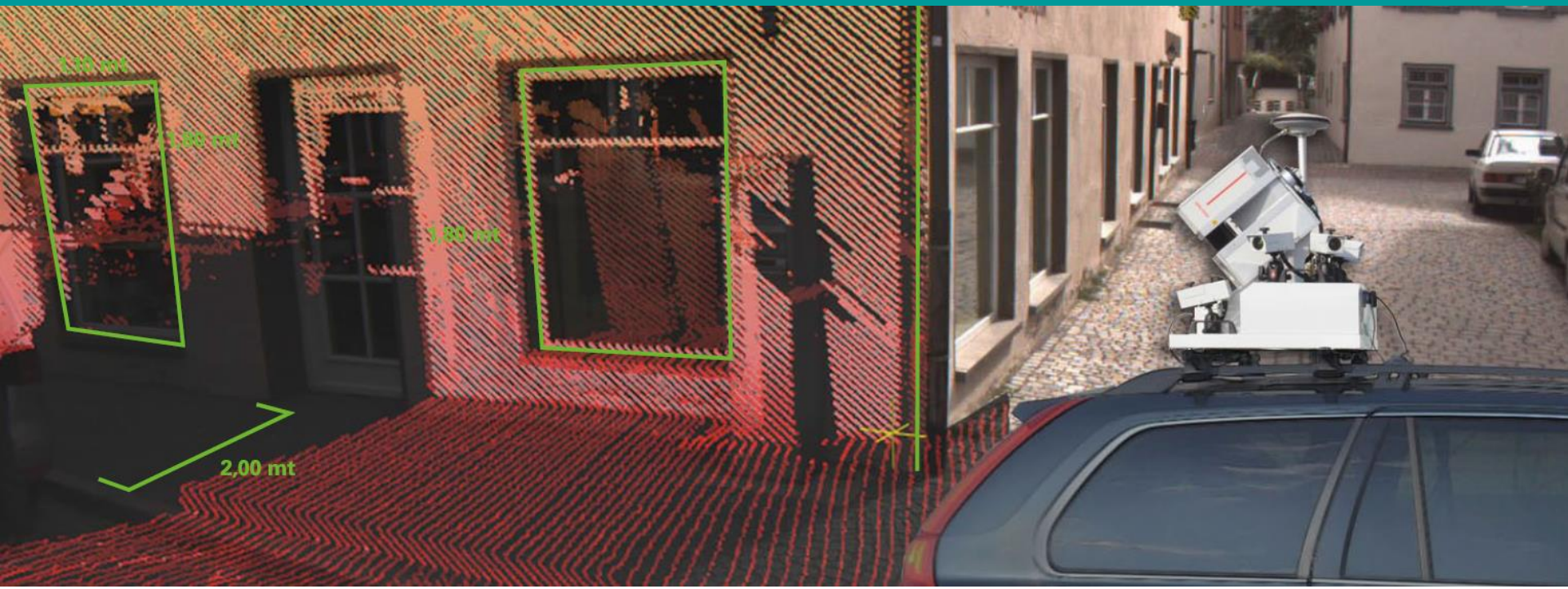


Mobile Lidar Mapping: Pegasus

HEXAGON

What is PEGASUS?

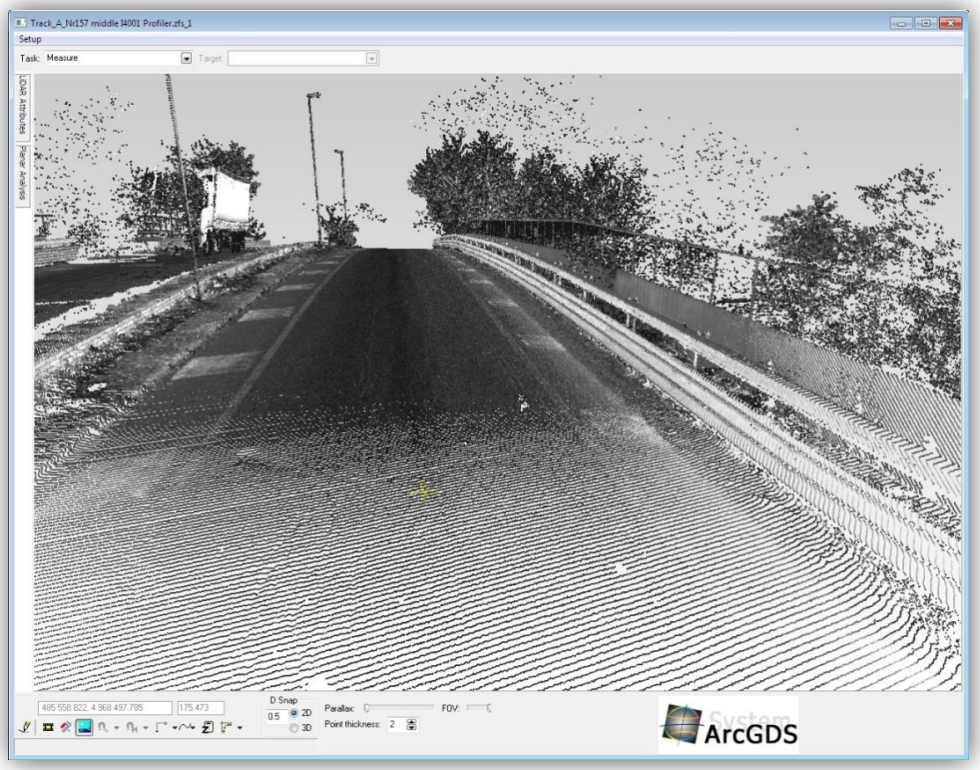
Pegasus is a comprehensive solution for

- LIDAR and image data acquisition
- Data post-processing
- Stereoscopic 3D GIS interface for digitising spatial objects
- Spatial data acquisition of the highest accuracy

Point Cloud Approach

“Everything from the point cloud” approach

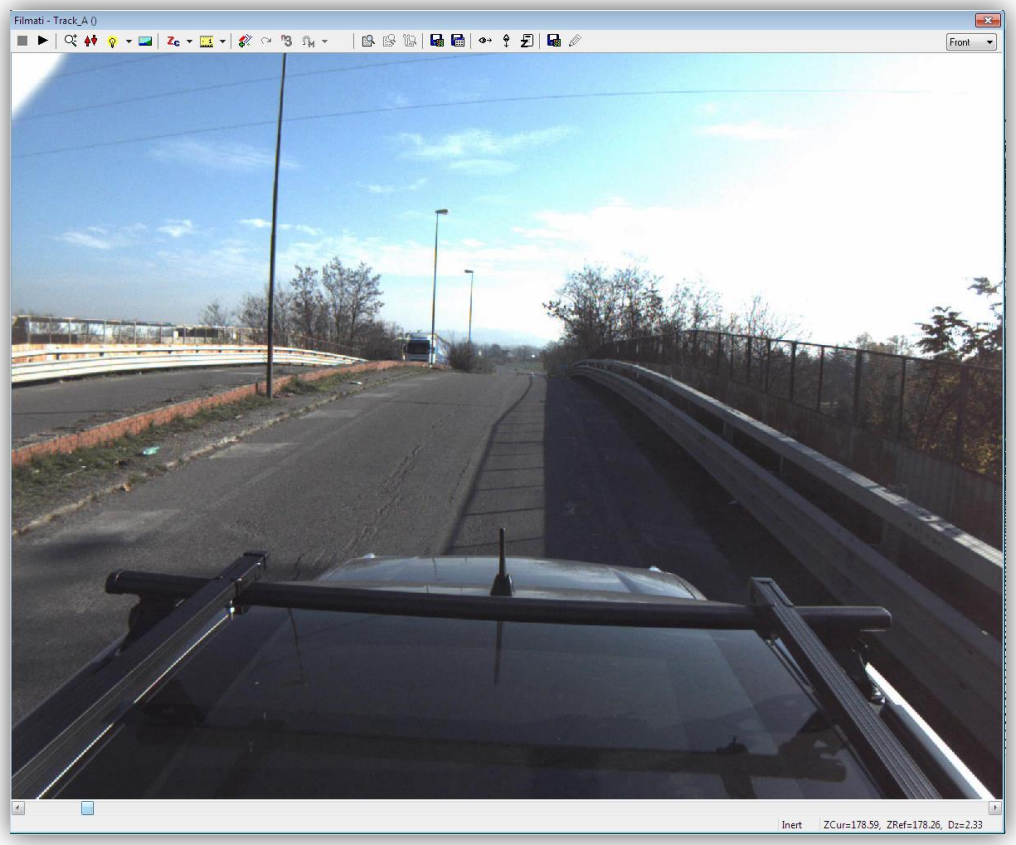
- Point clouds with a very high Level of detail are required.
- Meaning:
  - Several laser scanners
  - Lower acquisition speed of the mobile platform
  - Huge files
- Disadvantages:
  - High system costs
  - Lower acquisition throughput
  - Lower processing throughput



Photography Approach

“Everything from photographs” approach

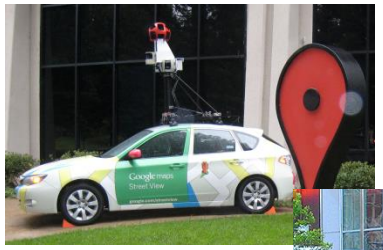
- At the face value, a more natural approach for nonprofessional users
- As regards accuracy, lags behind laser scanner systems
- Digitisation errors are difficult to discover
- Adequate for less accurate applications



Mobile Mapping Market Today

Video Logging

- Fast
- Intuitive
- Asset Management



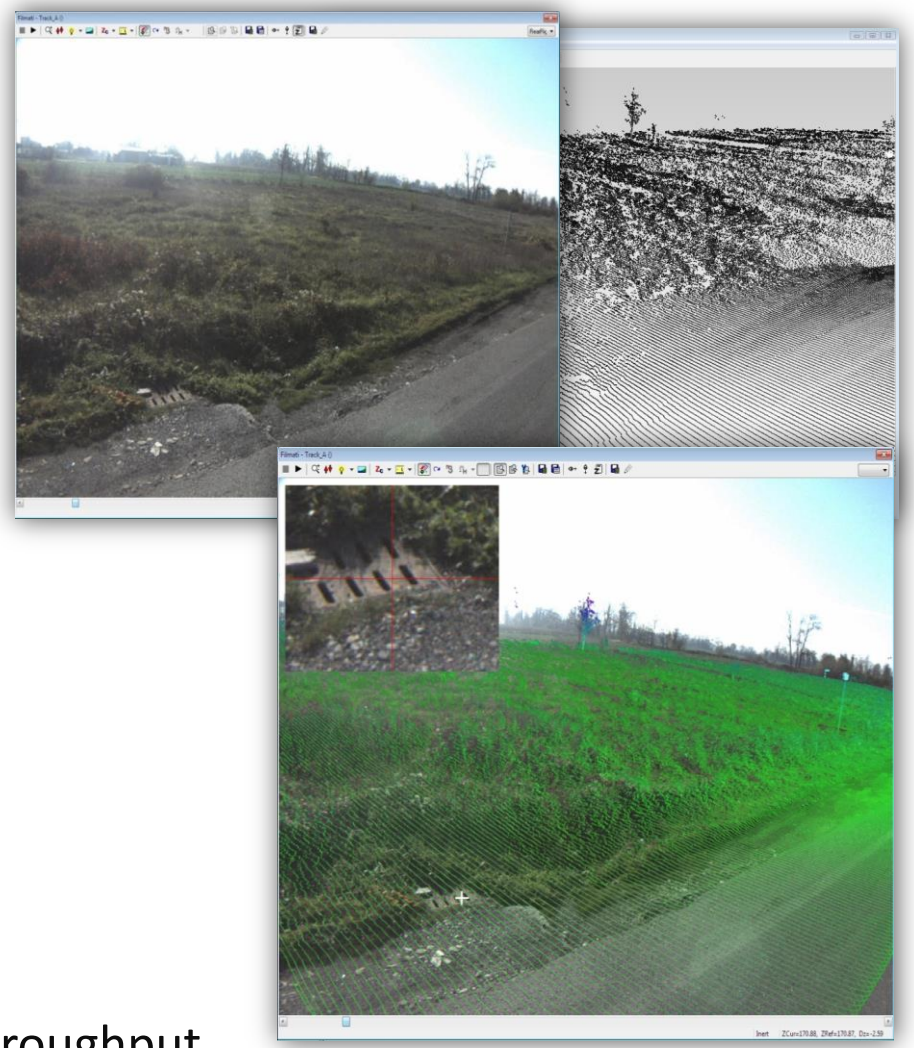
Survey Grade

- Accurate
- Complete
- Corridor Surveys

The Pegasus Approach

Combined “Pegasus” approach

- Using video-cameras for the rapid navigation through the dataset
- Use imagery for feature identification
- Use point clouds for measurements
- Meaning:
  - The density of point clouds is less critical
  - Amount of data manageable
- Your advantages:
  - Simple objects recognition
  - High acquisition and processing throughput



Pegasus Platform Principles

- **User portability and mobility**
  - Vehicle independence
  - Not limited by the sensor
- **Economic data collection / economical on time**
  - 1 km = 1.5 Gb data with Profiler 9012 scanner
  - 1 hr acquisition = 1 hr post-process, no colorization
  - Single scanner vs dual scanner
    - Single scanner lower noise, no calibration
- **Easy of use**
  - “Google street” style to spherical view interface

- **No Return to Site “Guarantee” – nothing missed**
  - Camera and Lidar calibrated to together, 360º view
  - Camera calibrated – photogrammetry to add to point cloud

Pegasus Operational Concepts

- **Single laser scanner** with GNSS receiver, Inertial Measurement Unit (**IMU**) and a Distance Measurement Instrument (**DMI**)
- Laser scanner determines relative position and reflectance properties of points
- Cameras provide 360 degree coverage to complement laser data.
- Images provide feature identification, rapid navigation through data and stereo measurements

Pegasus Two Operational Concepts

Density of the point cloud is dependent on the scan rate of the scanner, number of points collected per second, and the speed that the vehicle is traveling.

