.011	0.006	0.004
tp006	PRCS_009	0	tp006	10cm CVL	147.705	-135.0	-12.162	209.630	0.004	0.000	0.001
tp007	SCAN1-06	0	tp007	REGI F...	114.832	-174.8...	-15.672	209.751	-0.015	-0.022	0.028

Survey control uncertainty



Mobile System Uncertainties



Survey Control "and" Trajectory Uncertainty



Mobile System Uncertainties

Survey Control “and” Trajectory Uncertainty

LiDAR Across Operations

LiDAR technology will provide significant ROI in any operation



Survey/Mapping



Design/Engineering



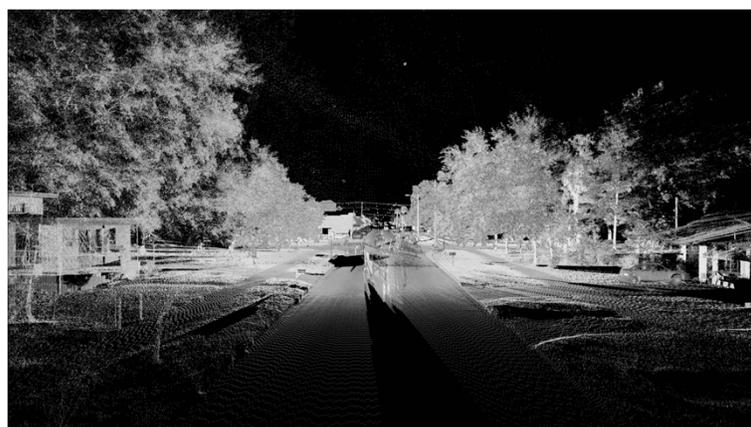
Construction

Focus, train, achieve ROI in one area at a time



Don't let data uncertainties bite you!!

Uncertainties



Extract quality metrics—do they meet requirements?

C3D's "MAeX" strategy for success

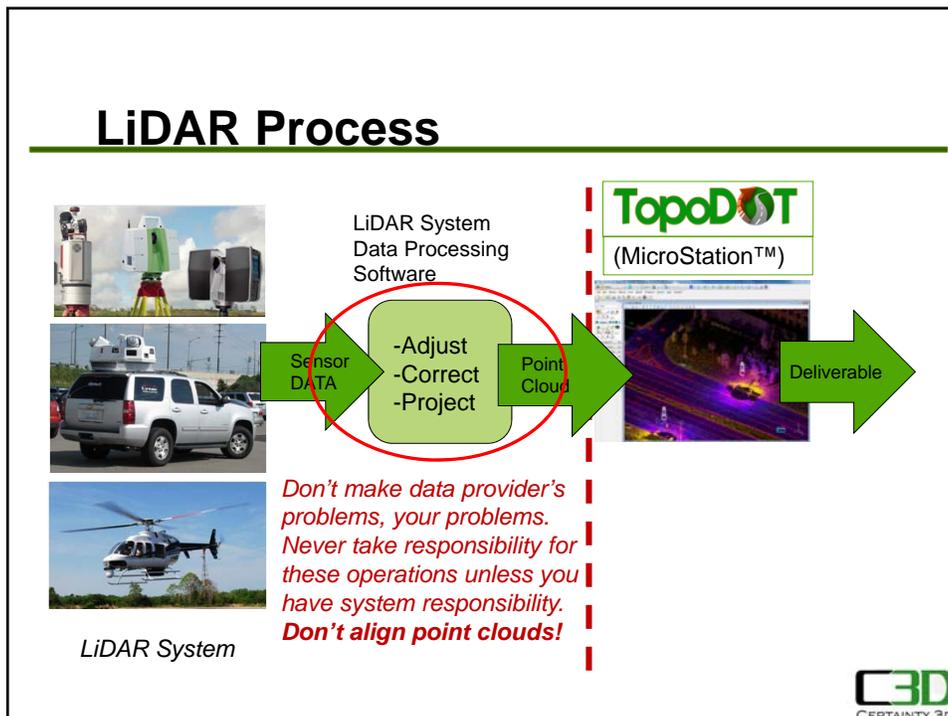
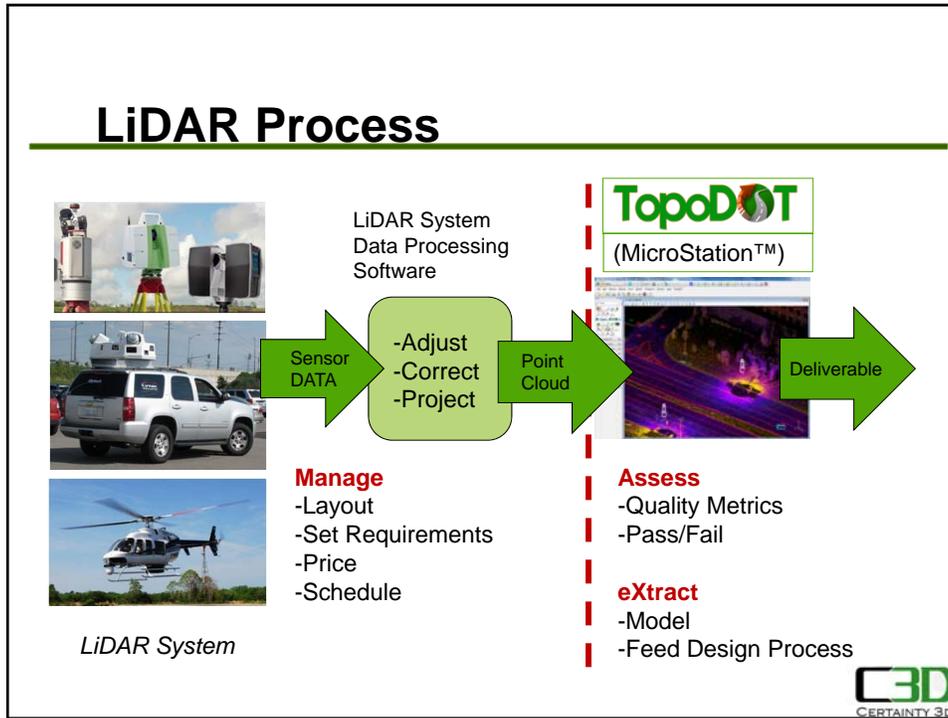
MANAGE

