High Resolution Multi-Lane Road Surface Mapping using 3D Laser Profilers

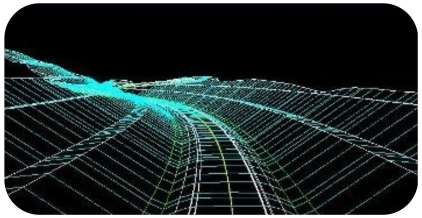
By
John Laurent
Pavemetrics Systems inc.
www.pavemetrics.com

The importance of road smoothness

- **Very bumpy roads:**
  - **30-40% increase of wear of road**
  - **Vertical acceleration increases dynamic load impact of traffic**
  - **Self destruction of bumpy road surfaces**
- **Driving comfort**
- **Fixed depth milling operations do NOT improve the longitudinal road profile**

Pavemetrics

Road Rehabilitation



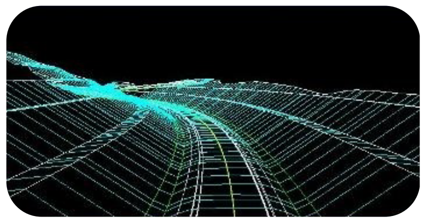
Ref.: Bentley Microstation InRoads ™

Ref.: http://construction.trimble.com/

Manual Road Surveying → Engineering CAD Tool → GPS/Laser Controlled Milling → GPS/Laser Controlled Paver

Pavemetrics

Road Rehabilitation

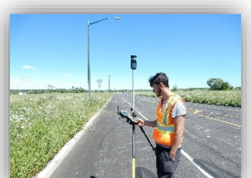


Ref.: Bentley Microstation InRoads ™

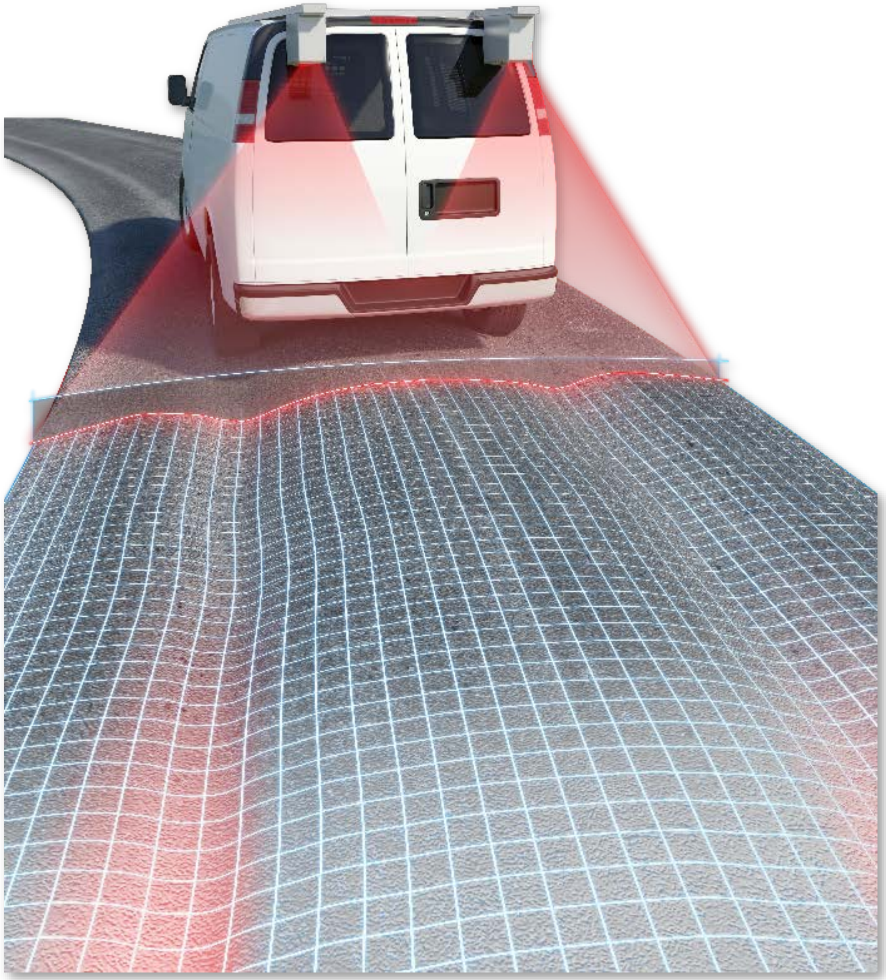
Ref.: http://construction.trimble.com/

LDTM Road Surveying (100km/h) → Engineering CAD Tool → GPS/Laser Controlled Milling → GPS/Laser Controlled Paver

Control Points Only → LDTM Road Surveying (100km/h)



LDTM – Surveyor grade Terrain Mapping



Pavemetrics

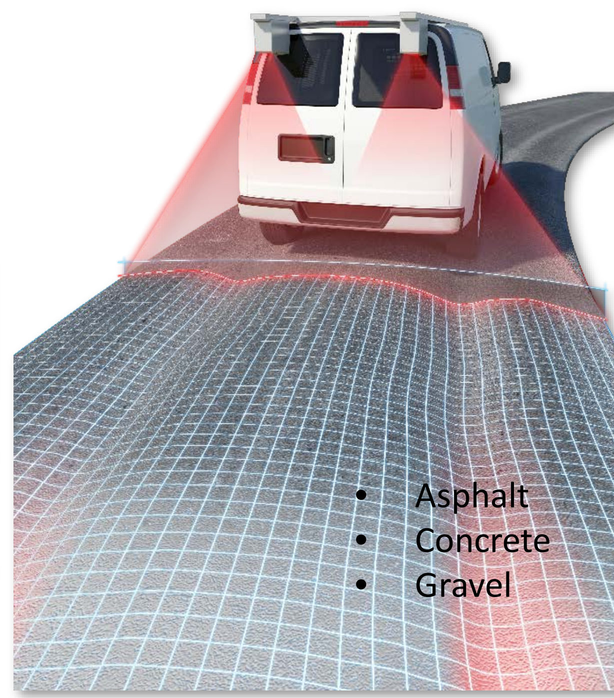
Pavemetrics LDTM solution

1. LCMS system

- 2 Laser profilers (4 meters field of view)
- 2 Inertial Measurement Units (IMU)
- Distance Measuring Instrument
- (DMI)