Density of the image coverage is based on an operator specified distance, and is limited by the maximum frame rate of the video cameras.

The geospatial accuracy of the point cloud and images are derived from the GNSS/INS system. The point cloud and imagery are time referenced to the vehicle trajectory.

The GNSS provides position updates to correct the INS position drift. The DMI provides another external position update for areas with GNSS outage.

Using base stations relatively close to the project area, the GNSS / INS errors are modeled and corrected to significantly improve the trajectory accuracy.

Pegasus Two Operational Concepts

The system is vehicle independent. It can easily be shipped and fitted to any vehicle with installed factory rails.

The system does not require a specialized laptop for operation. The system uses a laptop or tablet to remotely connect to an integrated PC.

Calibration of the system includes:

- Internal calibration of the video cameras to determine distortions and deformations.
- External calibration of the video cameras to establish spatial offset and orientation with respect to the IMU.
- Calibration of the laser scanner to establish spatial offset and misalignment with respect to the IMU.
- Calibration of GNSS lever arms to establish spatial offset between the GNSS antenna and the IMU

Pegasus Two Operational Concepts

Feature extraction is accomplished in the ESRI ArcGIS environment.

Feature data is populated directly into a user defined feature database.

Operator can collect both the spatial location of the features plus defined attributes.

Feature measurements can be accomplished on the point cloud, on the images registered to the point cloud, or on the images alone.

Spatial accuracy is a function of the GNSS/IMU trajectory, but relative adjustments between individual tracks can be accomplished, and the trajectory can be adjusted to ground control points.

Leica Pegasus Two System Configuration

Camera System
Sky / road camera

Laser Scanner
Leica P20 (removable)
Z+F 9012 Profiler

Power Supply
One cable connection
10 hours operation time

Roof Mounting
Standard roof rack
System fits in one case

Global GNASS/GPS
Triple band / all constellations / Novatel Propak 6

Light Sensor
Automatic light sensor / exposure control

Camera System
8 CCD Cameras
4 Mega Pixels, 360°
Coverage

Handles
Access around unit for easier mounting

Laser Scanning Options and Specifications

2D Profiler

Z+F Profile 9012

- 200 Hz rotation speed
- Profile every 5 cm @ 36 km/h
- Permanent installation

3D HDS

Leica P20

- 100 Hz rotation speed
- Profile every 10 cm @ 36 km/h
- Flexible installation

Supported Laser Scanner

Laser Scanner / Z+F profiler 9012

- 0.3 to 119 meter range
- 360 degree Field of View
- Maximum scan rate of 200 profiles per second
- Scan rate of 1.016 million points per second
- Data is stored on an internal 128 GB SATA drive
- Interface through a 1 GB ethernet connection
- Relative accuracy of point cloud is less than 3 mm
- Operating temperature range is -10 to 45 degrees Celsius

Pegasus system hardware components

Laser Scanner / P20

- Range out to 120 meters
- 360 x 270 degree Field of View (horizontal / vertical)
- Maximum scan rate of 100 profiles per second with external battery
- Scan rate of 1.016 million points per second
- Data is stored on an internal 256 GB solid state drive
- Interface through a 1 GB ethernet connection
- Relative accuracy of point cloud is 3 mm at 50 meters, 6 mm at 100 meters
- Operating temperature range is -20 to 55 degrees Celsius

Pegasus System Accuracy

Novatel SPAN IMU-FSAS

PERFORMANCE DURING GNSS OUTAGES[1]

Outage Duration	Positioning Mode	POSITION ACCURACY (M) RMS		VELOCITY ACCURACY (M/S) RMS		ATTITUDE ACCURACY (DEGREES)[2] RMS		
		Horizontal	Vertical	Horizontal	Vertical	Roll	Pitch	Heading
0 s	RTK[7]	0.020	0.050	0.020	0.010	0.008	0.008	0.023
	SP	1.200	0.600	0.020	0.010	0.009	0.013	0.024
	PP[8]	0.010	0.015	0.020	0.010	0.008	0.008	0.012
10 s	RTK[7]	0.130	0.060	0.026	0.010	0.010	0.010	0.025
	SP	1.340	0.670	0.035	0.011	0.014	0.014	0.026
	PP[8]	0.020	0.020	0.020	0.010	0.008	0.008	0.013
60 s	RTK[7]	3.500	0.320	0.135	0.015	0.015	0.015	0.040
	SP	4.440	0.870	0.151	0.015	0.018	0.018	0.040
	PP[8]	0.130	0.050	0.030	0.020	0.010	0.010	0.016

Pegasus System Accuracy

Novatel SPAN IMU-FSAS

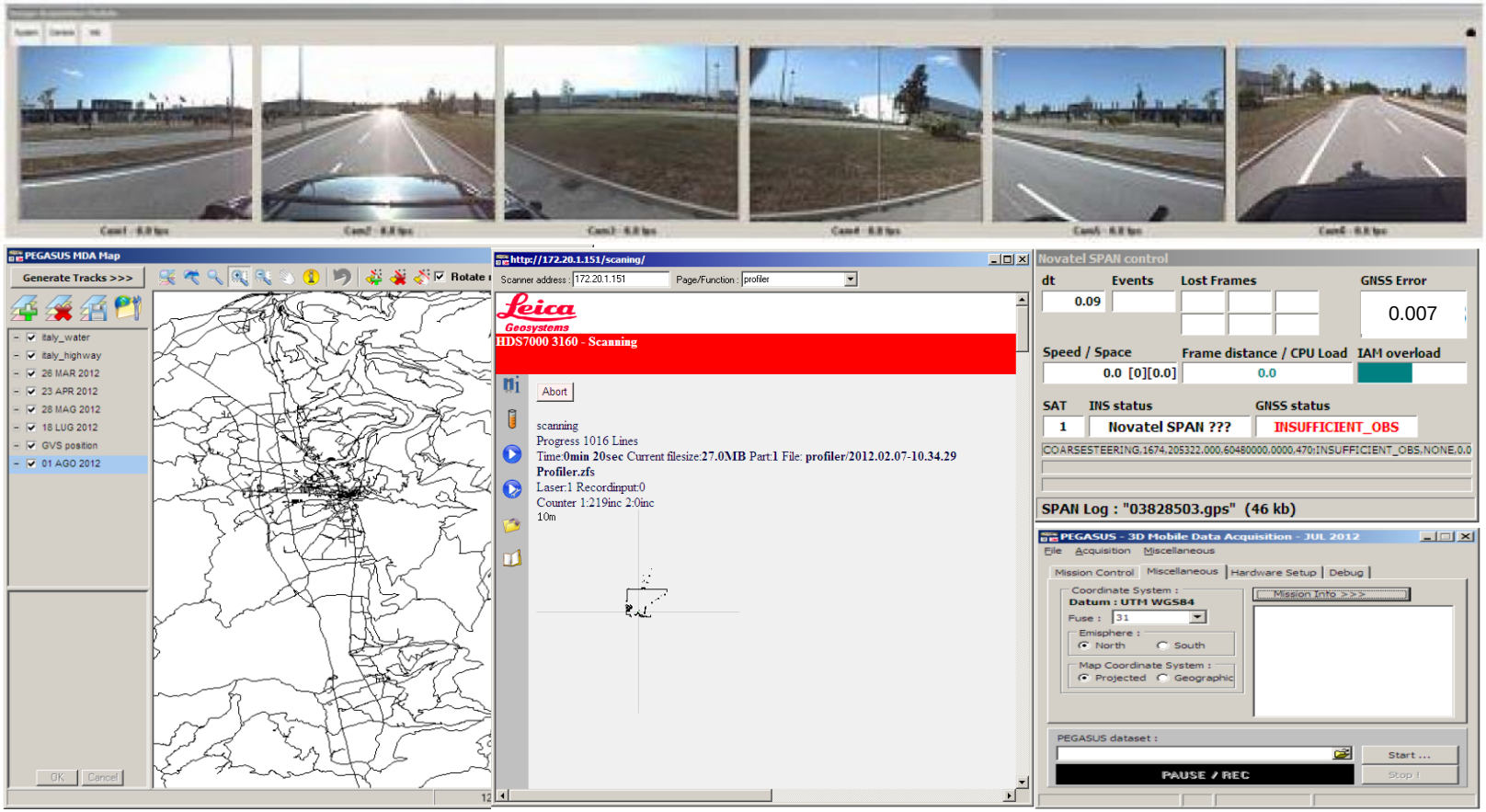
CS: 58151
JN: 119803C

I-75 From State Line to North of Erie Road
RAW LiDAR Data Compared to Control Targets (Z)
BEFORE TRAJECTORY ADJUSTMENTS

Track_A Southbound Outside Shoulder											
POINT ID	XORIG	YORIG	ZORIG	X	Y	Z	DX	DY	DZ		
973	4073651.421	29986.459	176.665	4073651.421	29986.459	176.639	0	0	-0.026		
734	4073647.94	30133.463	176.654	4073647.94	30133.463	176.632	0	0	-0.021	Track_A Southbound Outside Shoulder	
636	4073658.907	29688.583	176.449	4073658.907	29688.583	176.431	0	0	-0.018		
969	4073655.636	29824.414	176.466	4073655.636	29824.414	176.448	0	0	-0.018	Positive Max Error	0.023
737	4073648.476	30188.896	176.603	4073648.476	30188.896	176.584	0	0	-0.018	Negative Max Error	-0.026
1128	4073650.522	30224.064	176.608	4073650.522	30224.064	176.59	0	0	-0.018	Average	0.000
968	4073637.373	29823.881	176.394	4073637.373	29823.881	176.377	0	0	-0.017	Std Deviation	0.010
1077	4073616.686	30062.508	176.088	4073616.686	30062.508	176.071	0	0	-0.016	95%	0.021
961	4073659.401	29343.198	177.145	4073659.401	29343.198	177.131	0	0	-0.014		
960	4073643.331	29344.777	176.636	4073643.331	29344.777	176.621	0	0	-0.014		
977	4073685.958	30421.621	176.697	4073685.958	30421.621	176.683	0	0	-0.014		
624	4073539.458	28676.879	177.134	4073539.458	28676.879	177.121	0	0	-0.013		
733	4073633.297	30133.418	177.131	4073633.297	30133.418	177.119	0	0	-0.013		
901	4073053.601	26254.197	177.318	4073053.601	26254.197	177.306	0	0	-0.012		
632	4073647.498	29232.619	177.429	4073647.498	29232.619	177.417	0	0	-0.012		
631	4073633.313	29234.696	176.979	4073633.313	29234.696	176.967	0	0	-0.012		
696	4073634.593	29920.103	176.469	4073634.593	29920.103	176.456	0	0	-0.012		
738	4073634.169	30198.542	177.233	4073634.169	30198.542	177.222	0	0	-0.012		
972	4073631.953	29986.073	176.344	4073631.953	29986.073	176.333	0	0	-0.011		
1127	4073636.995	30242.674	177.236	4073636.995	30242.674	177.226	0	0	-0.011		
925	4073320.058	27583.621	176.855	4073320.058	27583.621	176.845	0	0	-0.01		
949	4073529.729	28628.232	176.871	4073529.729	28628.232	176.86	0	0	-0.01		

