Pavemetrics

3D Mapping of Pavements: Geometry and DTM

Vision Technology for Inspection of Transportation Infrastructures

PAVEMETRICS Systems Inc.

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Québec, Québec, CANADA
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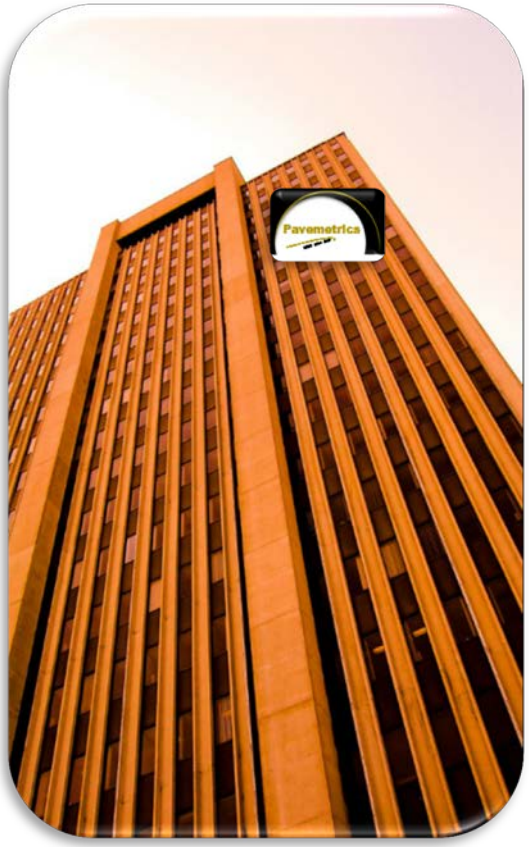
Pavemetrics; Infrastructure Vision Systems Specialists



Pavemetrics Headquarters
(Banque Nationale Bldg., QC)

- **Founded 2009; a "Spin-off" of Canada's National Optics Institute (INO)**
- **Develop high-speed, mm-level scanning and pattern analysis systems**
- **20,000,000+ Miles of Data Collected Since 1997**
- **300 Systems in 30+ countries**

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The Sensor Technology Most Relied-on by DOTs worldwide

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Collect Your Own, or Contract-out

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INTERNATIONAL CYBERNETICS
Where technology meets the road

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EnterInfo

Dynatest®
Pavement engineering specialists & equipment

LVM

SNC·LAVALIN

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LCMS – Certified Technology

NOT a prototype

<u>Certified</u> AND proven around the world.

AASHTO THE VOICE OF TRANSPORTATION

ASTM INTERNATIONAL

INTERNATIONAL CERTIFICATIONS ISO 9001

CE

FC

TÜV SÜD ISO 9001

DEPARTMENT OF HEALTH & HUMAN SERVICES • USA FDA

NEMA

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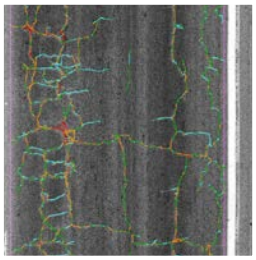
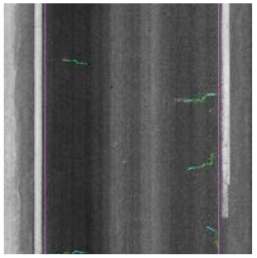
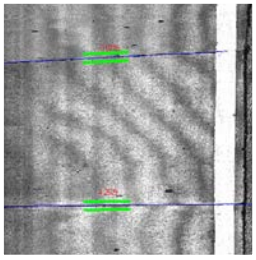
Any Paved Surface