ASSESS

eXTRACT

Survey/Mapping Operations, . . .

- *Save money*
- *Improve Safety*
- *Accelerate schedules*
- *Enhance DTM quality*





MANAGE

MANAGE -Requirements



Layout, Schedule, Cost Static LiDAR Projects

MANAGE -Requirements



Layout, Schedule, Cost Mobile LiDAR Projects

MANAGE -Requirements

Set Requirements:

- Random Noise
- Point Cloud Density
- Data Coverage
- Relative Data Alignment
- Lineage to Control
- Image Alignment

MANAGE -Requirements

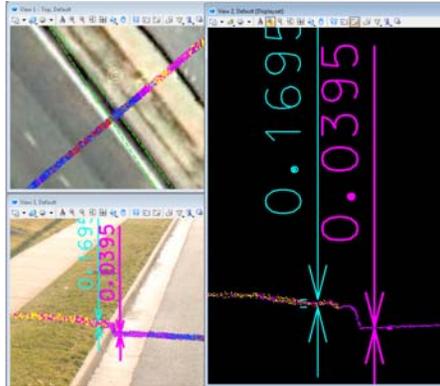
Random Noise (“Fuzziness”)

The Question. . .

What noise level contributes to extraction errors exceeding project requirements?

Rule of thumb:

You'll want the random noise to be about $\frac{1}{4}$ of feature dimension you are attempting to identify.



MANAGE -Requirements

Random Noise (“Fuzziness”)

Answer. . .

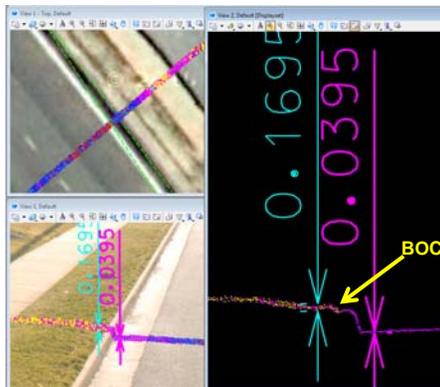
For civil uses, many modern LiDAR noise levels are low, so keep it simple

Set Requirements—

Noise levels should not exceed about 0.04ft peak-to-peak.

Metric—

Identify flat surface(s) in scene. Measure peak-to-peak data to confirm.



MANAGE -Requirements

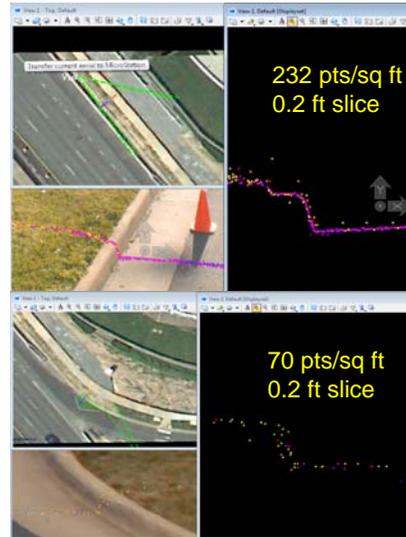
Density

Question. . .

What data density is required to identify and extract features to project requirements?

Rule of thumb—

Depends on feature area (in scanner view) and geometric structural cues (GSC). Note: Calibrated images are synergistic. Much depends on extraction techniques.



MANAGE -Requirements

Density

Answer. . .