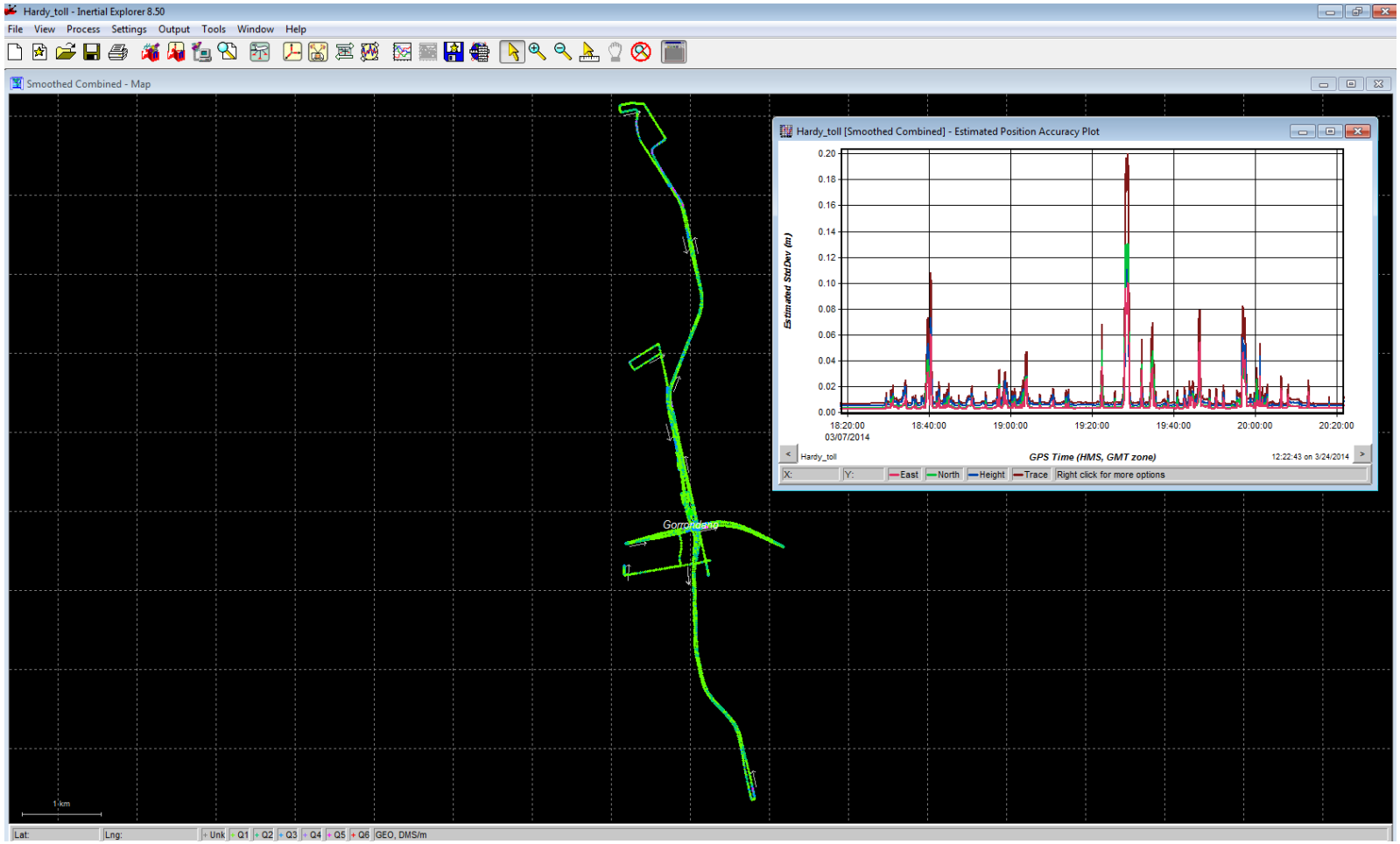
Pegasus system software components

Mobile Data Acquisition



Pegasus system software components

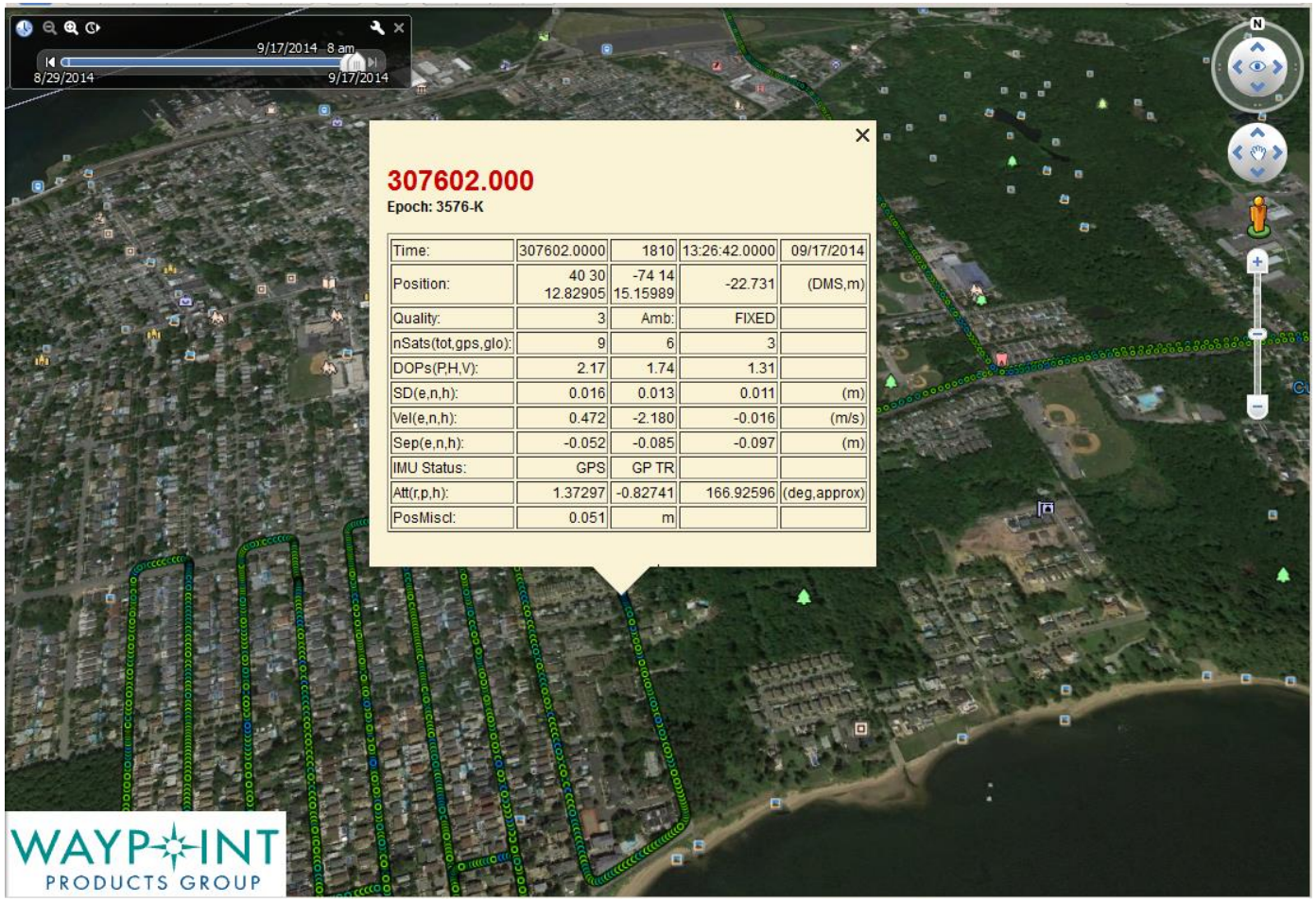
Novatel Inertial Explorer



HEXAGON

Pegasus system software components

Novatel Inertial Explorer



Pegasus system software components

Novatel Inertial Explorer

Figure 2: E4_Sciences_Bridge [Smoothed TC Combined] - Estimated Position Accuracy Plot

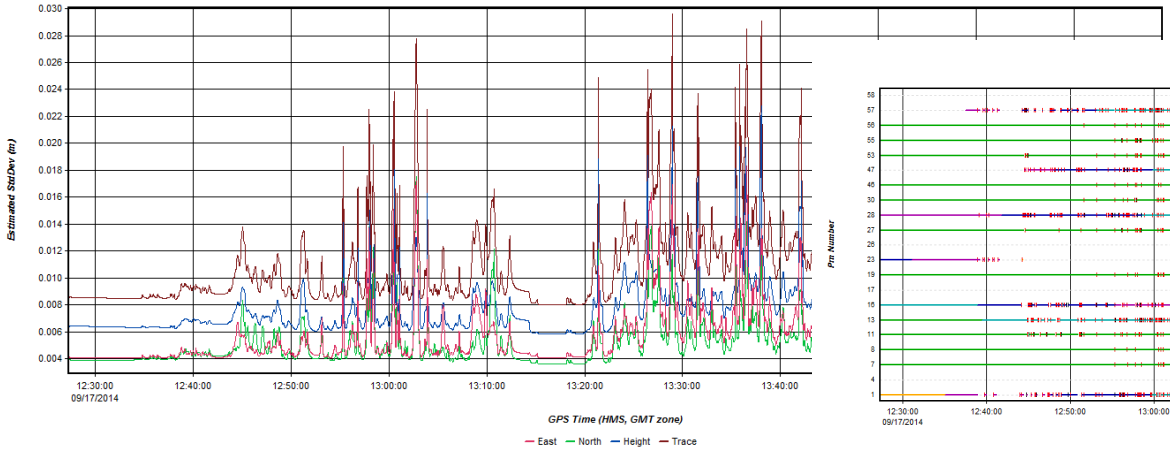


Figure 5: Remote - L1 Satellite Lock/Elevation

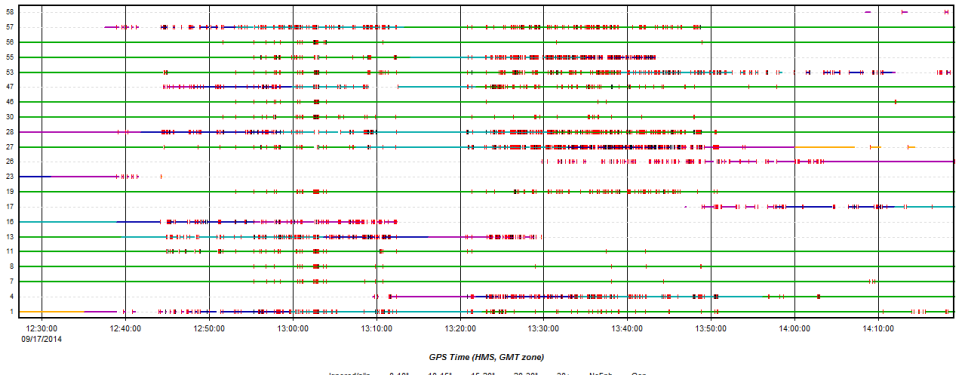


Figure 4: E4_Sciences_Bridge [Smoothed TC Combined] - Forward/Reverse or Combined Separati

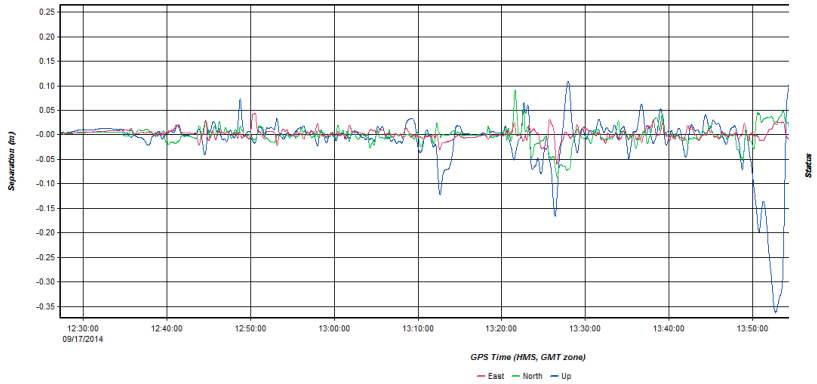
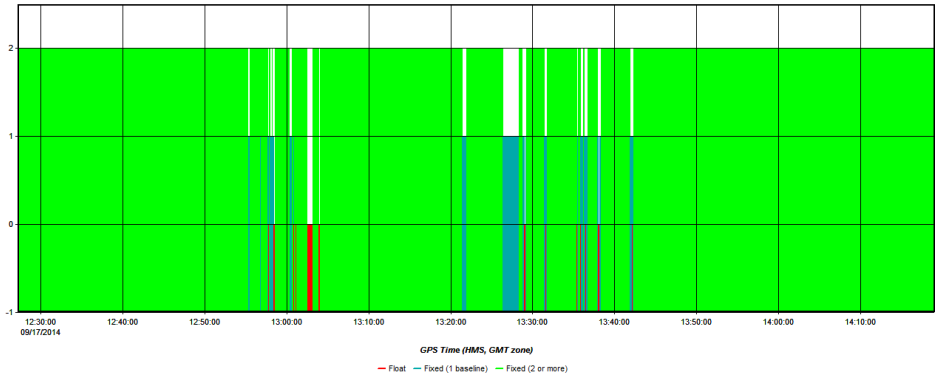