Hotmix

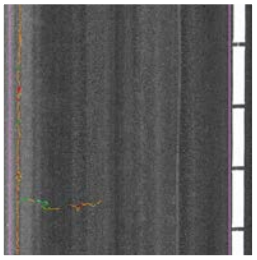
Chipseal





Concrete

Porous



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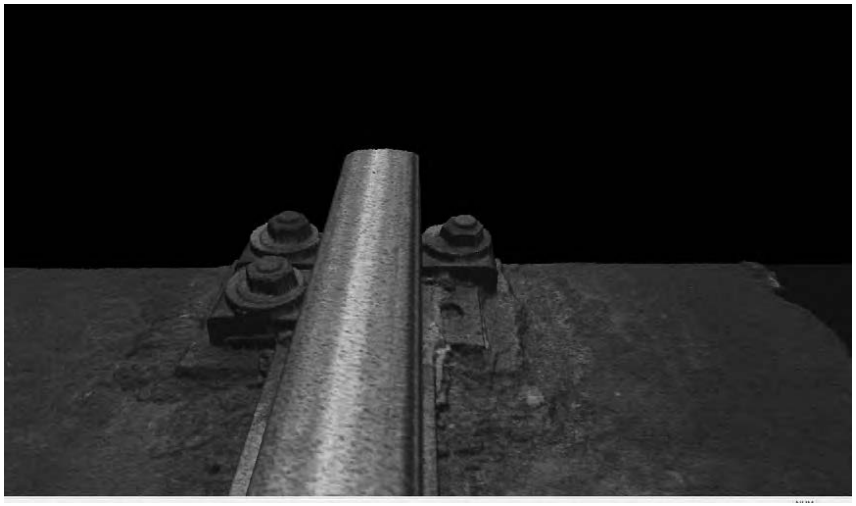
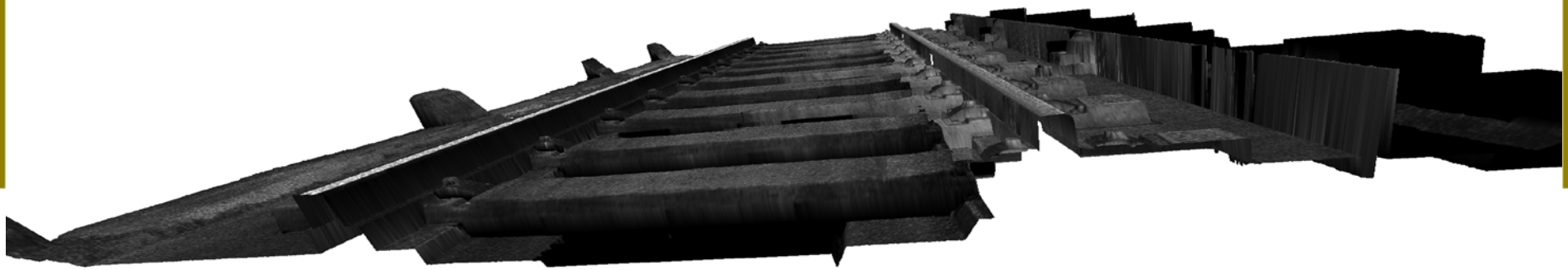
APPLICATION: Rails





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APPLICATION: Tunnels

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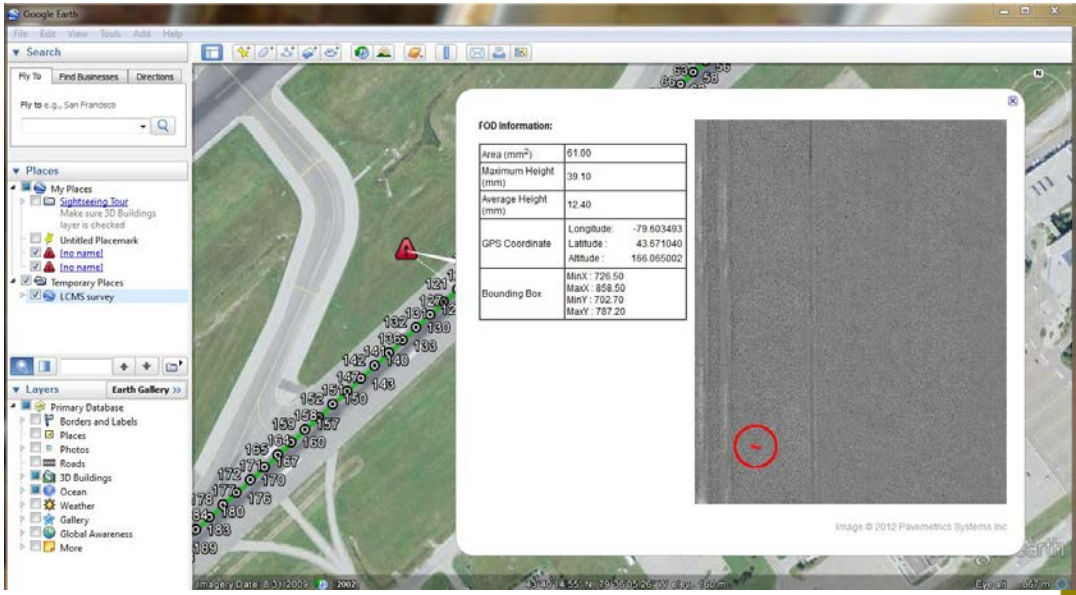
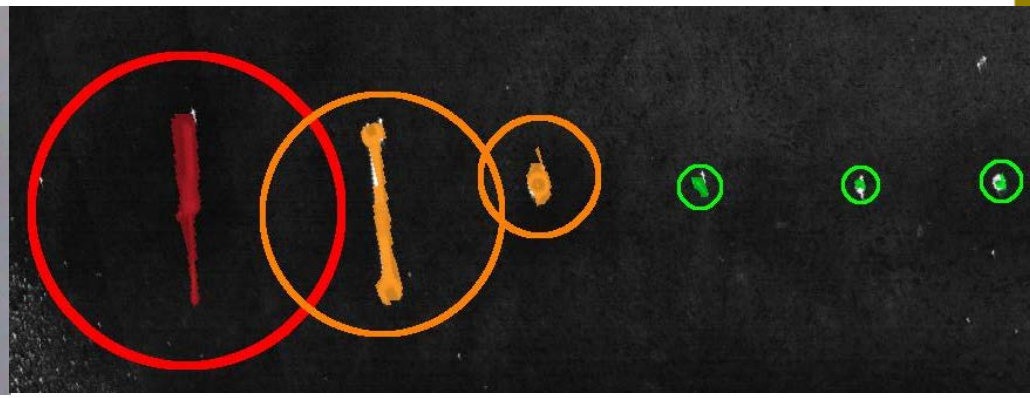
Application: Airports - FOD