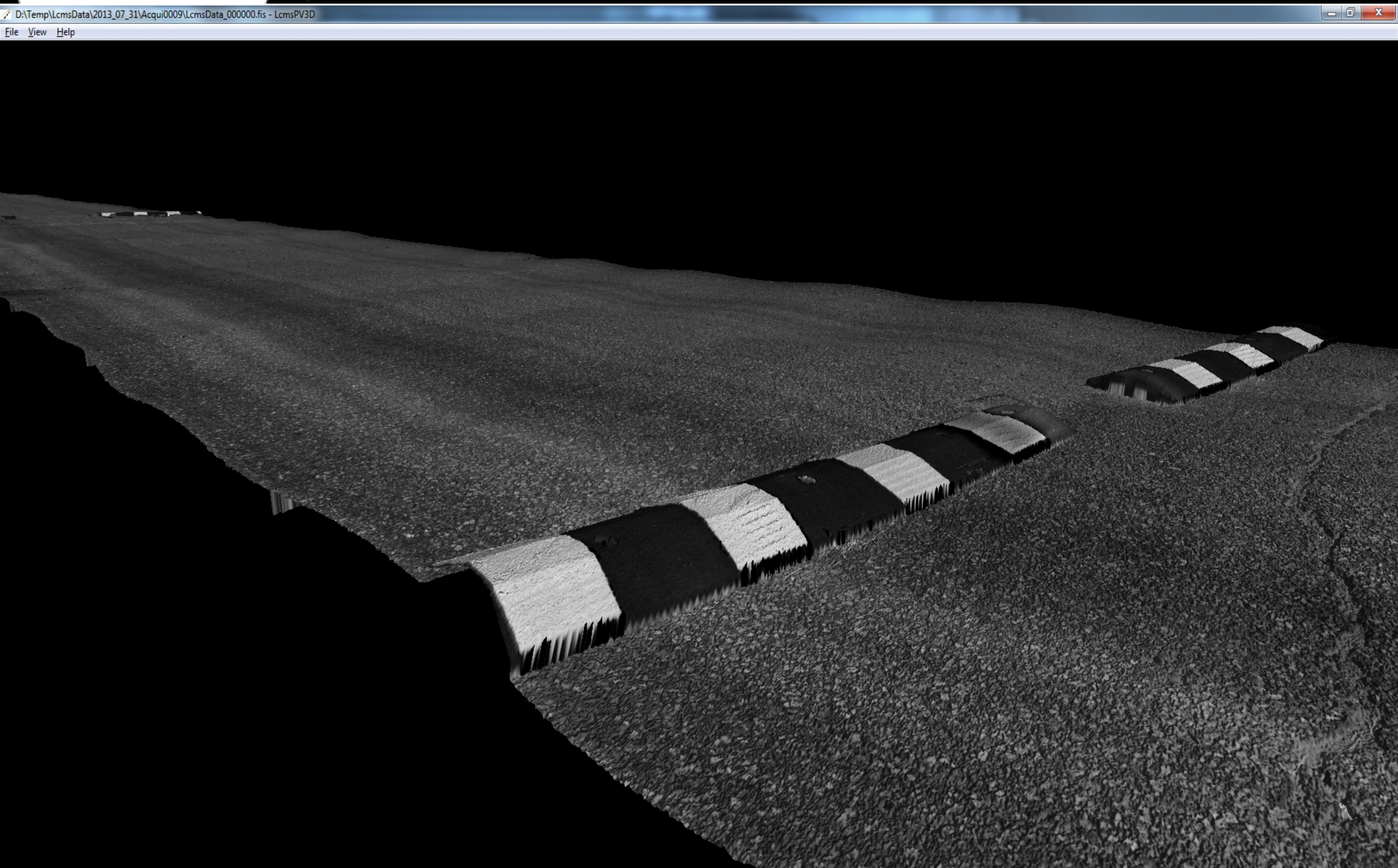
2. Applanix POS-LV 420

- Optical encoder (DMI)
- Inertial Measurement Unit (IMU)
- GNSS



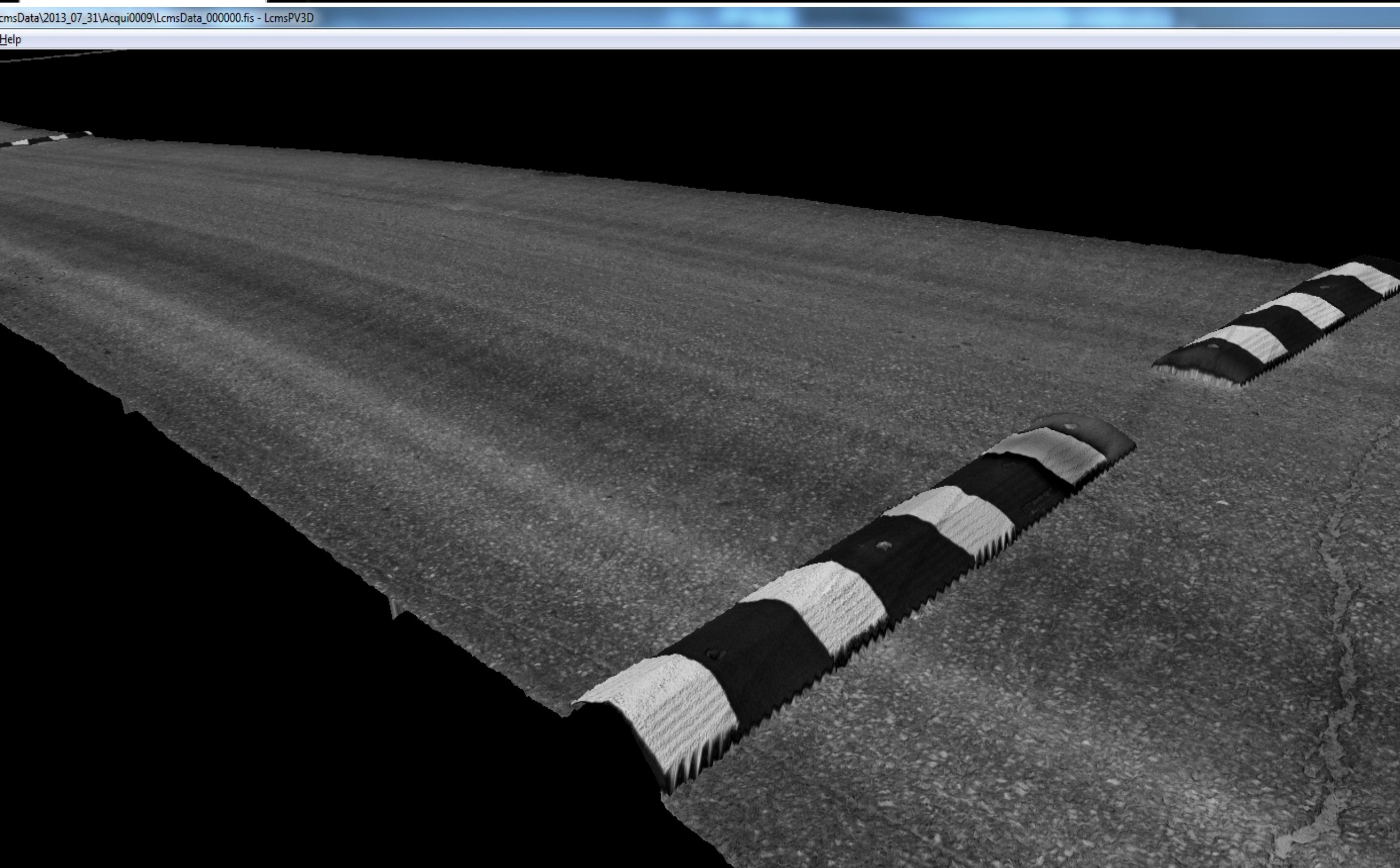
Pavemetrics

3D Road Profile Before Dynamic Corrections



Pavemetrics

3D Road Profile After Dynamic Corrections



Pavemetrics

LDTM - Steps

- Equipment Calibration
- Survey
- Processing
  - Navigation solution
  - Controls Points
  - Stitch lanes
- Data Exportation

LDTM Calibration

1 - Scan of the calibration validation object

2 – Stop and GO

3 – Measurement of the position of the sensors

Done only once during sensors installation

LDTM Calibration

LDTM Survey

Data Processing

Control Points

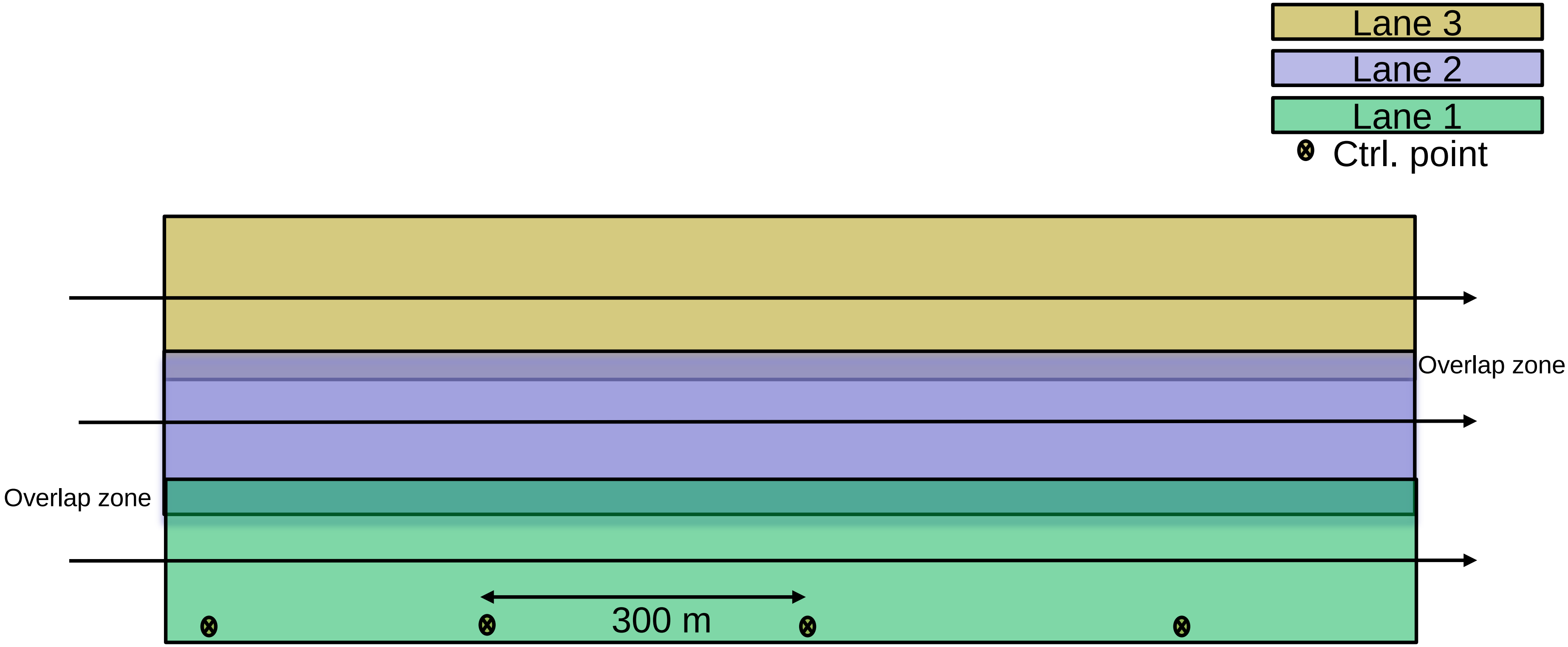
Tie Points

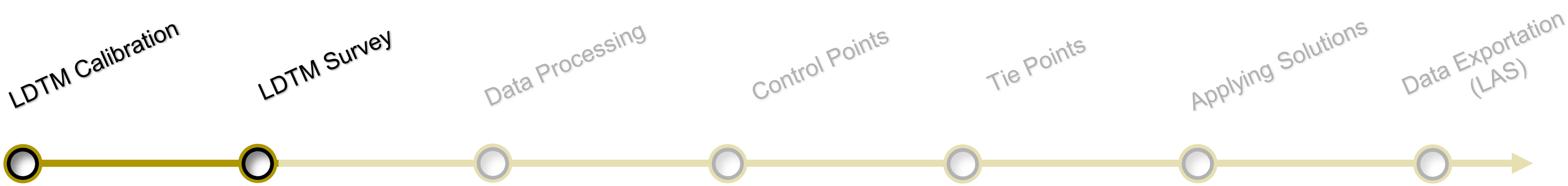
Applying Solutions

Data Exportation (LAS)

Pavemetrics

LDTM Survey



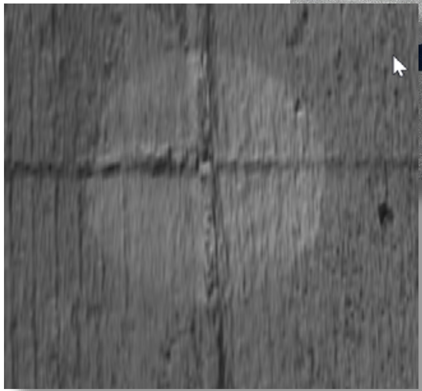


Ground Control Points Survey

Pavemetrics

Ground Control Points

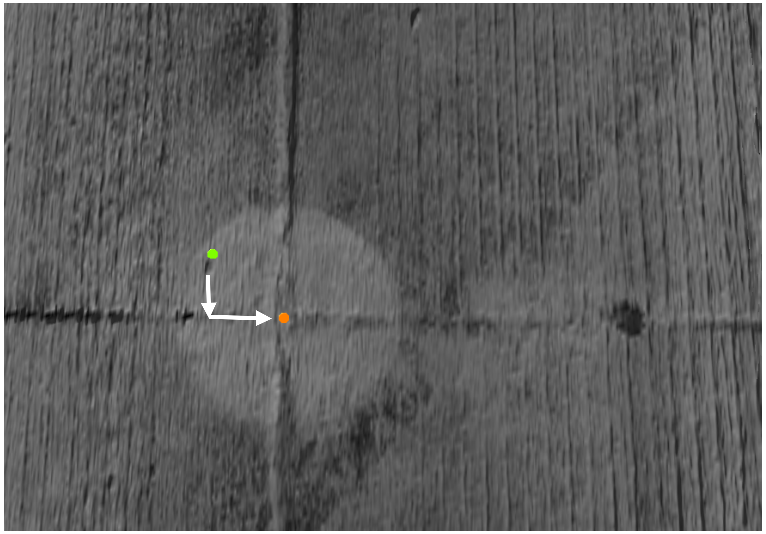
- Surveyed using a robotic total station
- One point every 300 meters on road surface or shoulder
- Converted in UTM
- Imported in LCMS-PV3D software