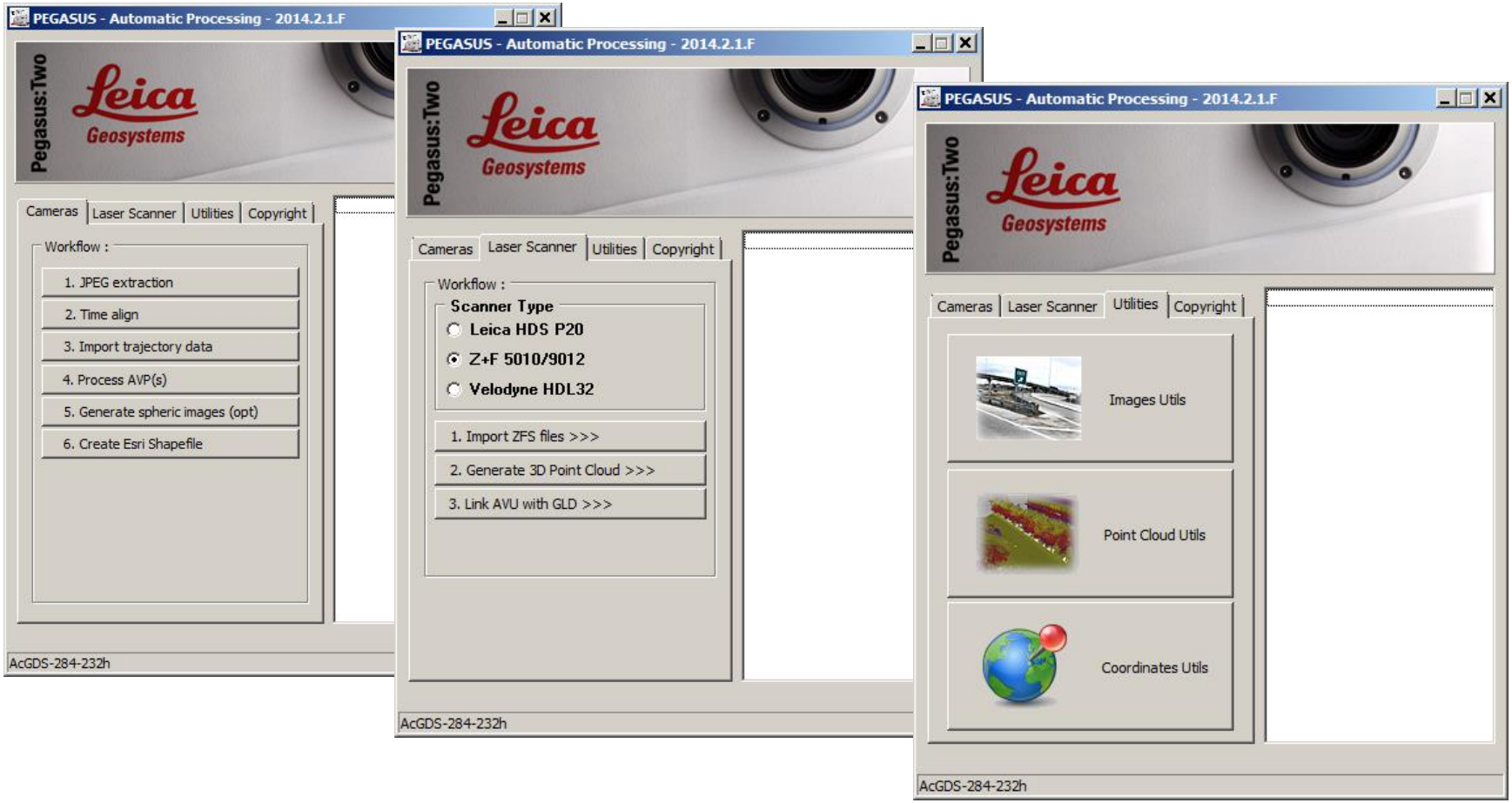
Figure 7: E4_Sciences_Bridge [Smoothed TC Combined] - Float or Fixed Ambiguity



HEXAGON

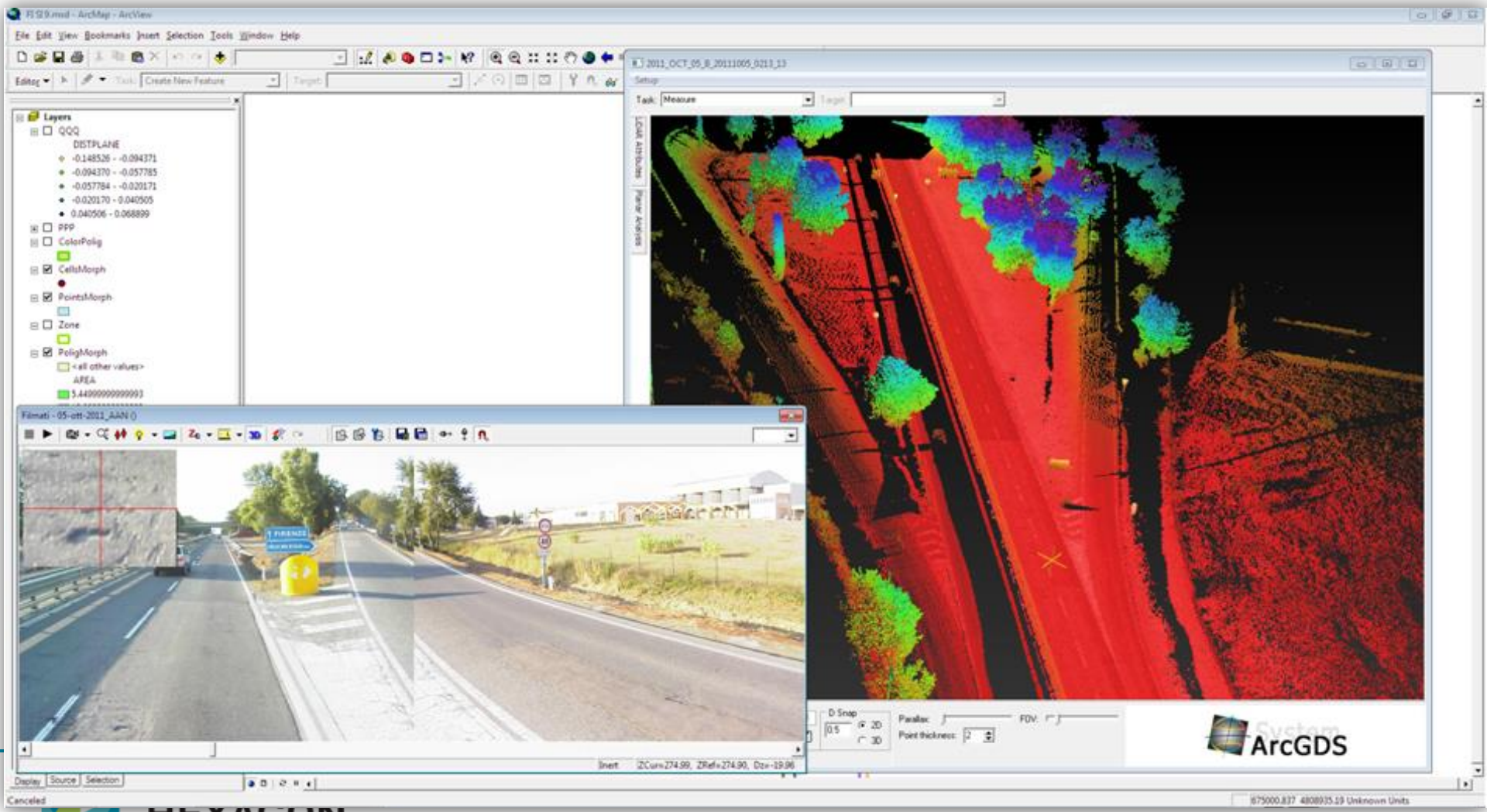
Pegasus system software components

Pegasus Automatic Post Processing Software



Pegasus system software components

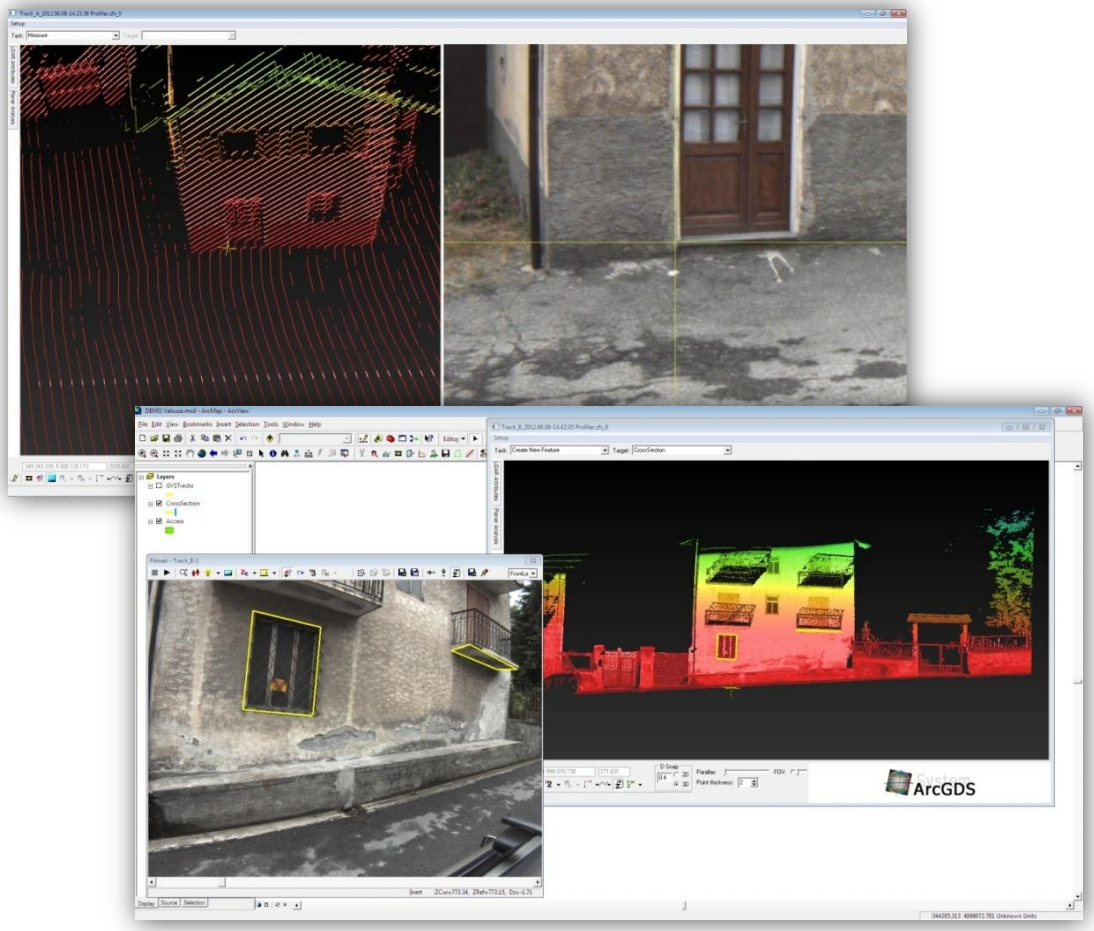
- **ArcGDS Software**



3D acquisition of spatial data

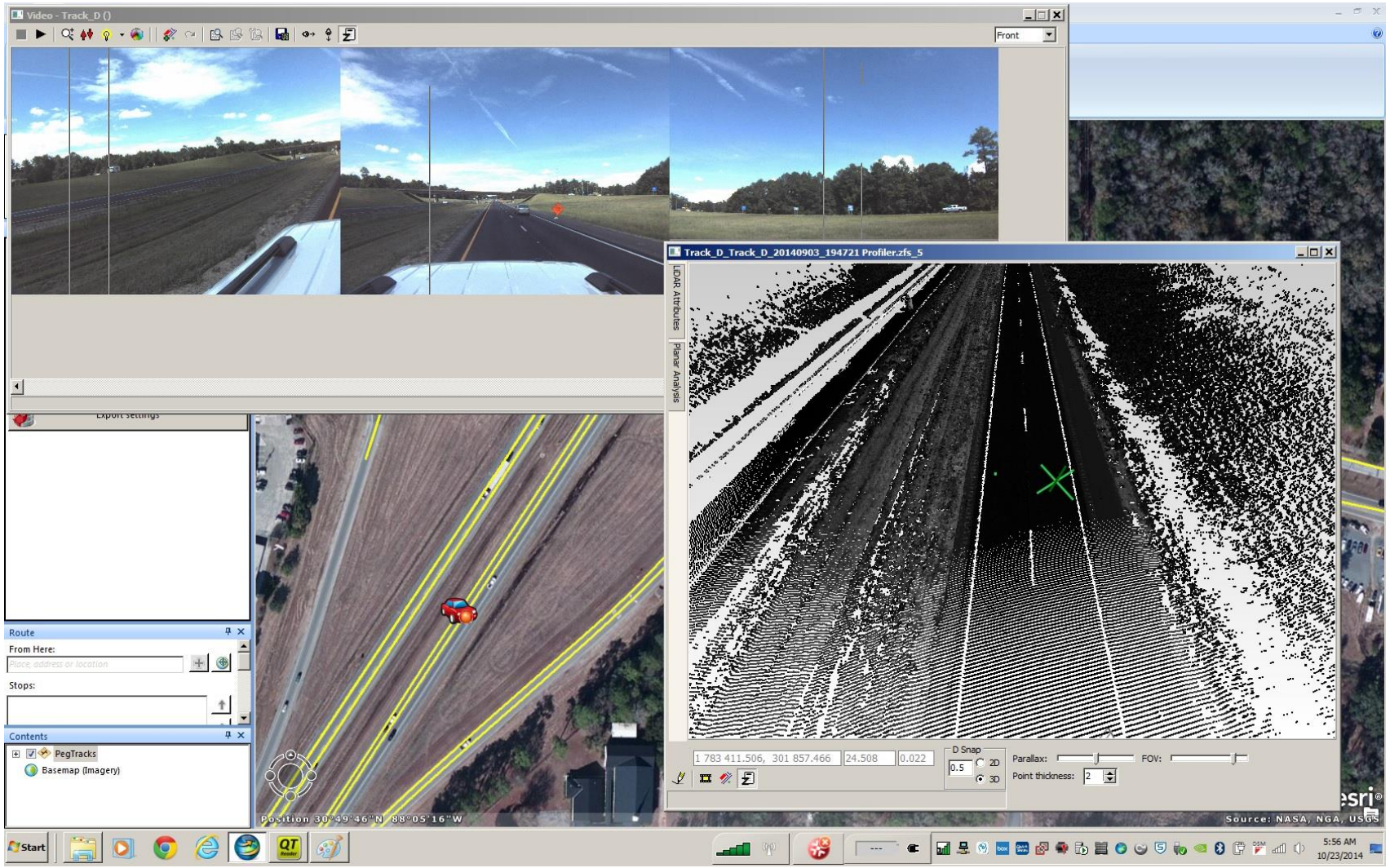
The aim is to create and manage GIS objects from images and clouds in a full 3D environment