Use successful projects to extract balance between practical application of technology and maximum field productivity versus cost.

Set Requirements (civil)—

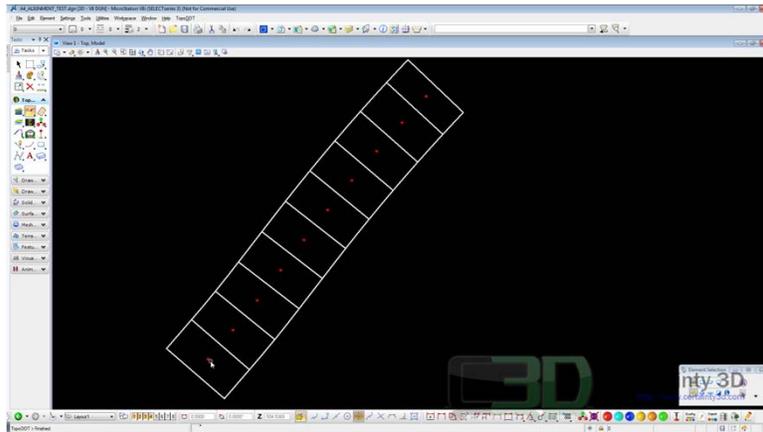
Complex analyses aside. . .
 Airborne - >5 pts/sq ft
 Mobile - >50 pts/sq ft
 Static - > 70 pts/sq ft

Metric—

Sample data in areas along corridor to extract point density.



TopoDOT MANAGE

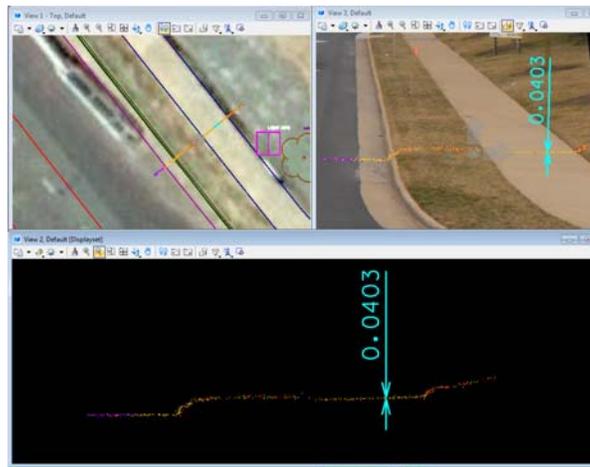


Automatically Parse Data Files

TopoDOT

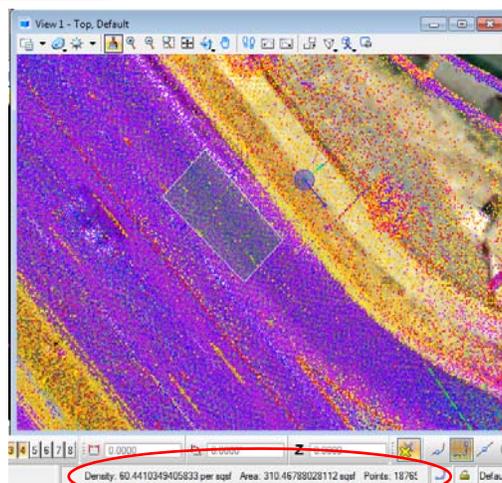
ASSESS

TopoDOT ASSESS



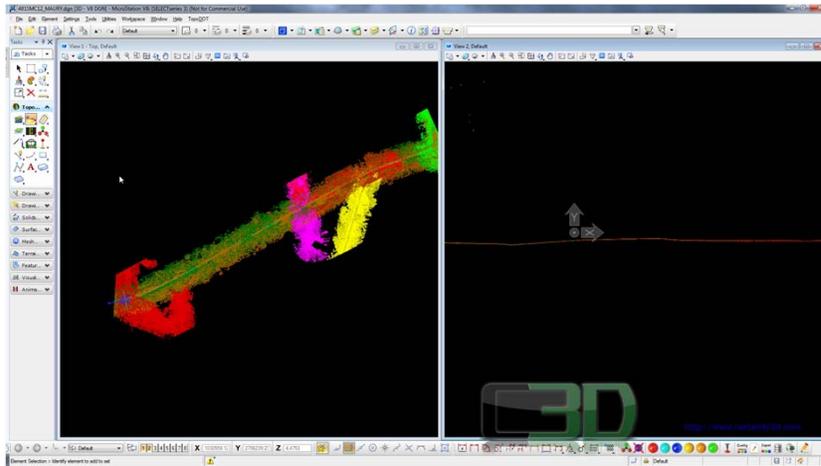
Data Characteristics: Random noise (“fuzz”)