LDTM Calibration — LDTM Survey — Data Processing — Control Points — Tie Points — Applying Solutions — Data Exportation (LAS)

Control and Alignment Points

LCMSPV3D ALIGNMENT POINTS CREATION

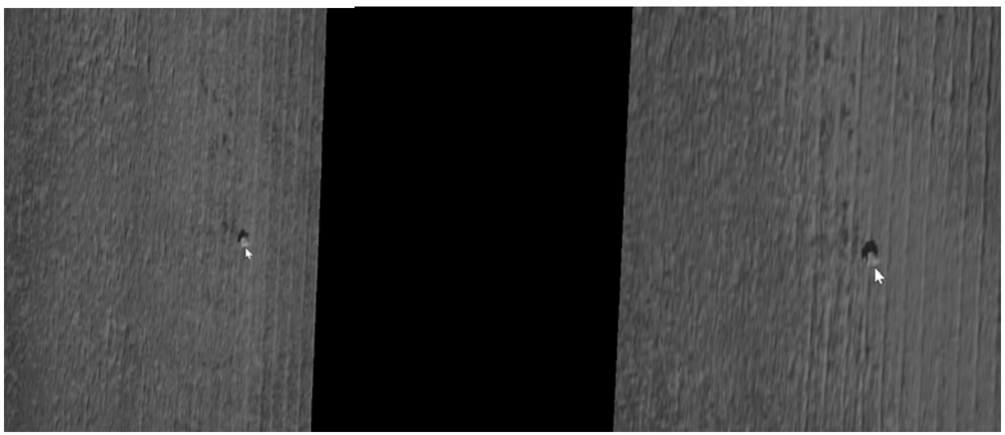


Green dot – Ground Control Point
Orange dot – Alignment point

Conclusion:
The entire surface is shifted down and right

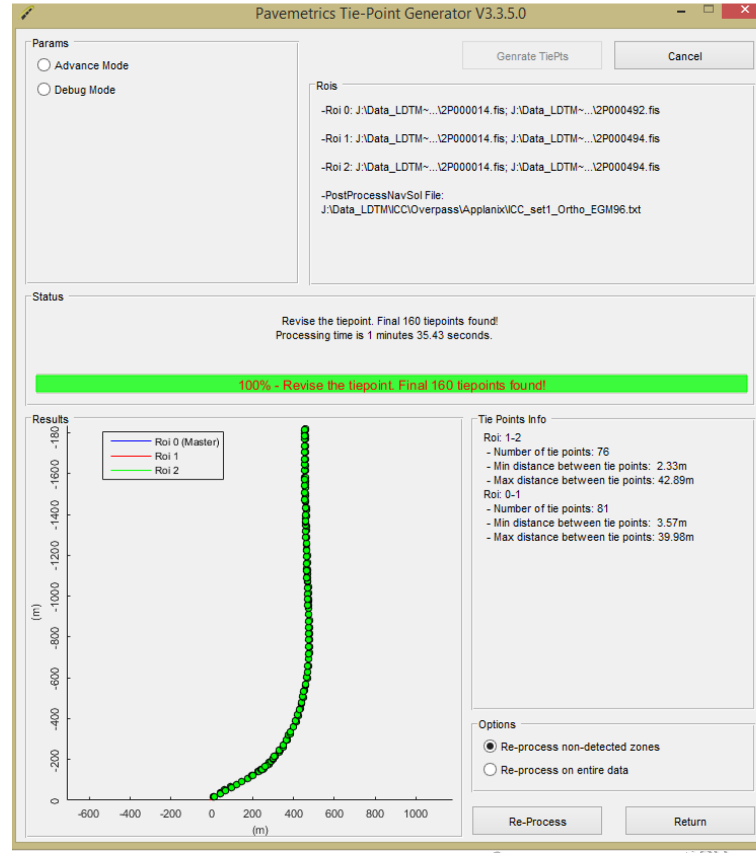
Tie Points Creation - Automatic mode

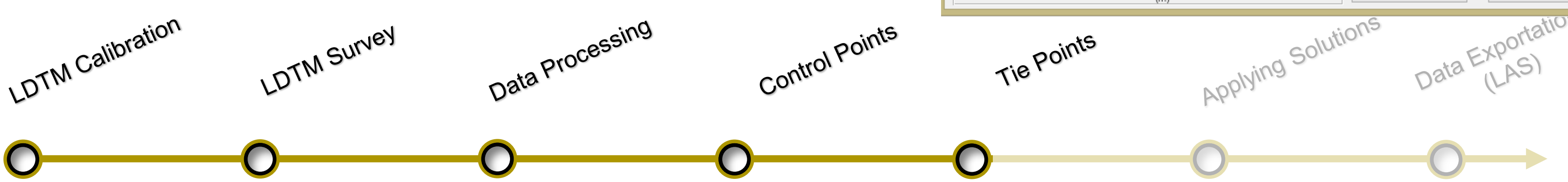
PV3D - Finds and select common features in overlapping areas