- Image sequence (video) for the rapid navigation and object recognition
- Point clouds for an accurate measurement
- 3D stereoscopic view to decrease errors and increase throughput



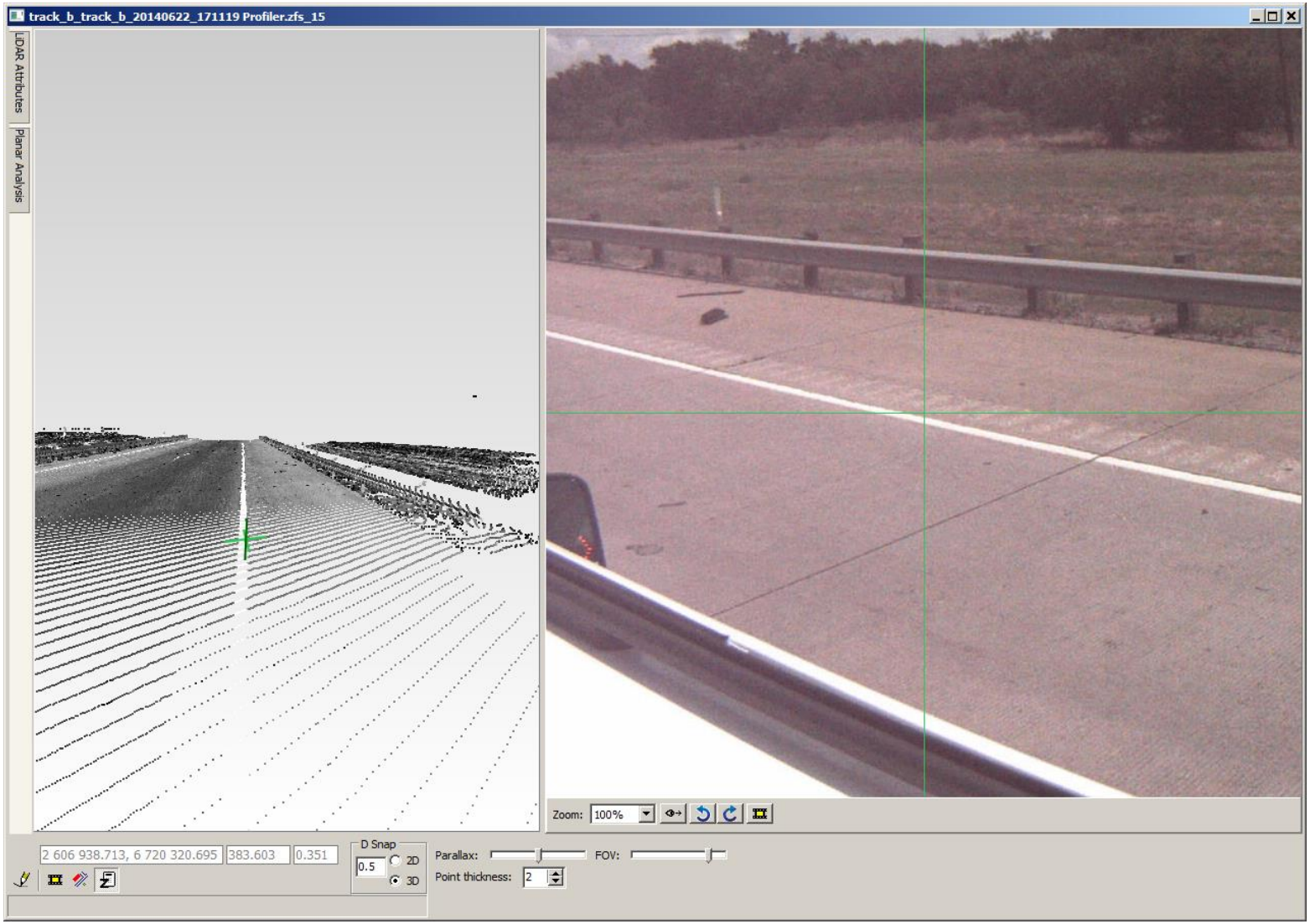
HEXAGON

Navigation Through Data



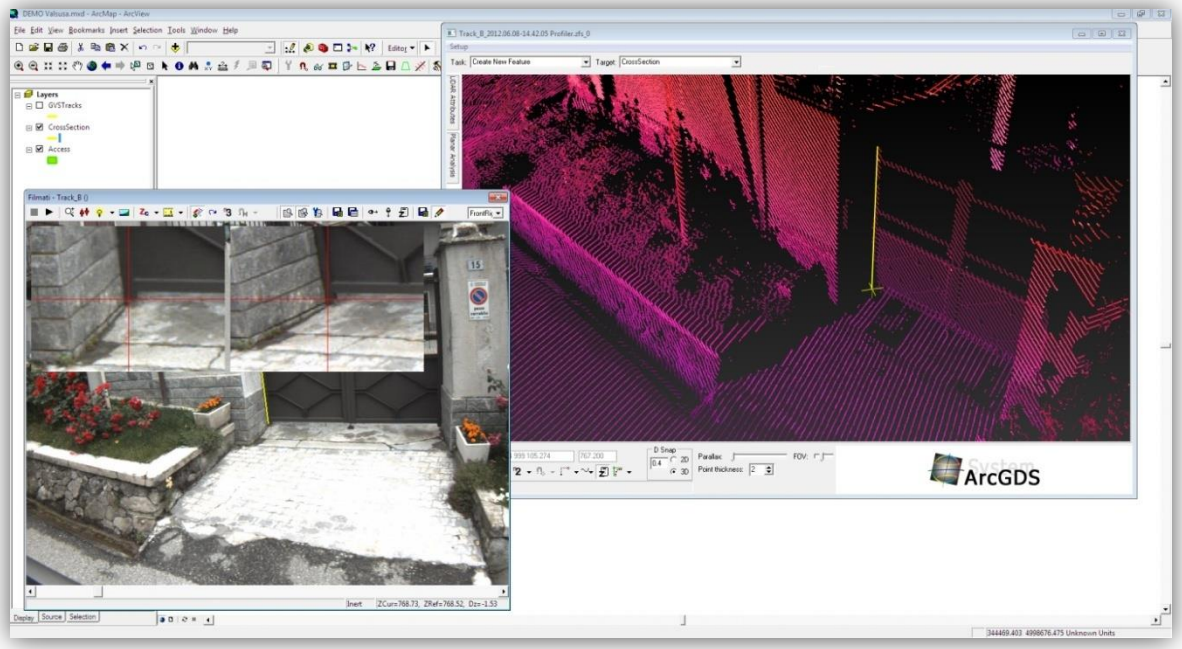
HEXAGON

Feature Recognition



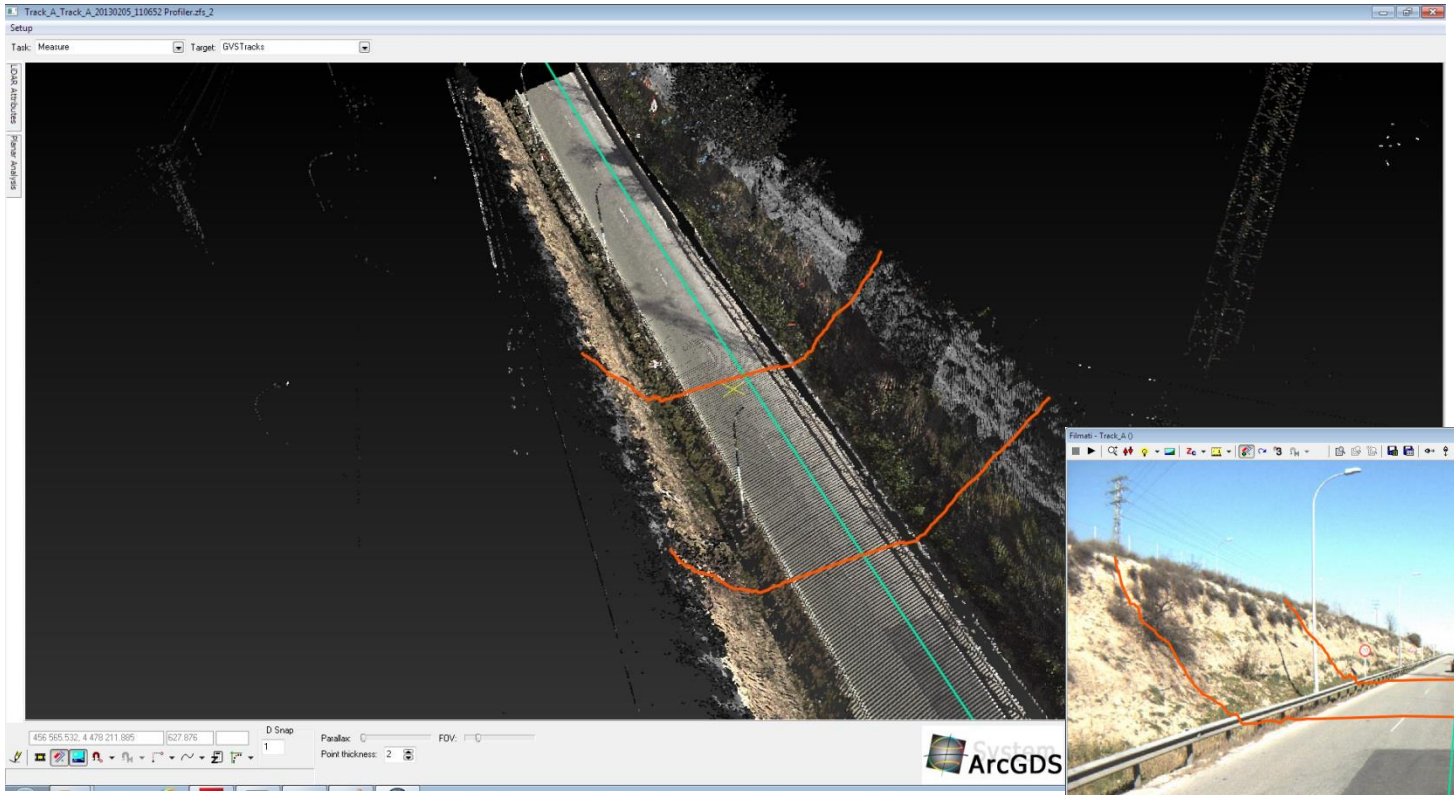
HEXAGON

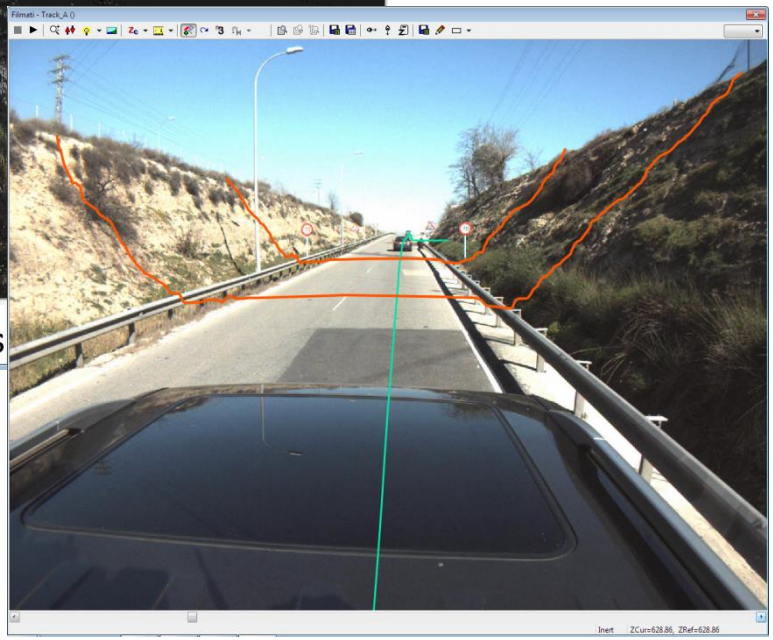
3D acquisition of spatial data



- Wherever 3D points can be acquired also via photogrametric process, e.g. when laser scanner data are missing
- Unique 3D pointer (current 3D position) to determine the location in 3D stereoscopic view from the iz point cloud or any camera image
- The pointer snaps automatically and continuously onto the point cloud (snapping)