TopoDOT ASSESS



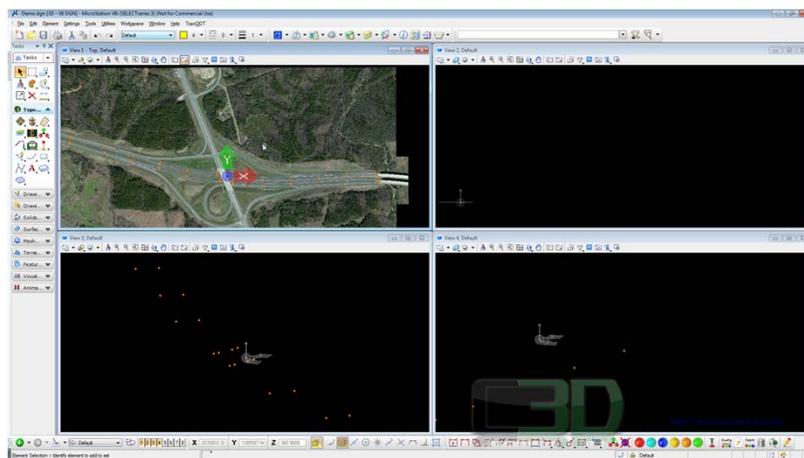
Data Characteristics: Point Cloud Density

TopoDOT ASSESS



Relative Data Alignment

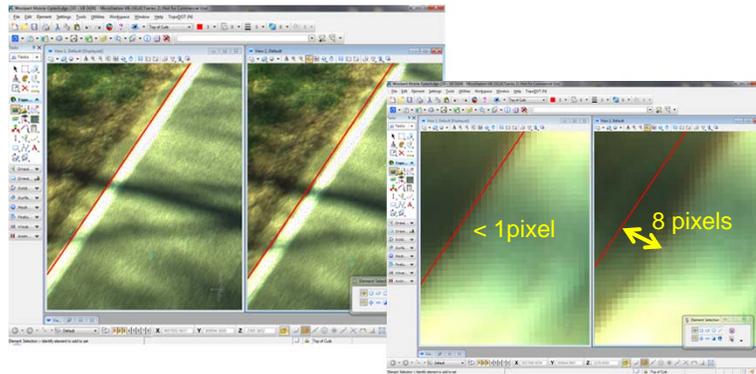
TopoDOT ASSESS



Data Alignment to Survey Control



Calibrated Image Uncertainty



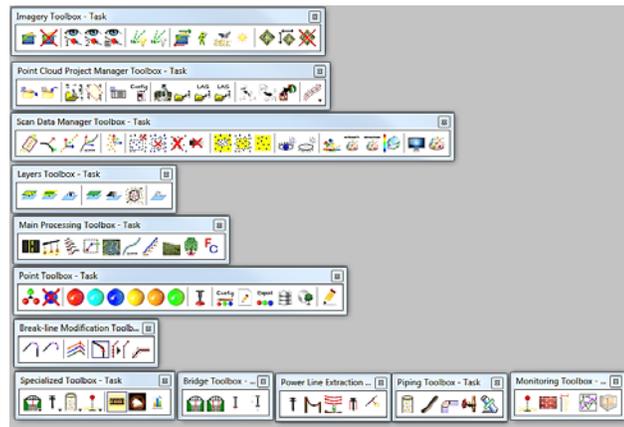
Measured in “pixel distance from feature extracted in point cloud”