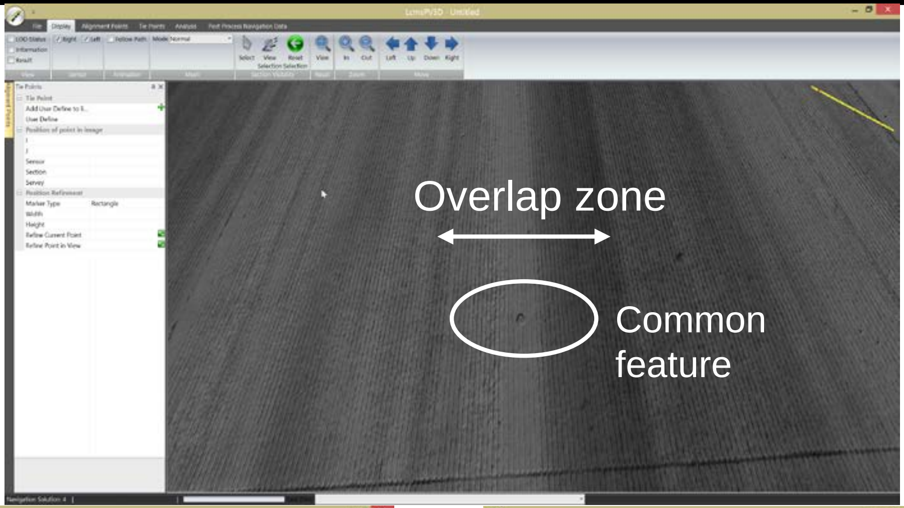
Run 3

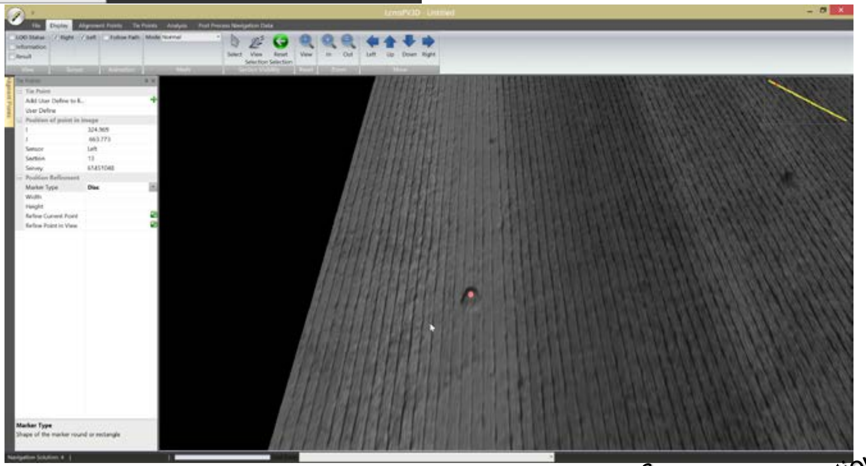
Run 2





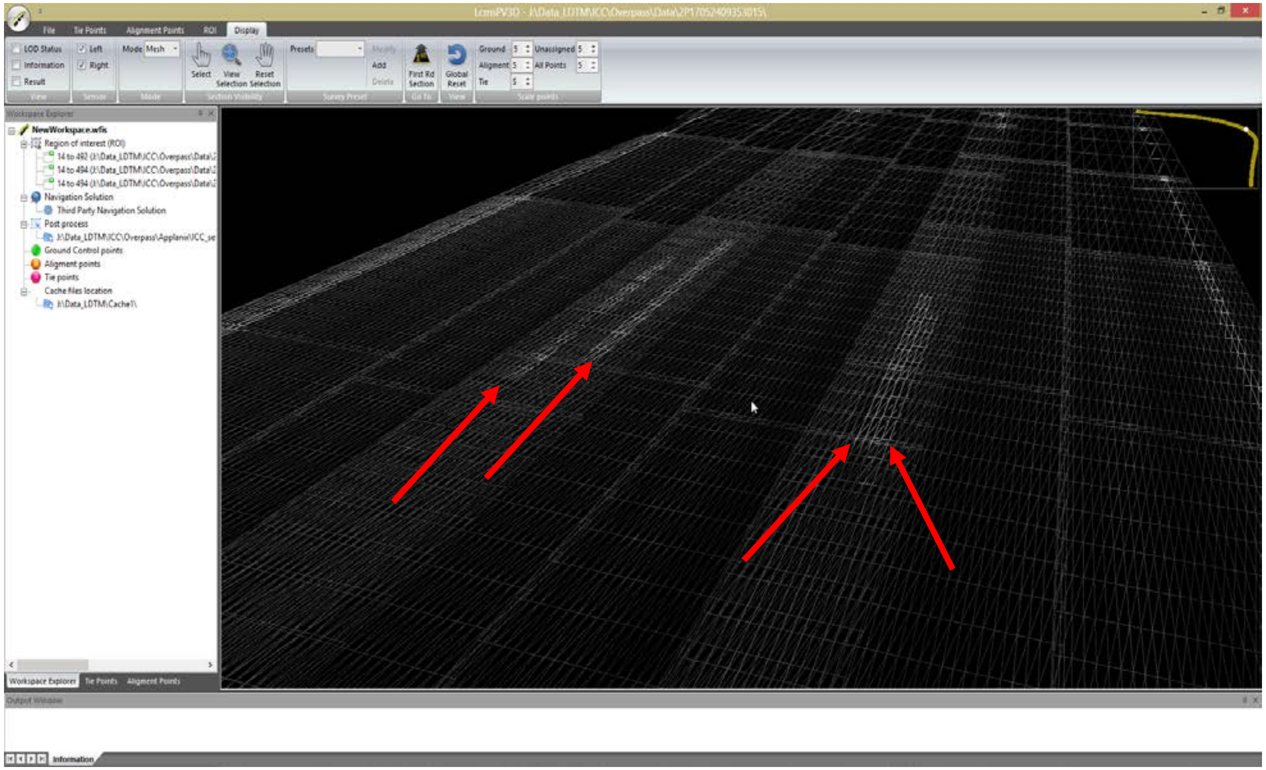
Tie Points Creation





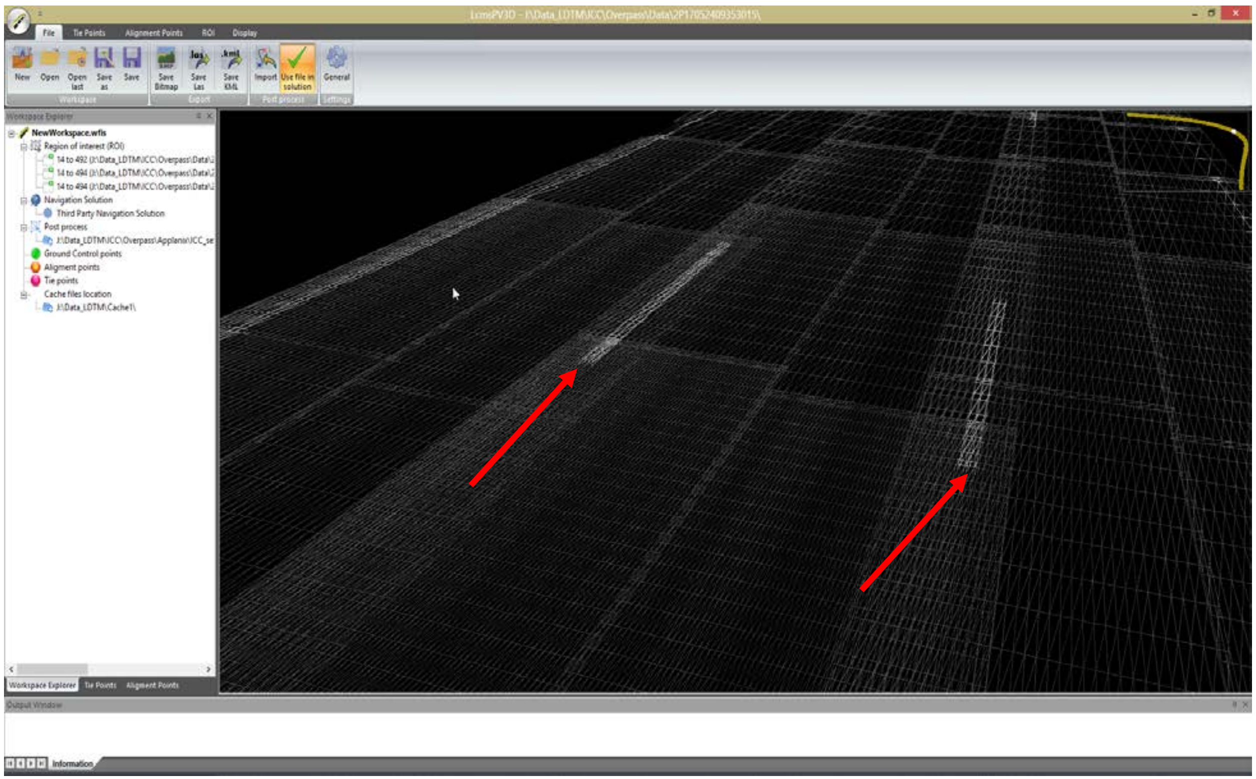
LDTM Calibration
LDTM Survey
Data Processing
Control Points
Tie Points
Applying Solutions
Data Exportation (LAS)

Shift Between Runs Before Processing Results (example)



Pavemetrics

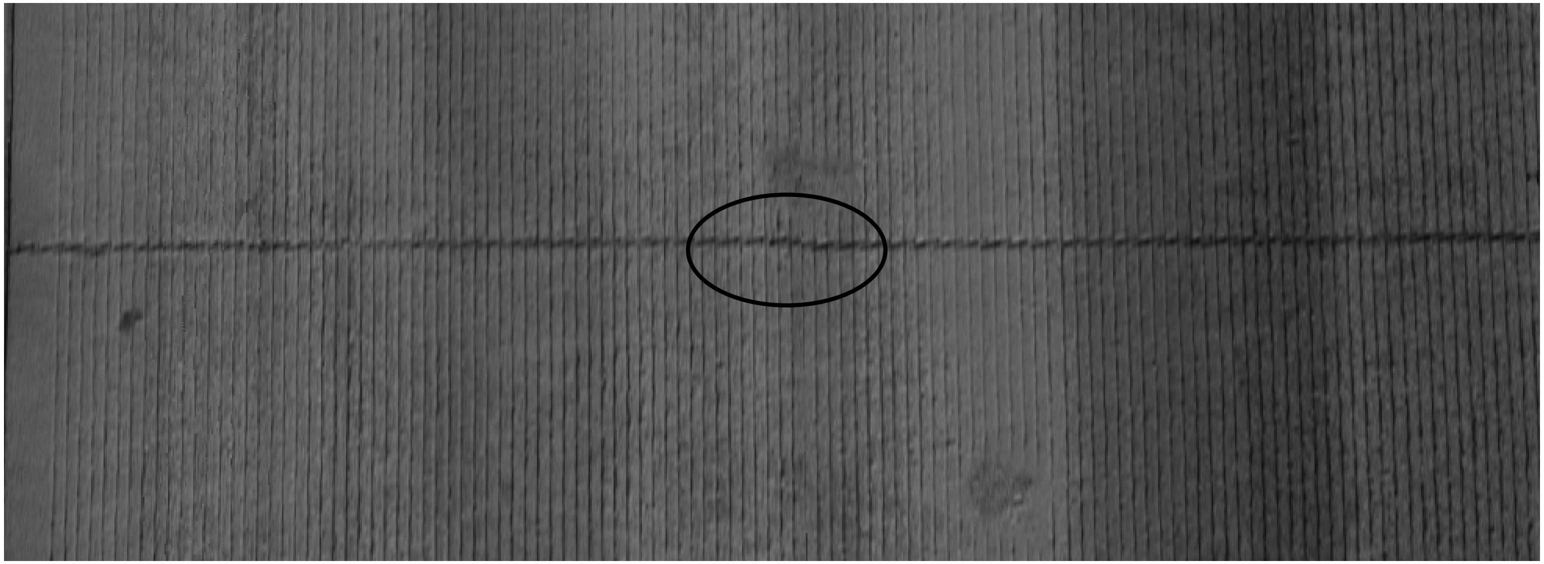
No more shift between runs after processing is applied



Pavemetrics

Stitching

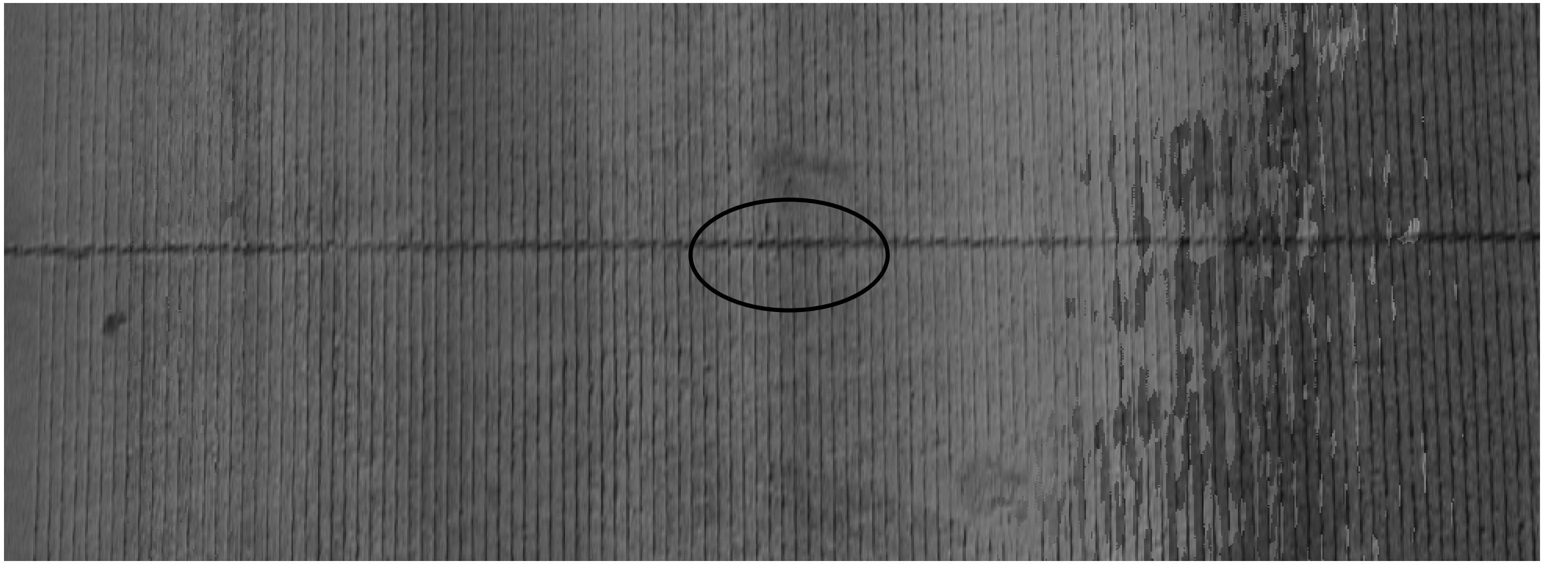
Stitching Runs (before processing)