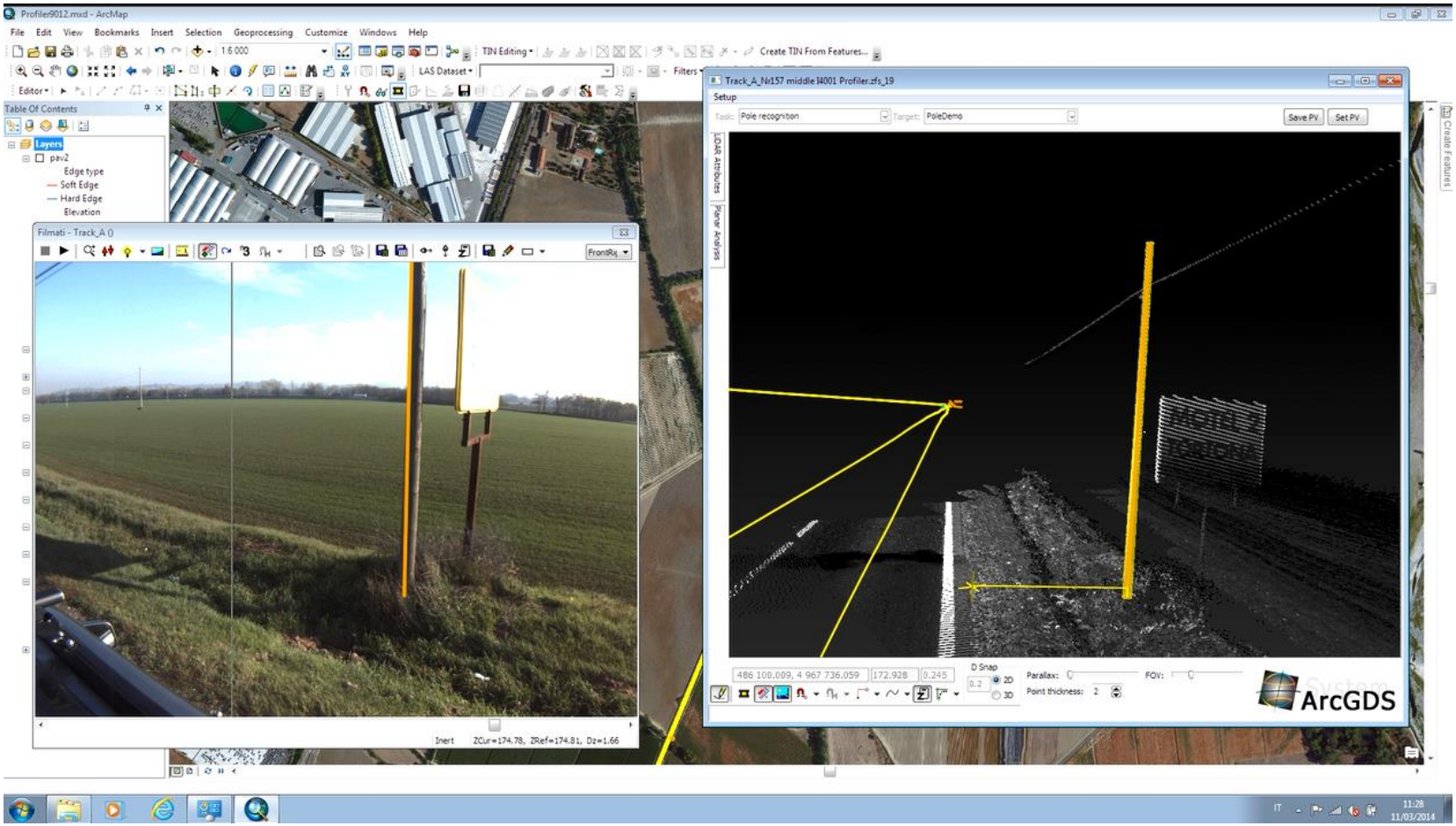
ArcGDS Tools - Cross Sections





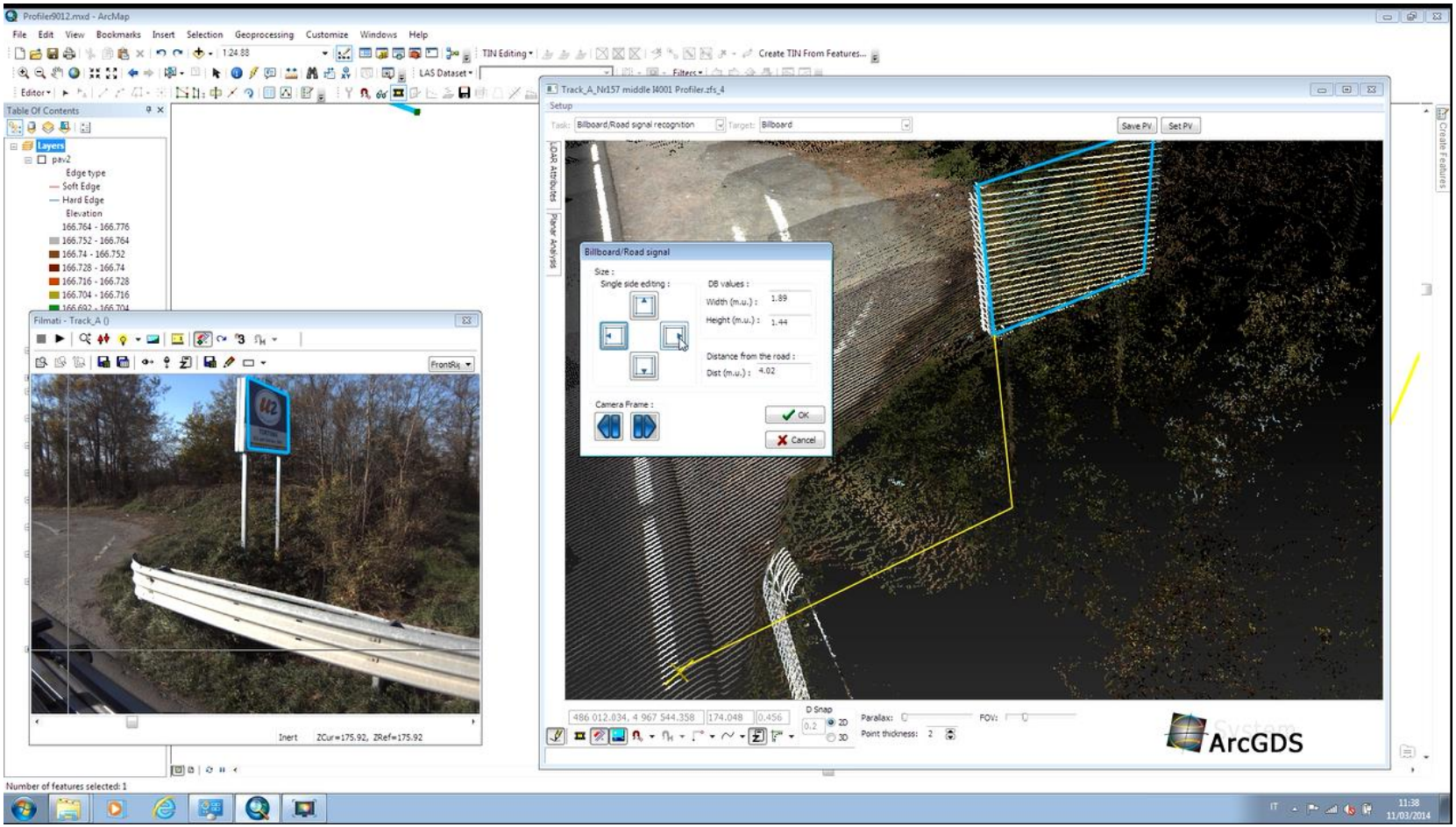
ArcGDS Tools

Automated Pole Extraction



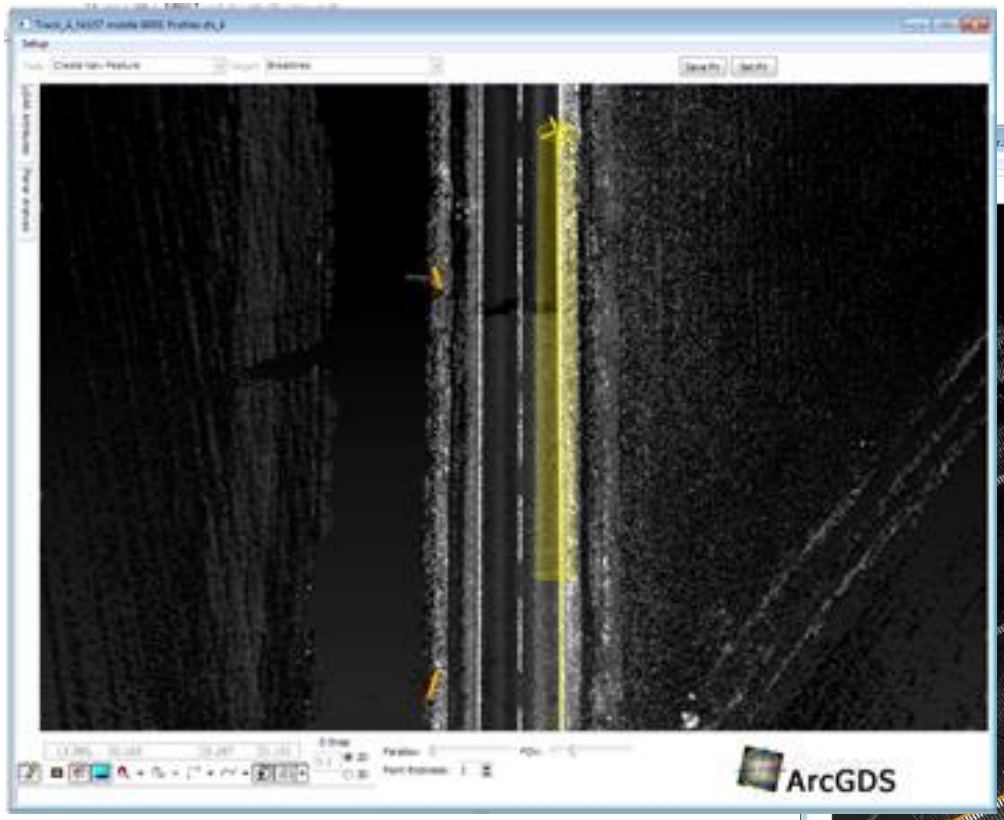
ArcGDS Tools

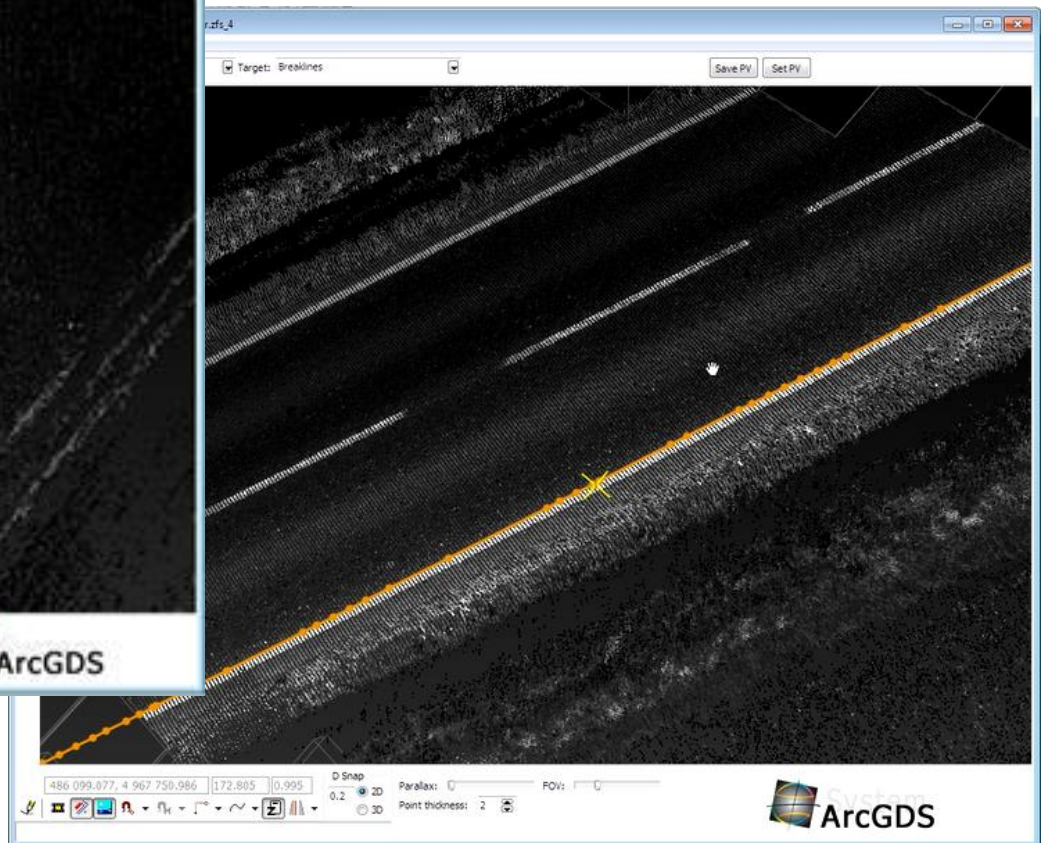
Automated Sign Extraction



ArcGDS Tools

Edge Detection and Road Centerline





Applications

High accuracy measurements (15-20 mm)