eXTRACT

TopoDOT

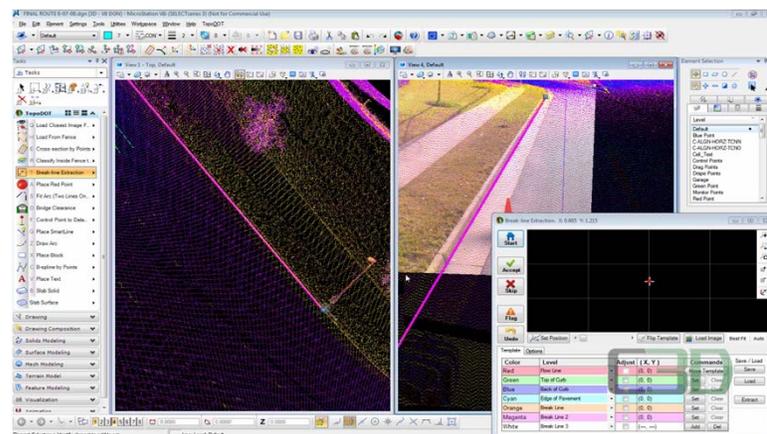
Point Cloud Processing Software



Comprehensive Tool Suite

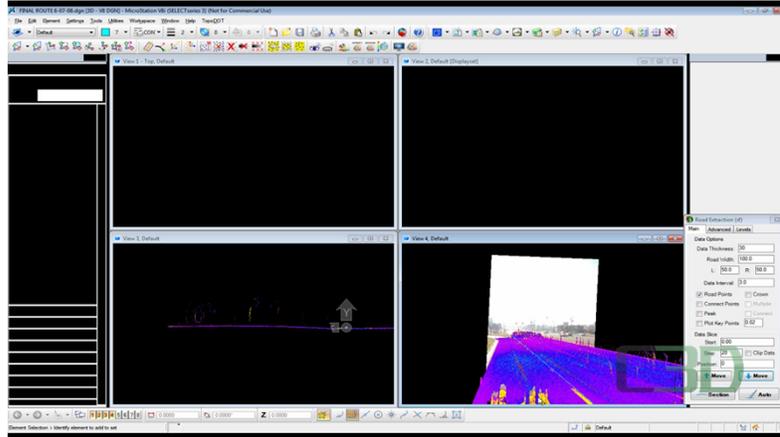


TopoDOT eXTRACT



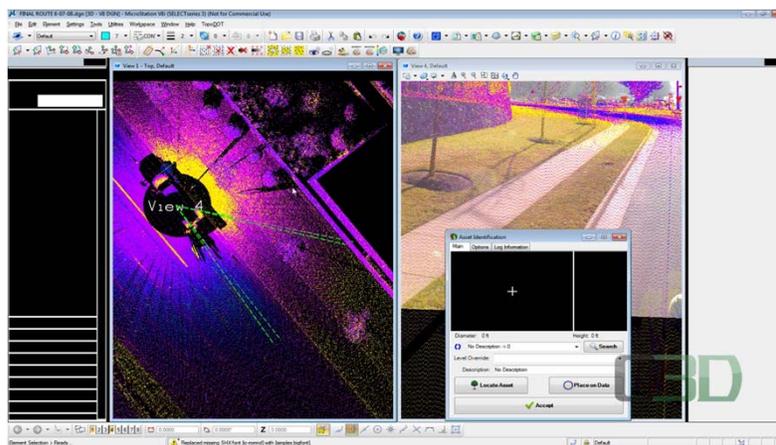
Break lines

TopoDOT eXTRACT



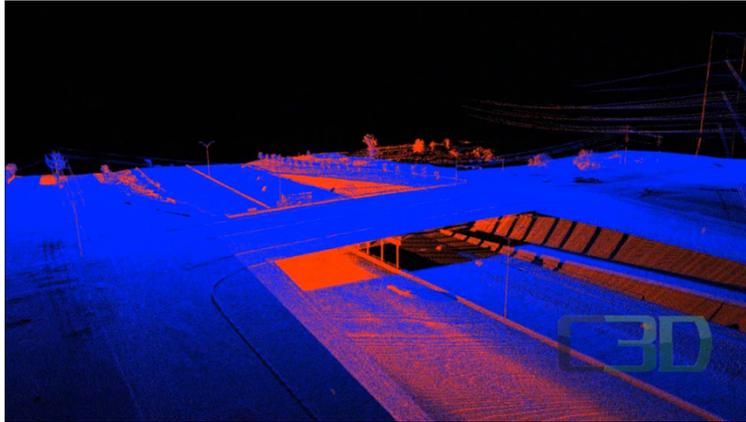
Road Surface No Need to Clean or Classify Data!!!

TopoDOT eXTRACT



Asset Identification - Cell Placement

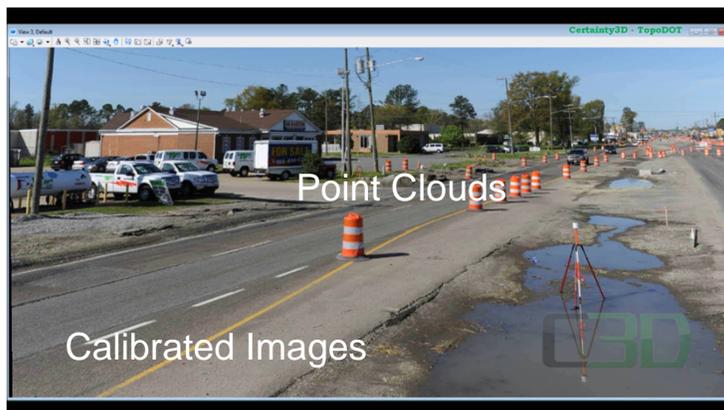
TopoDOT eXTRACT



Feed your DTM engine!!!



TopoDOT eXTRACT



Unrivaled Processing Synergy!!!