LDTM Calibration
LDTM Survey
Data Processing
Control Points
Tie Points
Applying solutions
Data Exportation (LAS)

Stitching

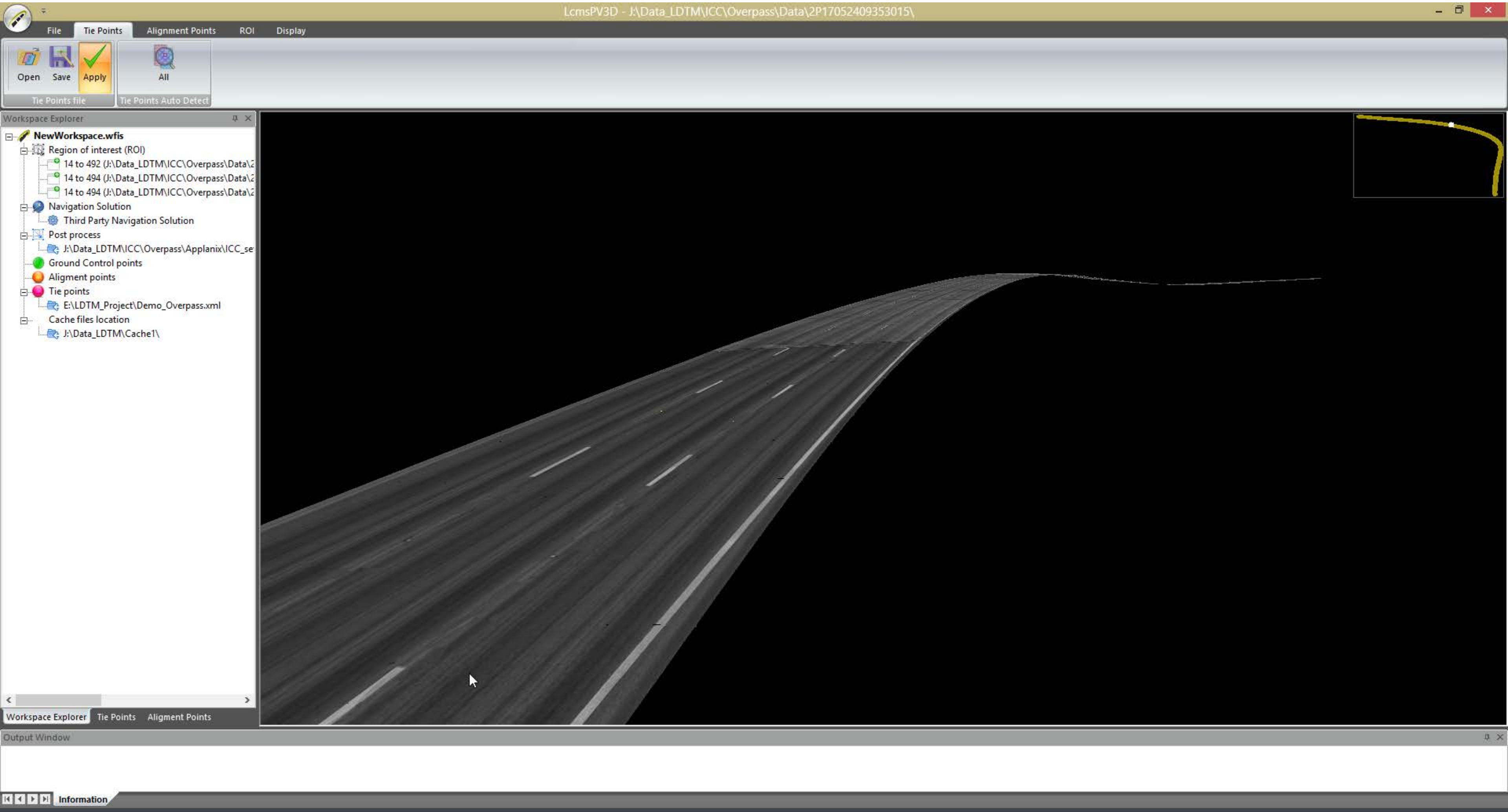
Stitching Runs (after processing)



LDTM Calibration
LDTM Survey
Data Processing
Control Points
Tie Points
Applying solutions
Data Exportation (LAS)

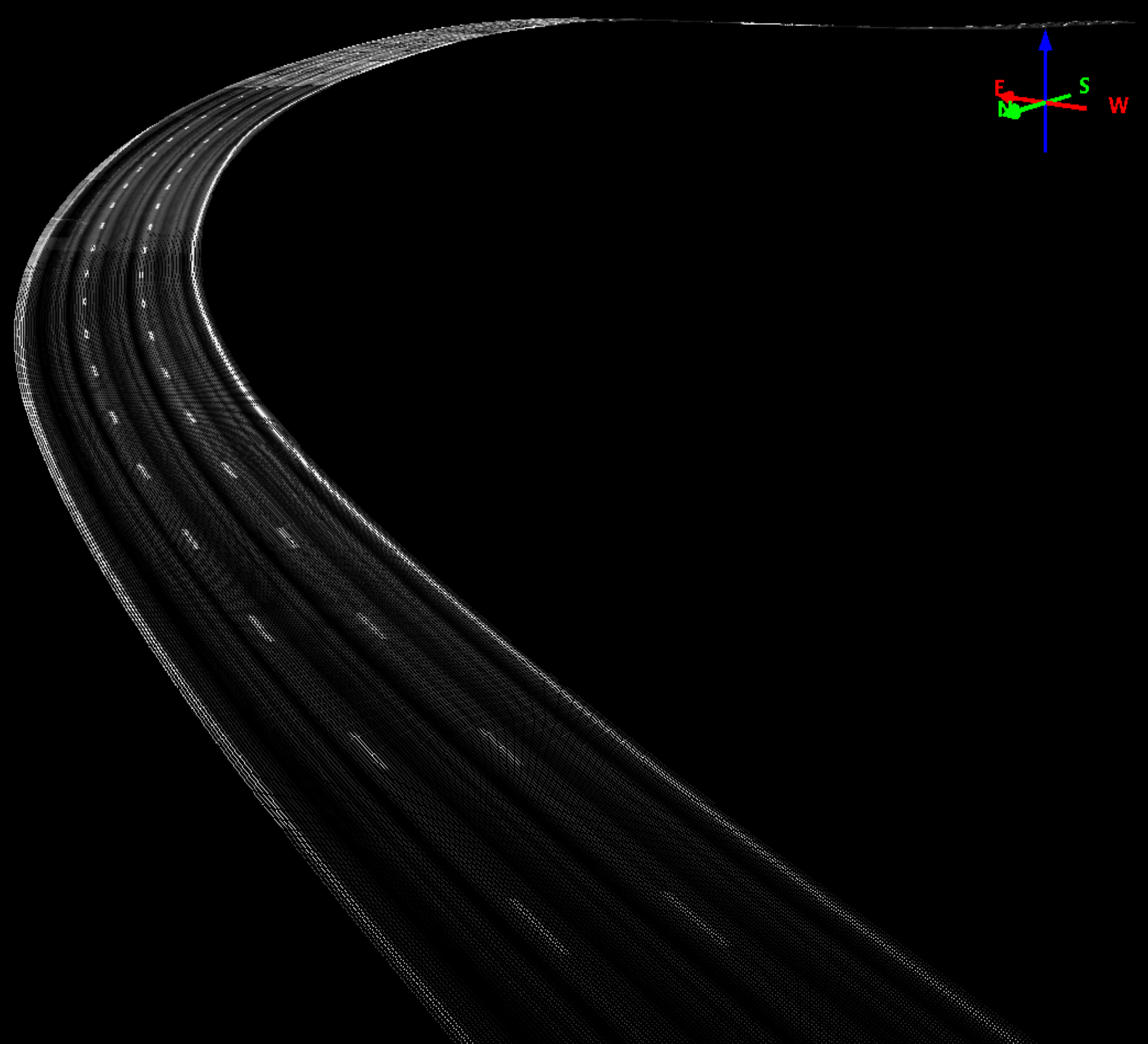
Pavemetrics

Final surface



Pavemetrics

LAS file (10cm x 10cm)



LDTM vs Ground Truth – 300m

Accuracy compare to GT (Avg. in mm): X: 5.0 Y: 4.0 Z: 2.5
Repeatability compare to first scan (mm)*: X: 3.0 Y: 5.0 Z: 2.0

*Mean of RMS Error over 12 scans

Runway 08-26, Montmagny, QC

Runway 08-26, Montmagny, QC

Runway 08-26, Montmagny, QC

Survey Specifications

Total length of runway: 900 meters

Total width of runway: 30 meters

6 surveyed control points were used (3 on each end of the runway)

44 surveyed test points were distributed over the entire runway surface.