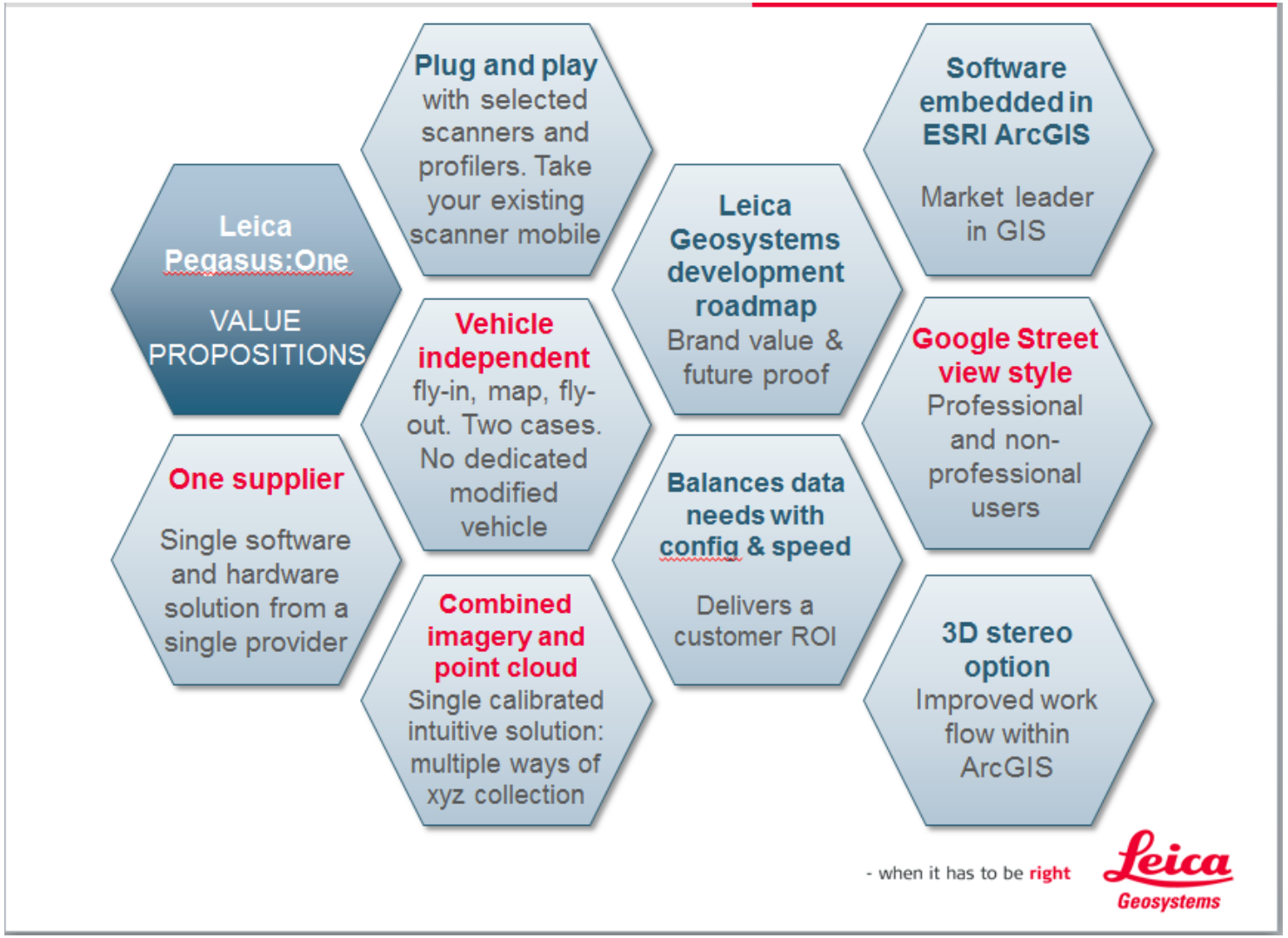
- Engineering topography
- As-builts and construction monitoring
- Detailed profiles of tunnels and bridges
- Measurement of deformations

Medium accuracy measurements (3 cm)

- Designing and planning corridors
- Detailed descriptions of transport infrastructure
- Environmental measurements
- Earthworks measurements
- Mapping urban areas
- Analysis of erosion of coastal areas

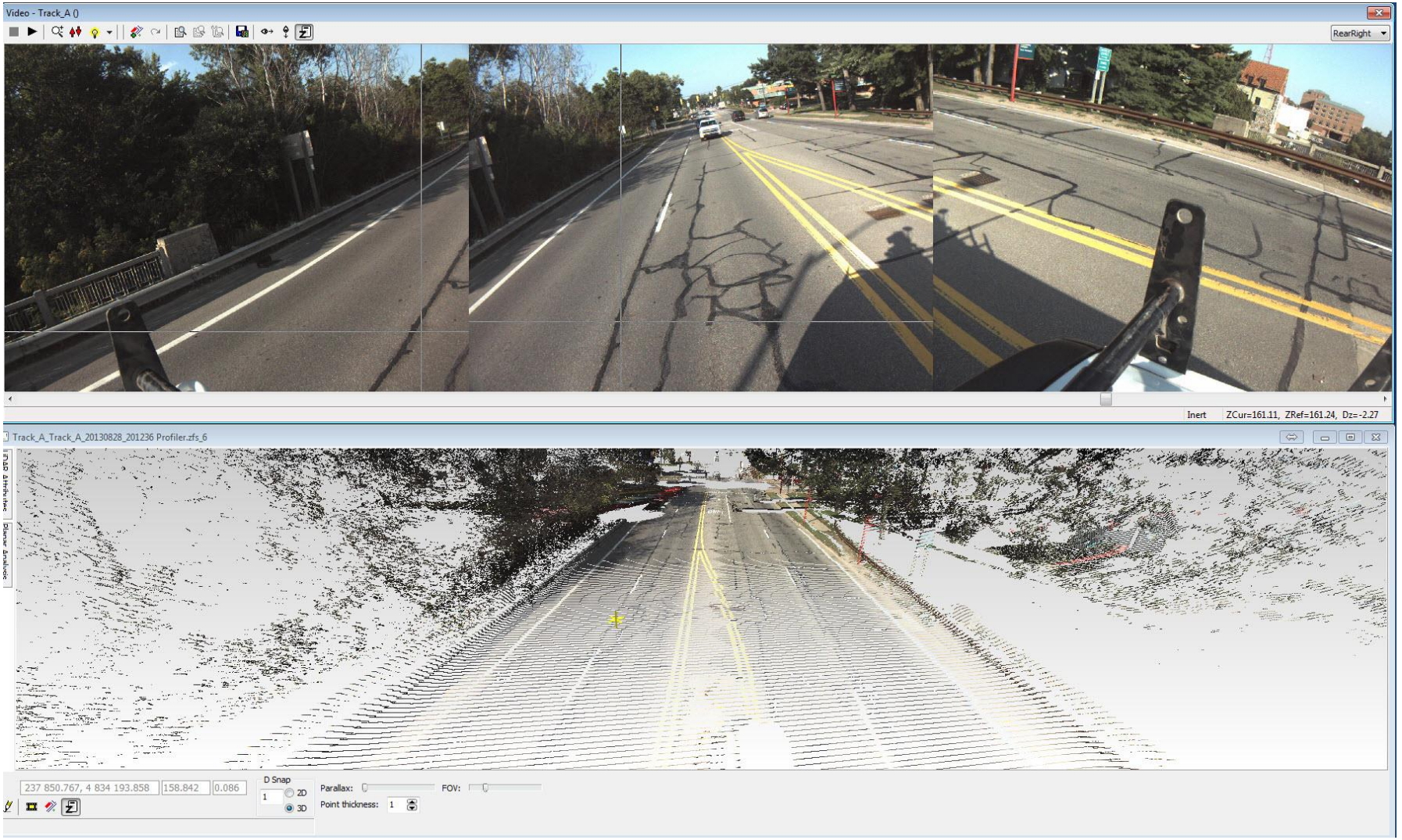
Lower accuracy measurements (10 cm)

- Asset collection
- Preliminary town and rural planning
- Statistics of transport routes
- General descriptions of transport infrastructure


Leica Pegasus:One
VALUE PROPOSITIONS
Plug and play with selected scanners and profilers. Take your existing scanner mobile
Vehicle independent fly-in, map, fly-out. Two cases. No dedicated modified vehicle
Combined imagery and point cloud Single calibrated intuitive solution: multiple ways of xyz collection
One supplier Single software and hardware solution from a single provider
Leica Geosystems development roadmap Brand value & future proof
Balances data needs with config & speed Delivers a customer ROI
Software embedded in ESRI ArcGIS Market leader in GIS
Google Street view style Professional and non-professional users
3D stereo option Improved work flow within ArcGIS
- when it has to be right
Leica Geosystems