Design and Engineering Processes

- *Improve 3D Models*
- *Feed Design Solution*
- *Accelerate Schedules*



Feeding the Design/Engineering Process

Case Study: Route 60 Richmond, VA

How LiDAR Saved a \$30 million Project



Project Participants



Owner



Design Engineer



QA-QC

**American
Infrastructure
Technologies, Inc.**

Contractor



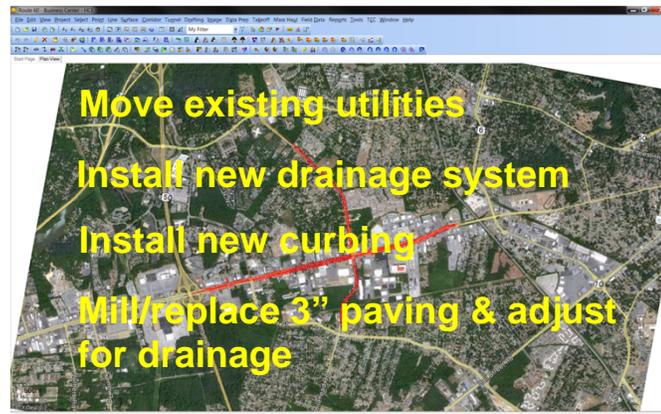
FLORA SURVEYING ASSOCIATES, PC
AND DATA PRO LTD.

Constructability Analysis



The Route 60 Project

Two Mile Reconstruction of 4 Lane Road





Design Not Working

Four Months into the Project . . .



Identify the Problem

Flora Surveying Reacted Quickly with a *Rolling Survey*. . .

- Drive the main line paving areas with dual GPS/RTK system on survey truck
- Identify and isolate the problem areas

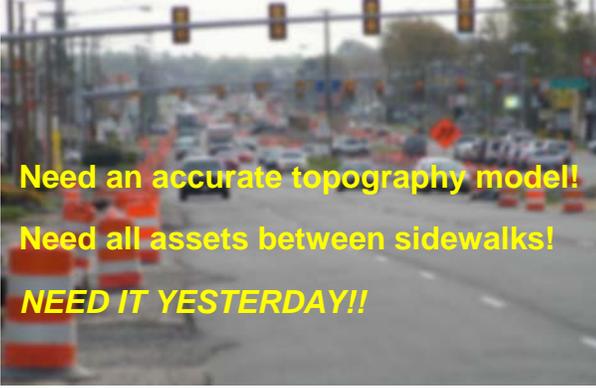




2012 Existing Conditions Survey

Flora Surveying to Certainty 3D . . .

“Hello Orlando, we have a problem!!”



Need an accurate topography model!
Need all assets between sidewalks!
NEED IT YESTERDAY!!



Introducing the Go-To Team

 <p>FLORA SURVEYING ASSOCIATES, PC AND DATA PRO LTD. Glenns, VA (804) 694-4578 / www.florasurvey.com Bruce Flora</p>	Construction Analysis / New Control Survey
 <p>Orlando, FL (407) 351-6730 / www.leadedges.com Rich Jackson</p>	LiDAR Scanning Services
 <p>Orlando, FL (407) 248-0160 / www.certainty3d.com Ted Knaak</p>	Data Processing / Project Coordination



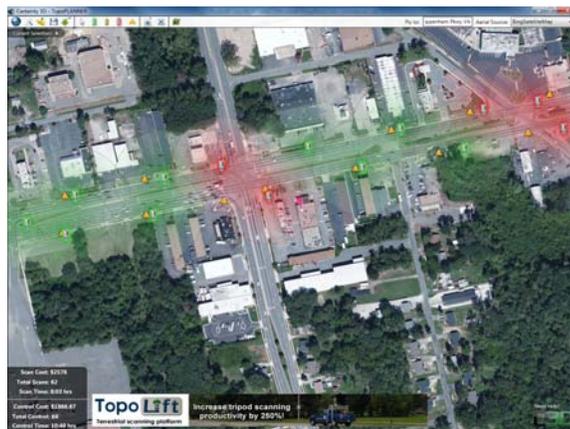
Why LEADING EDGE?



Experience -- Productivity -- Quality



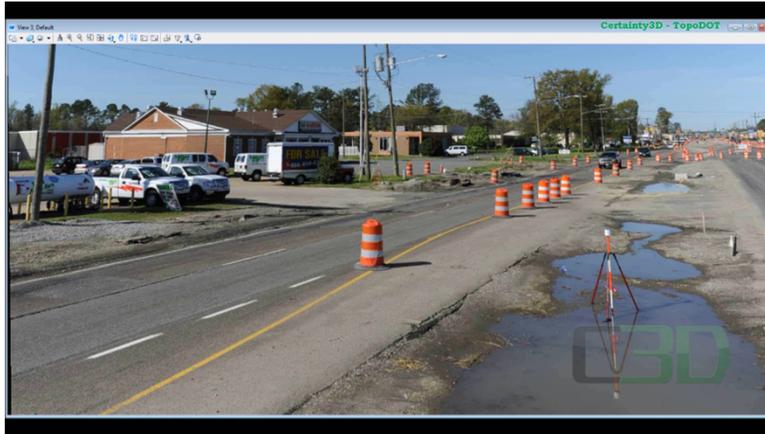
LiDAR/TopoLIFT Field Productivity



TopoLIFT/VZ400 LiDAR Survey – 3 DAYS!!!!