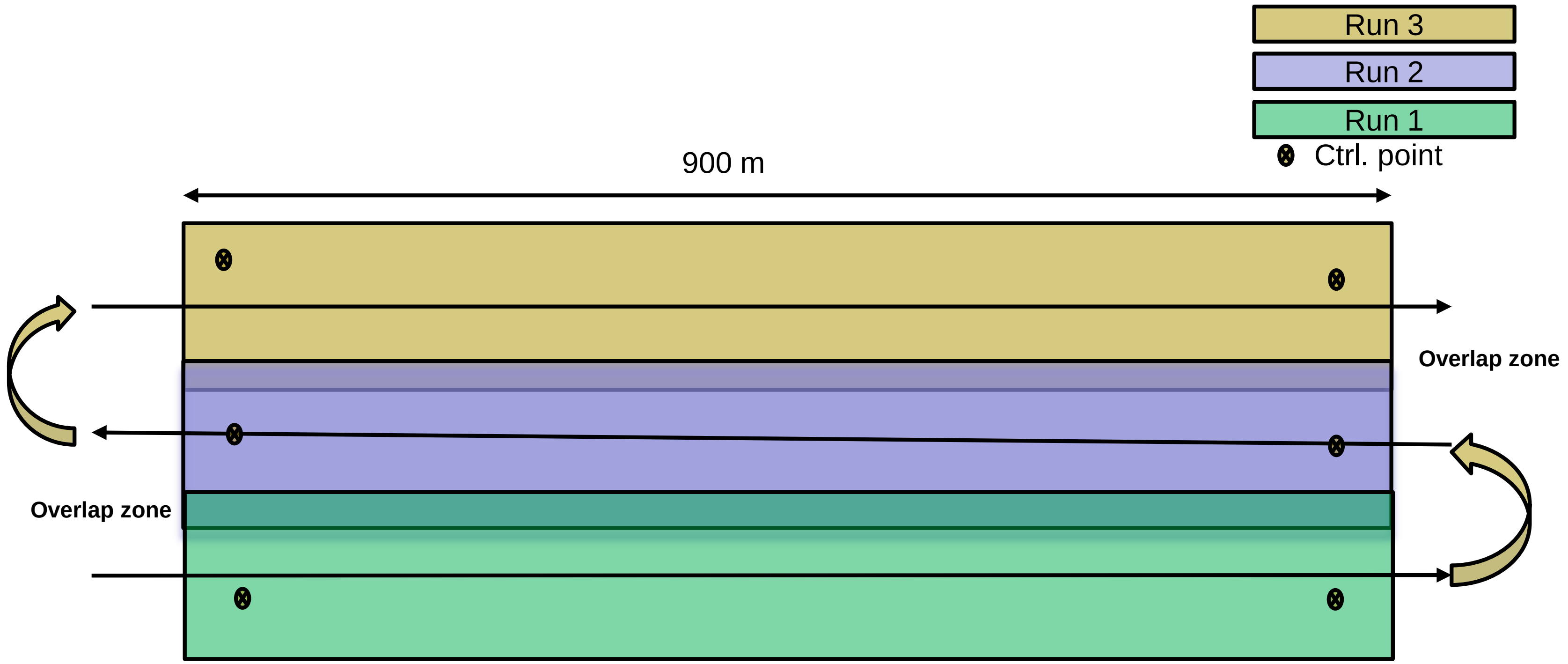
Total survey time 15 minutes

Total survey length 12km

Number of scans used to cover runway surface: 11* (total in both directions)

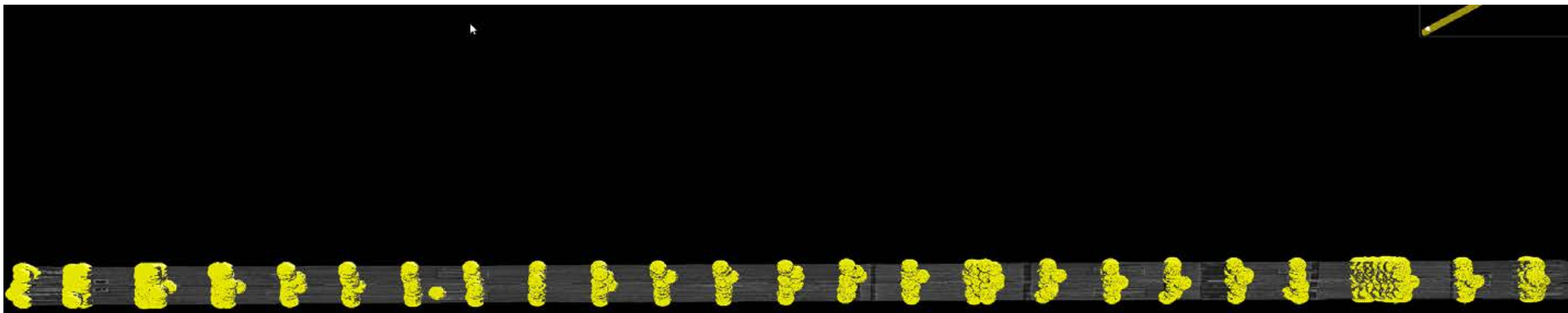
***A large number of scans were used to insure overlap between runs**

Survey (11 runs with approx. 1m overlap between runs)



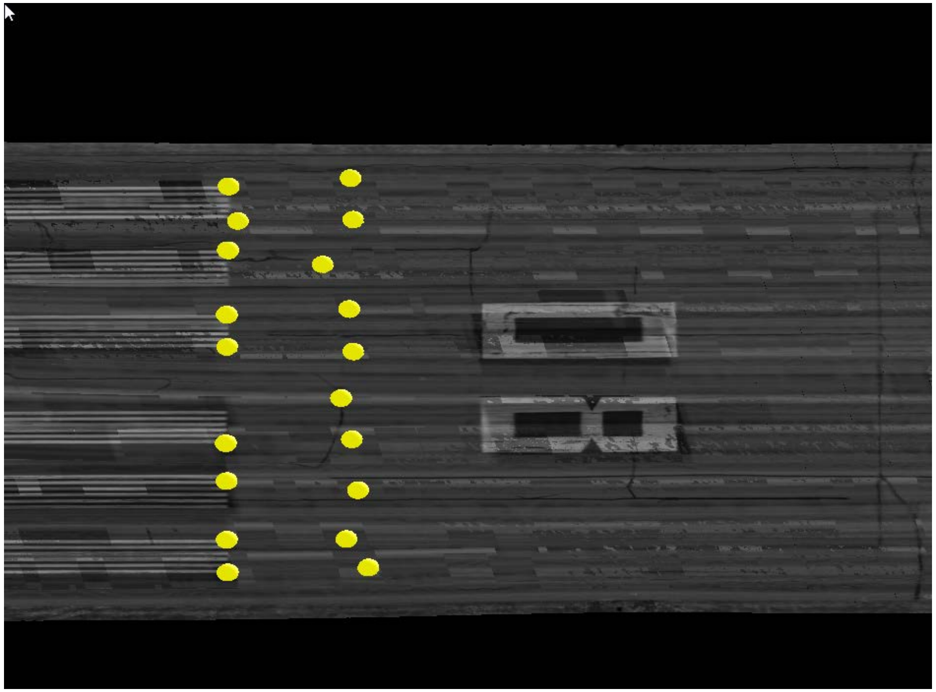
Pavemetrics

Tie Points (every 40m)



349 tie points were automatically generated and used to automatically stitch the 11 runs

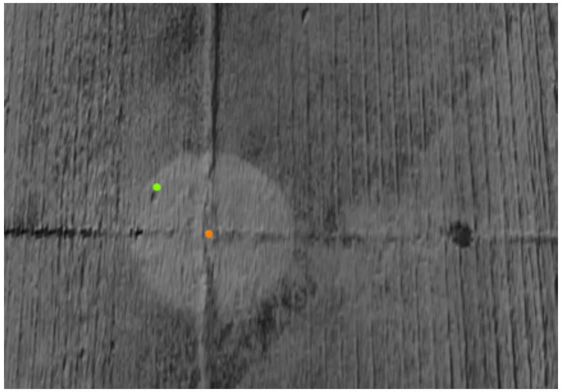
Tie Points



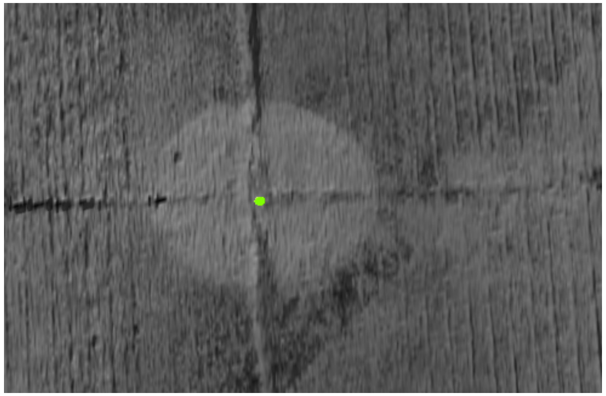
Control Points

6 surveyed control points (located on the ends of the runway) were used to align the Pavemetrics data to the traditional survey

Control Points (manual)