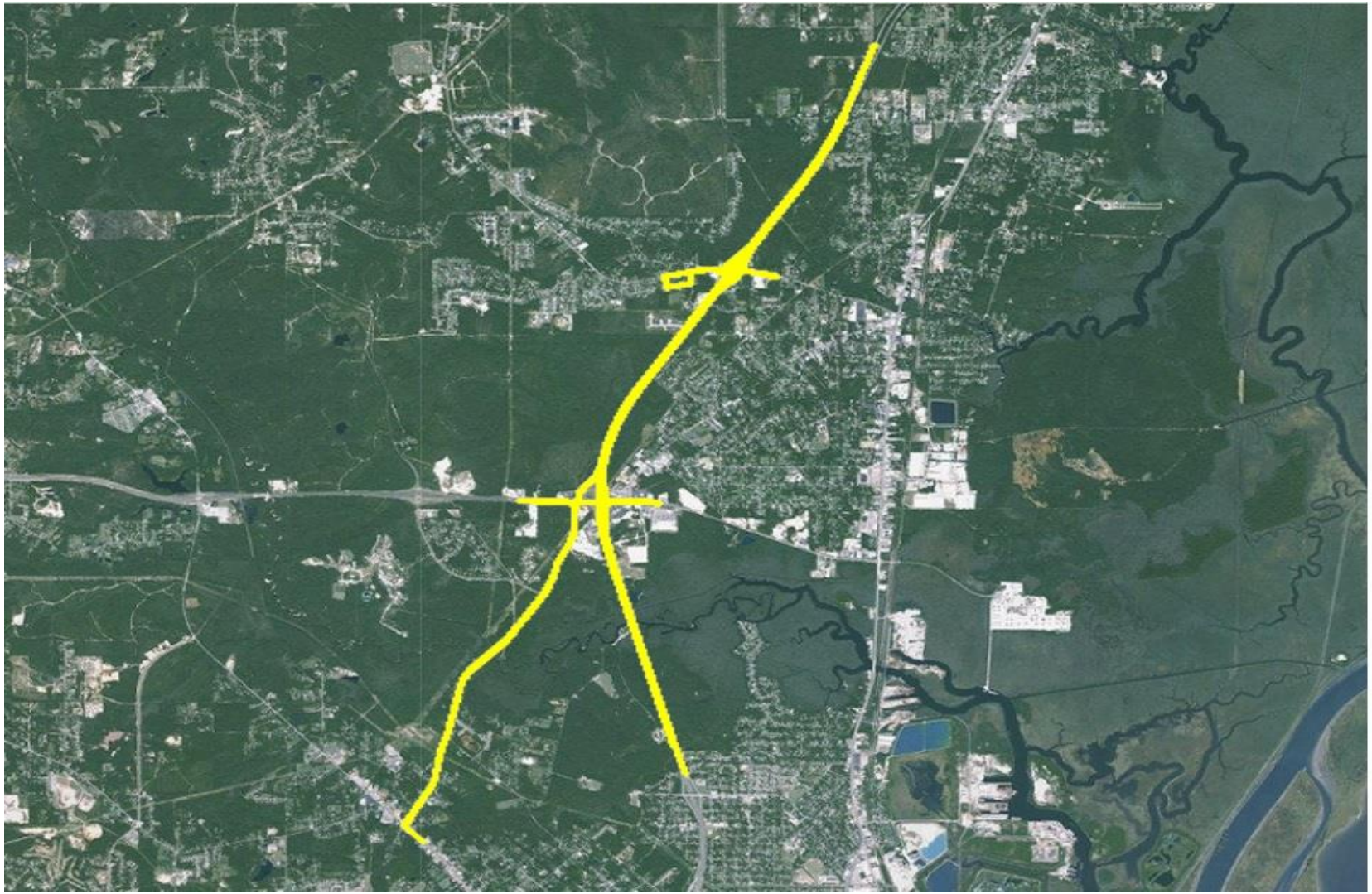
HEXAGON

Pegasus Example Data



HEXAGON

Pegasus Example Data



HEXAGON

Pegasus Example Data

HEXAGON

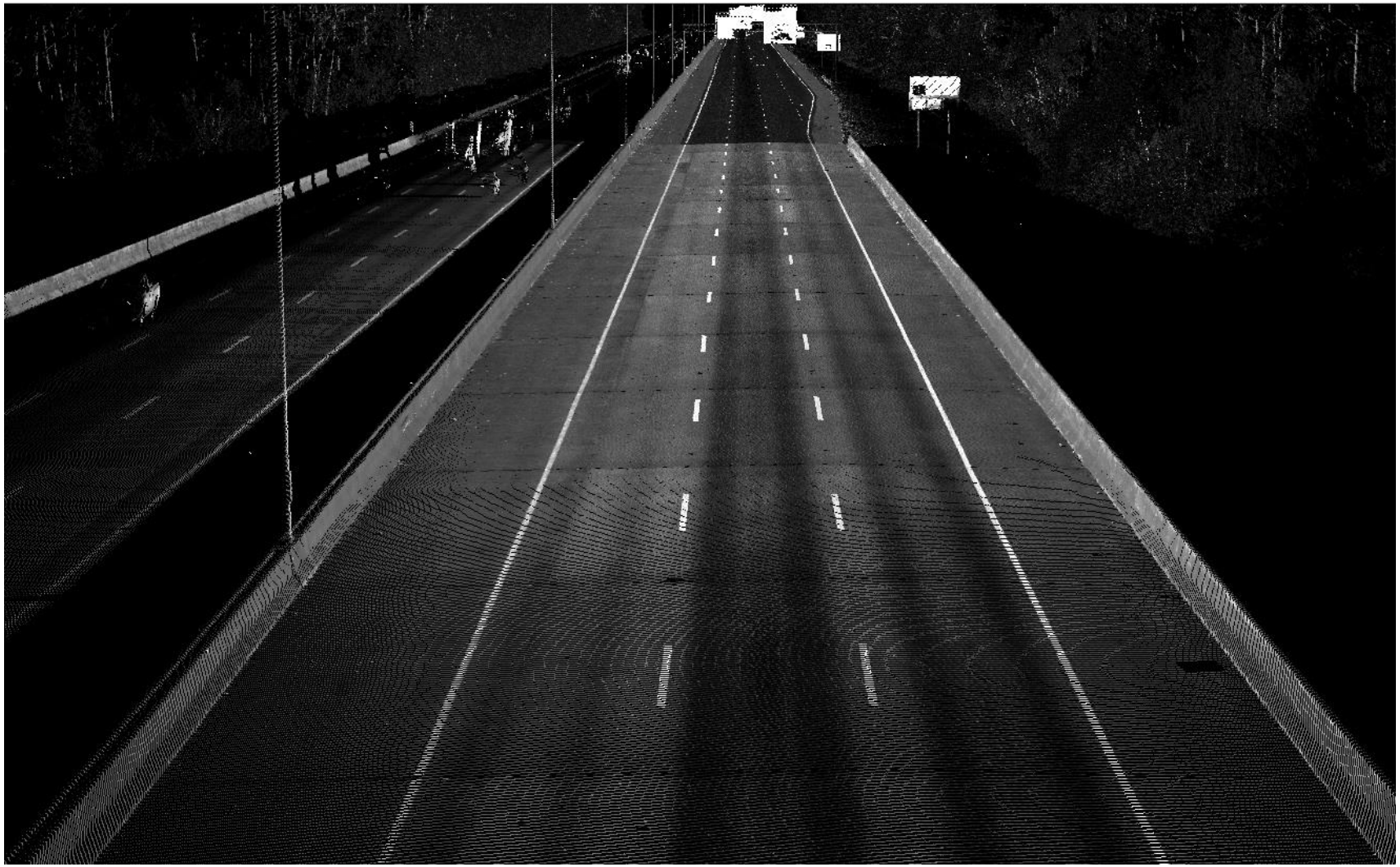
Pegasus Example Data

HEXAGON

Pegasus Example Data

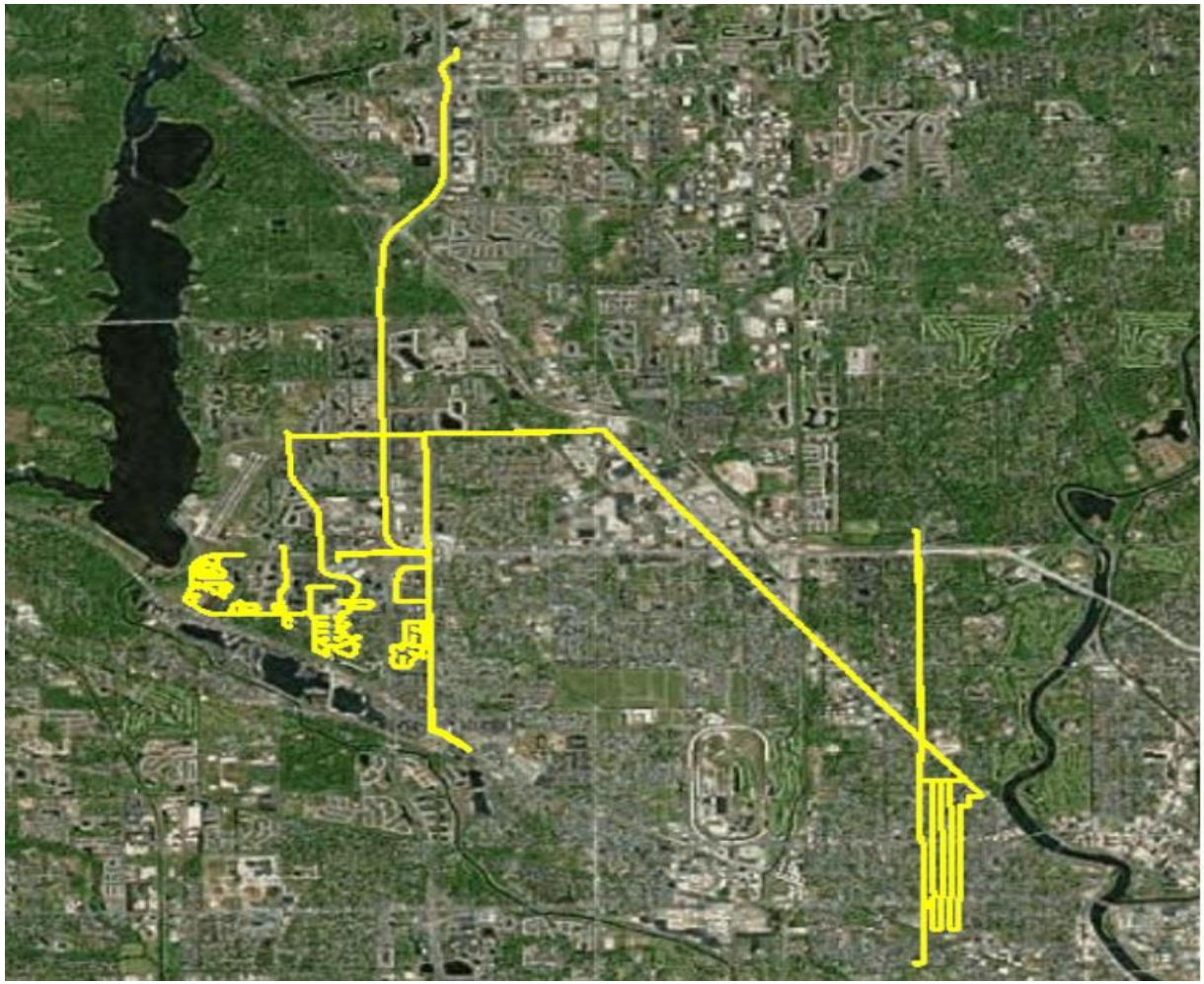
HEXAGON

Pegasus Example Data



HEXAGON

Pegasus Example Data



HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

Pegasus Example Data

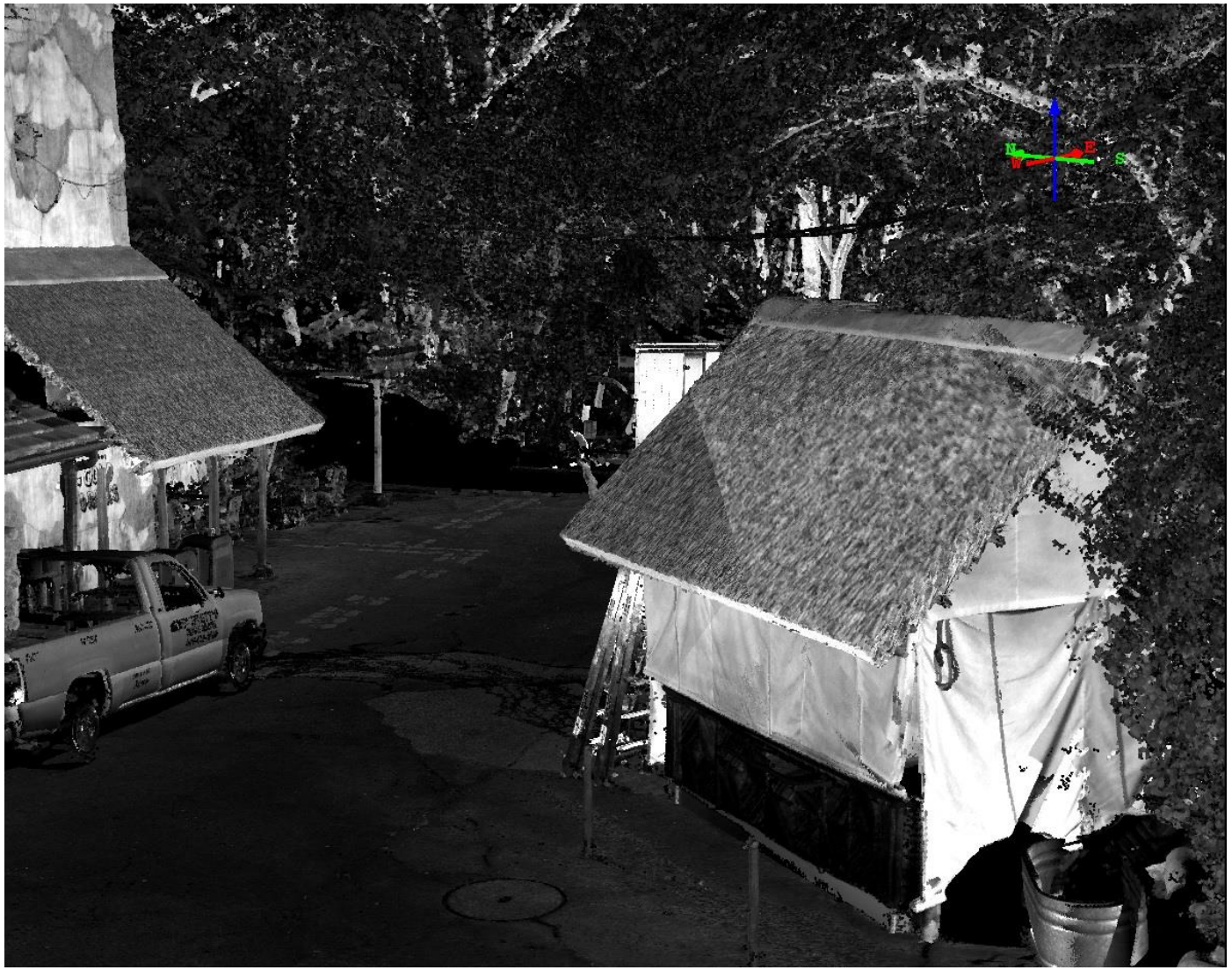
HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

Pegasus Example Data



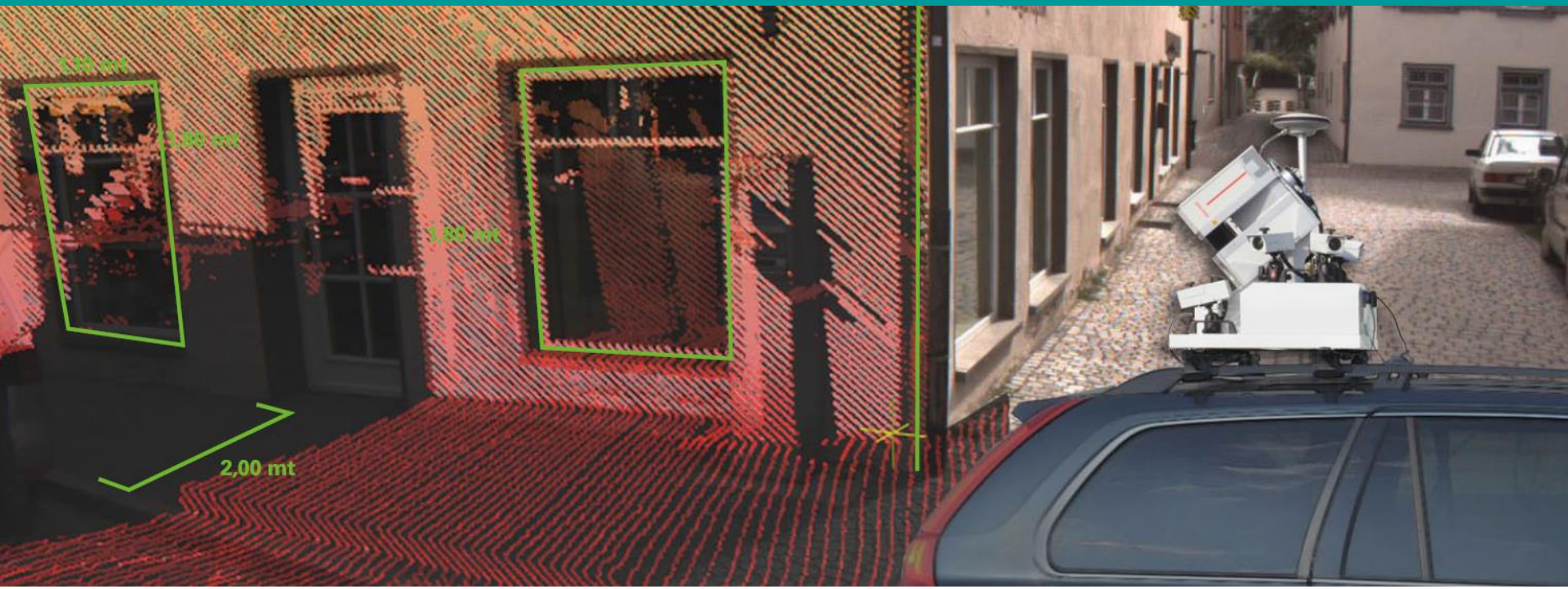
HEXAGON

Pegasus Example Data

HEXAGON

Pegasus Example Data

HEXAGON



Thank You

HEXAGON