Post Processing at Certainty 3D



TopoDOT eXtracts high quality DTM



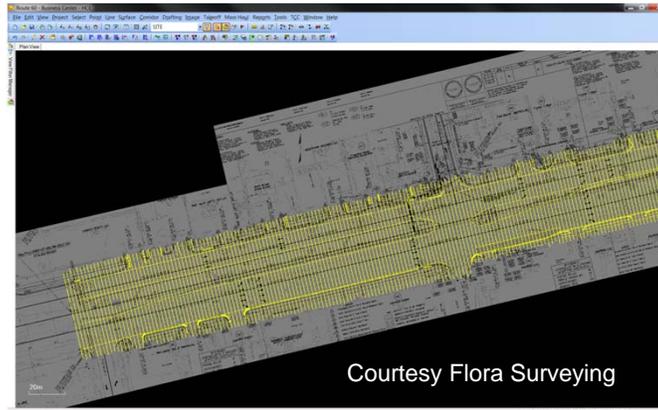
Design Solution



Feeds the Design Solution!!!



Design: Overlay LiDAR Model on Design



Courtesy Flora Surveying

- Convert CAD Design Cross-Sections to 3D modeling format
- Overlay TopoDOT™ LiDAR model every 10 meters



Design: Find and Fix Problems

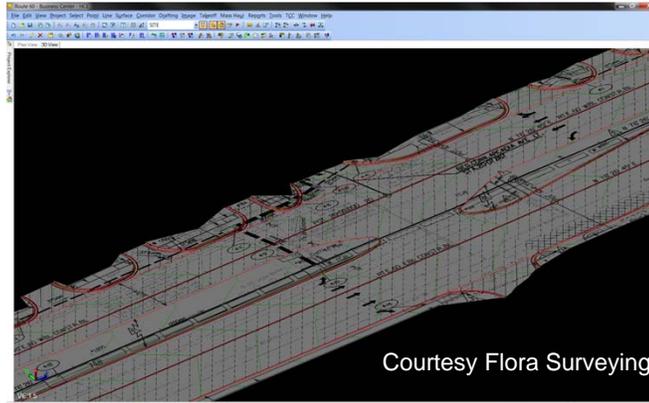


Courtesy Flora Surveying

Find problem areas and solutions at 10 Meter sections along entire route



Design: Recreate High Res Model

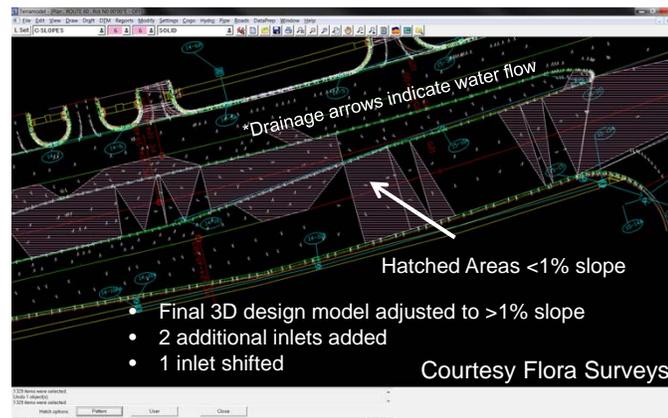


Courtesy Flora Surveying

- Recreate 3D design model at **2 meter intervals** and key event points
- Overlay on design drawings to verify plans



Design: Constructability Analysis



Constructability Analysis of 3D Design Model



Design: Automated Machine Guidance



- Convert 3D Design Model to Automated Machine Guidance format
- Proof machine data using simulators



Project Completed January 2013



“Results couldn’t have been better!!”

- Rich Leininger, AECOM project manager

Construction/Engineering Processes

- *Improve Operational Logistics*
- *Minimize Risk*
- *Accelerate Schedules*
- *Validate Construction*

Construction Monitoring

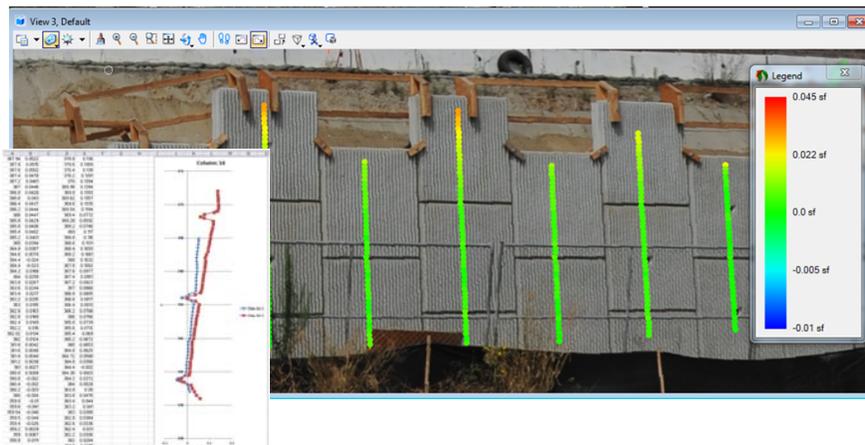


Figure 32: TopoDOT™ extracts data at each column

Did retaining wall move? Will it fail?