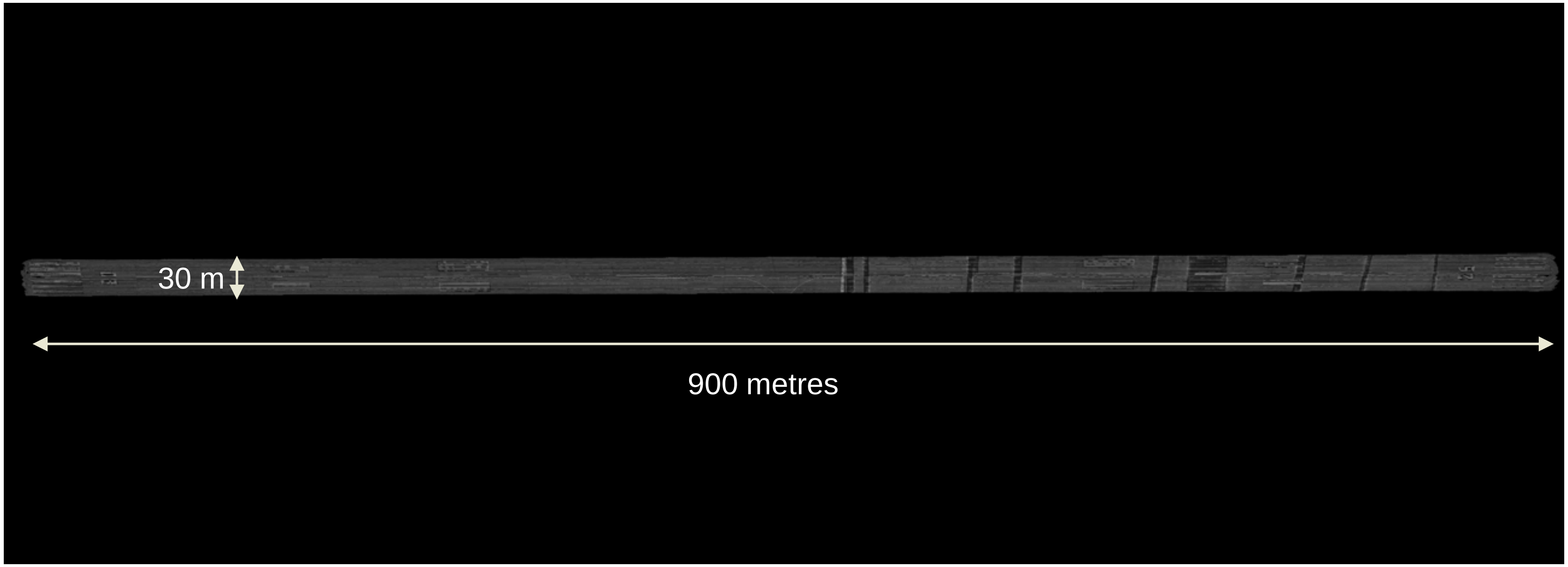


Green: Position of control point before alignment.
Orange: Alignment point



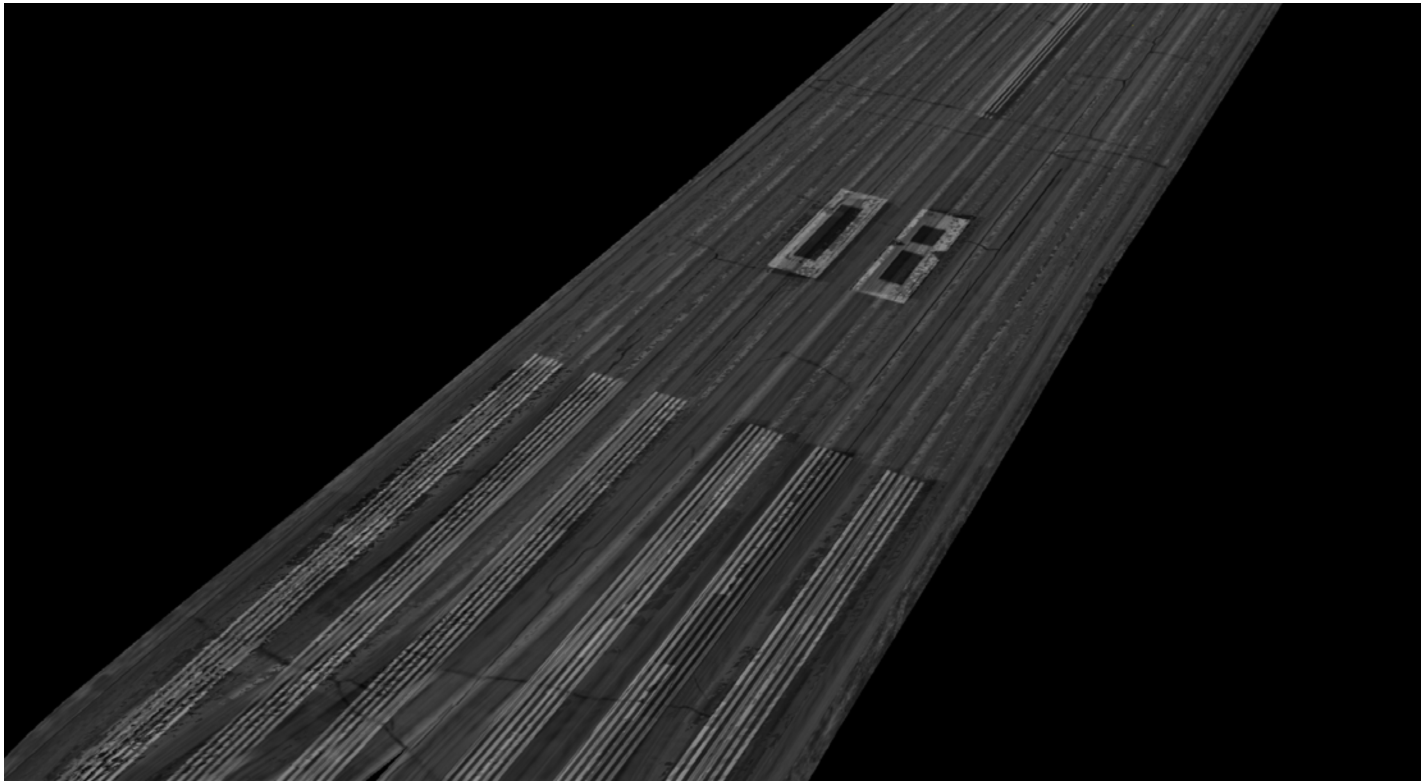
Green: Position of control point after alignment

Runway 08-26 - result

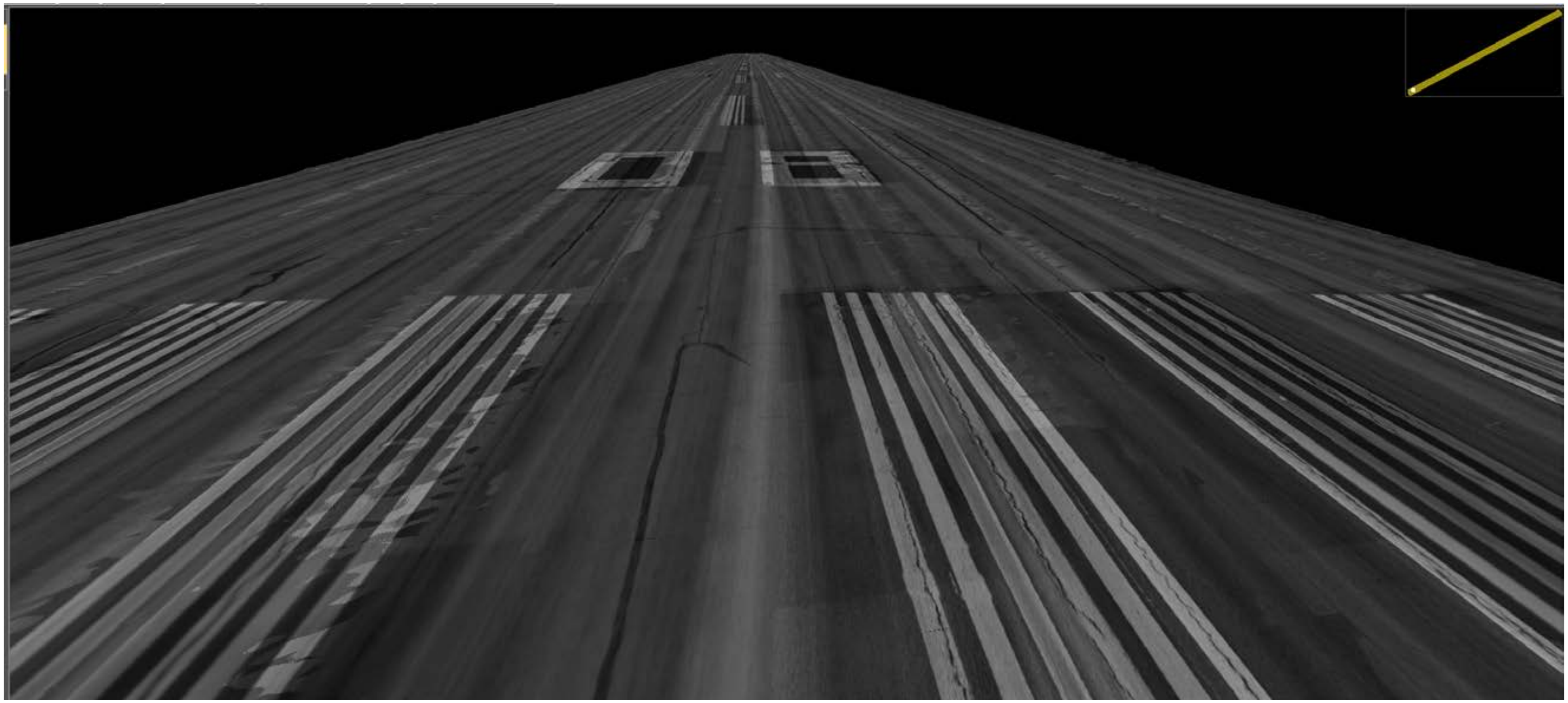


Pavemetrics

Runway 08-26 - result



Runway 08-26 - result

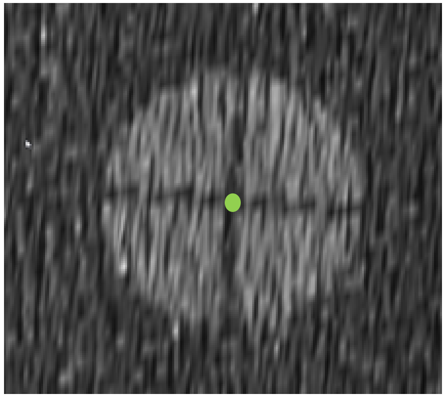


Pavemetrics

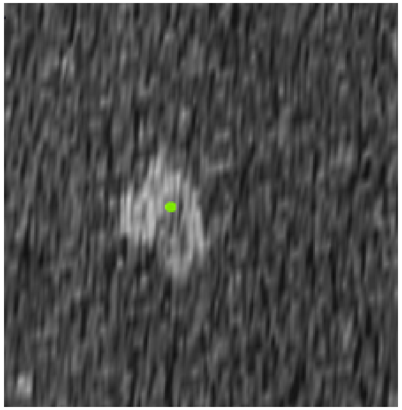
Accuracy Analysis

The accuracy of the LDTM solution was evaluated using 44 survey targets which were painted on the runway

Due to the shape of the painted targets X, Y coordinates were difficult to match, however elevation data (Z) was excellent

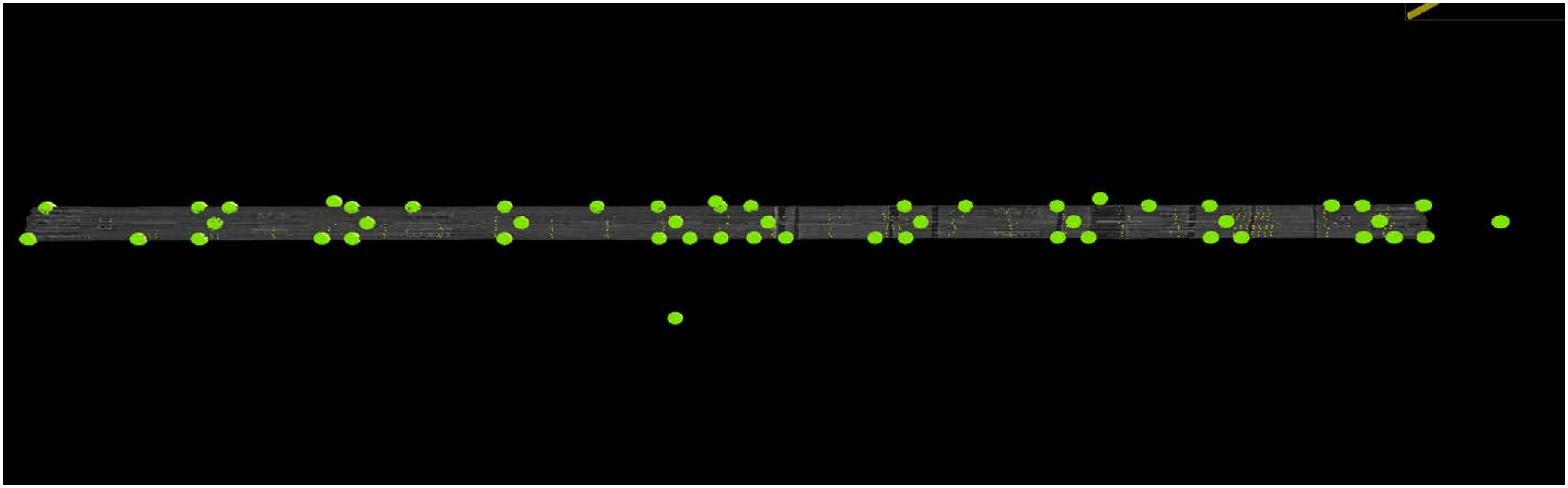


What we wanted!



What we got!

Survey Target Locations Overlaid on Pavemetrics' Data



Surveyed test points used to evaluate the accuracy of the LDTM solution

Accuracy analysis

RTK Base GNSS used for the post-processing

- Base station was in La Pocatière, QC which is 62 km from the site

Survey time was only 15 minutes

Data preparation and processing time took 3 hours

The entire runway LDTM surface data was then compared to the 44 surveyed points to evaluate the overall errors

Pavemetrics

Conclusions

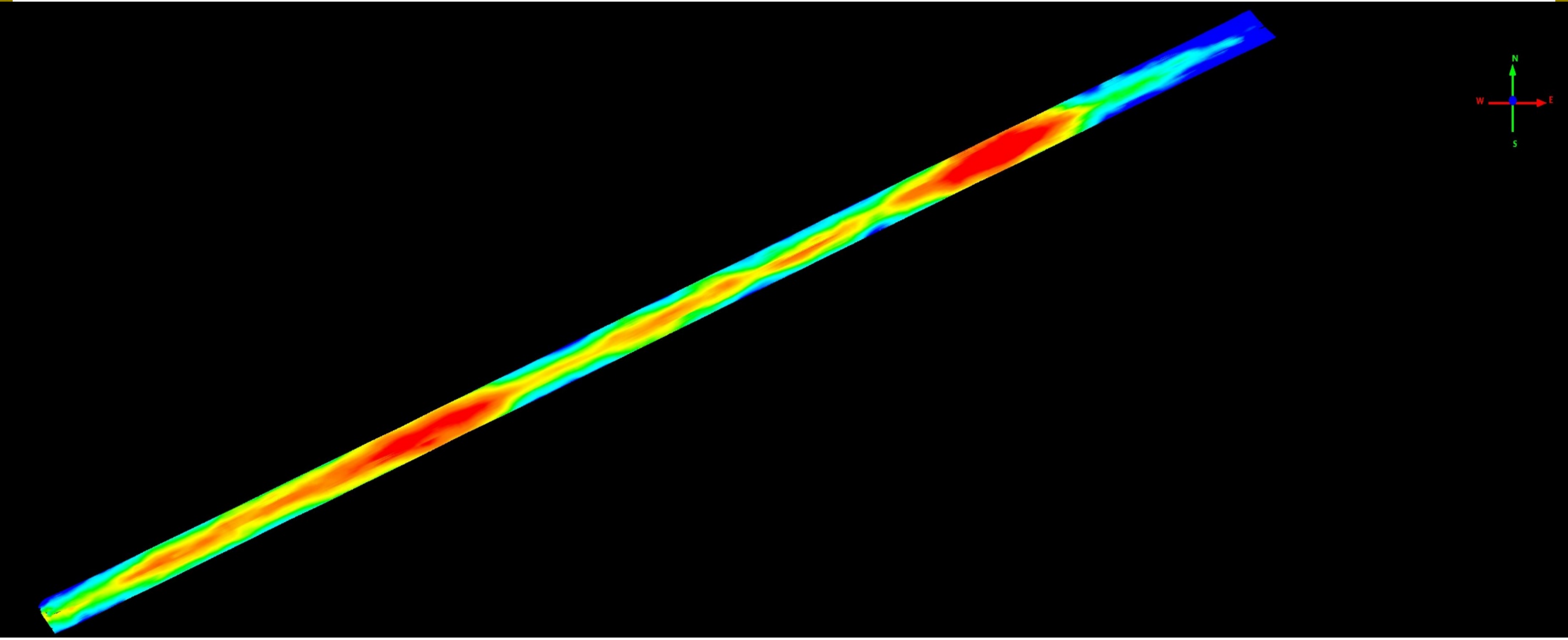
Accuracy versus survey results:

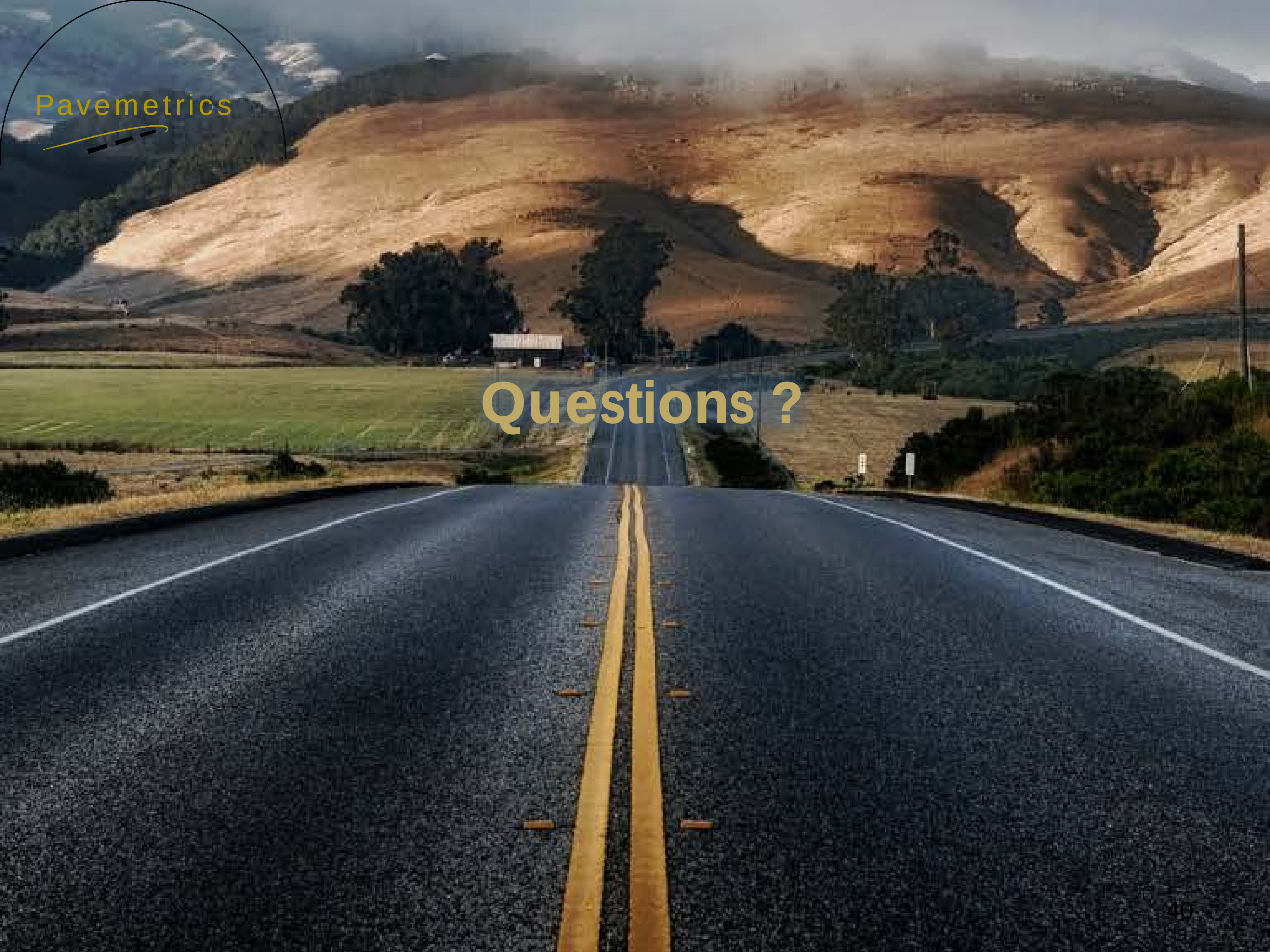
Average RMS Error [X; Y; Z]=[0.016; 0.011; 0.003]m

As expected X, Y accuracy was lower because of shape of painted survey markers.

Elevation accuracy was an amazing 3mm overall!

LAS file output (10cm x 10cm)




Pavemetrics
Questions ?