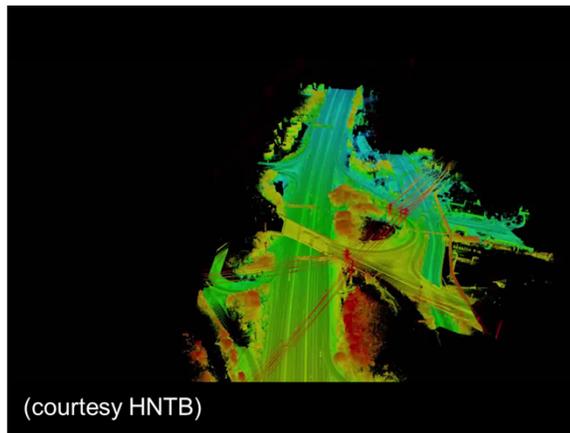
Construction Monitoring



Has retaining wall settled? How much? Ready to start construction?



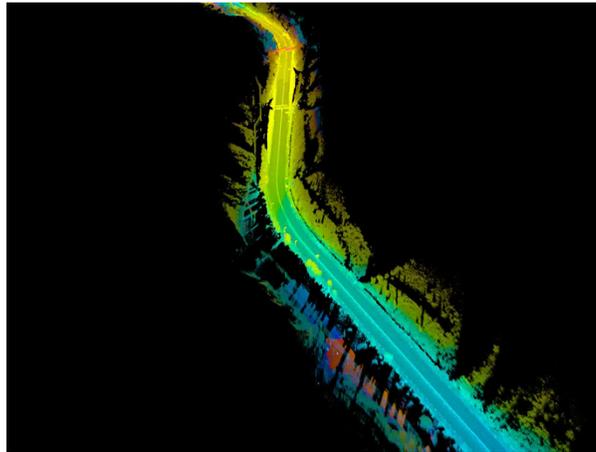
Design Visualization



Virtual High Occupancy Traffic Lane Design in Existing Environment



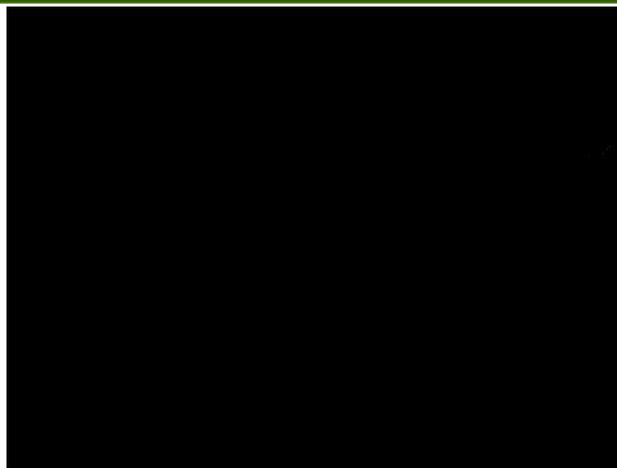
Construction



Basic measurements available instantly



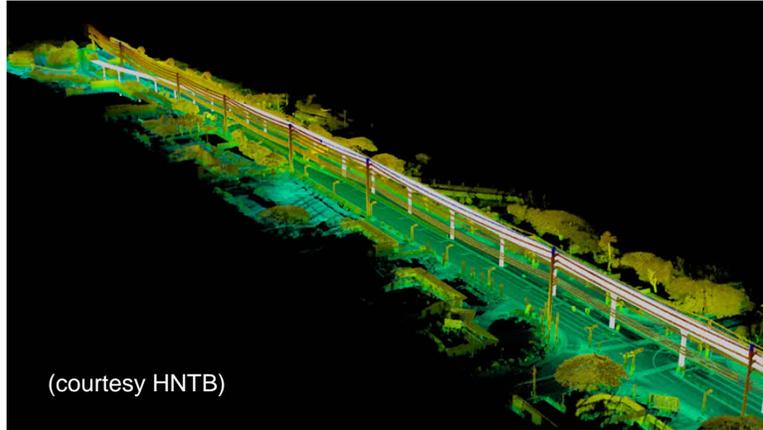
Construction Progress Feedback



Continuous LiDAR data updates provides access to current conditions



Construction Logistics



Clearance between power lines and crane?
Where is crossover through power lines?



Demonstration



TopoDOT LIVE!!!

TopoDOT Customers

Join our community!

150+ Companies/Agencies
1600+ Users (as of June 2013)

Information? Demo? Trial?

Certainty 3D, Orlando, FL - (407) 248-0160 - info@certainty3d.com - www.certainty3d.com