Runways currently scanned with Pavemetrics Technology

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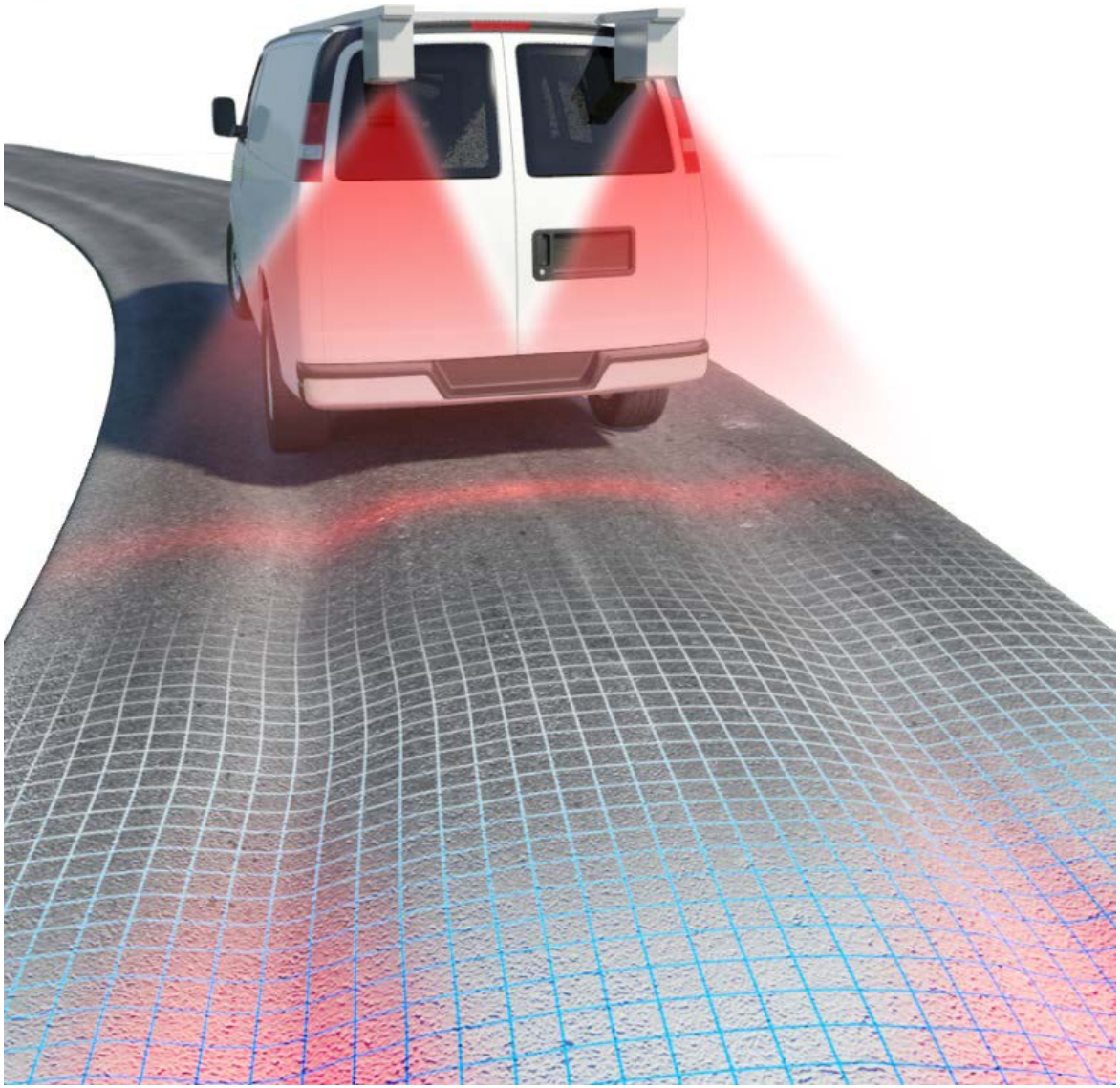
Application: ROADS distress and DTM



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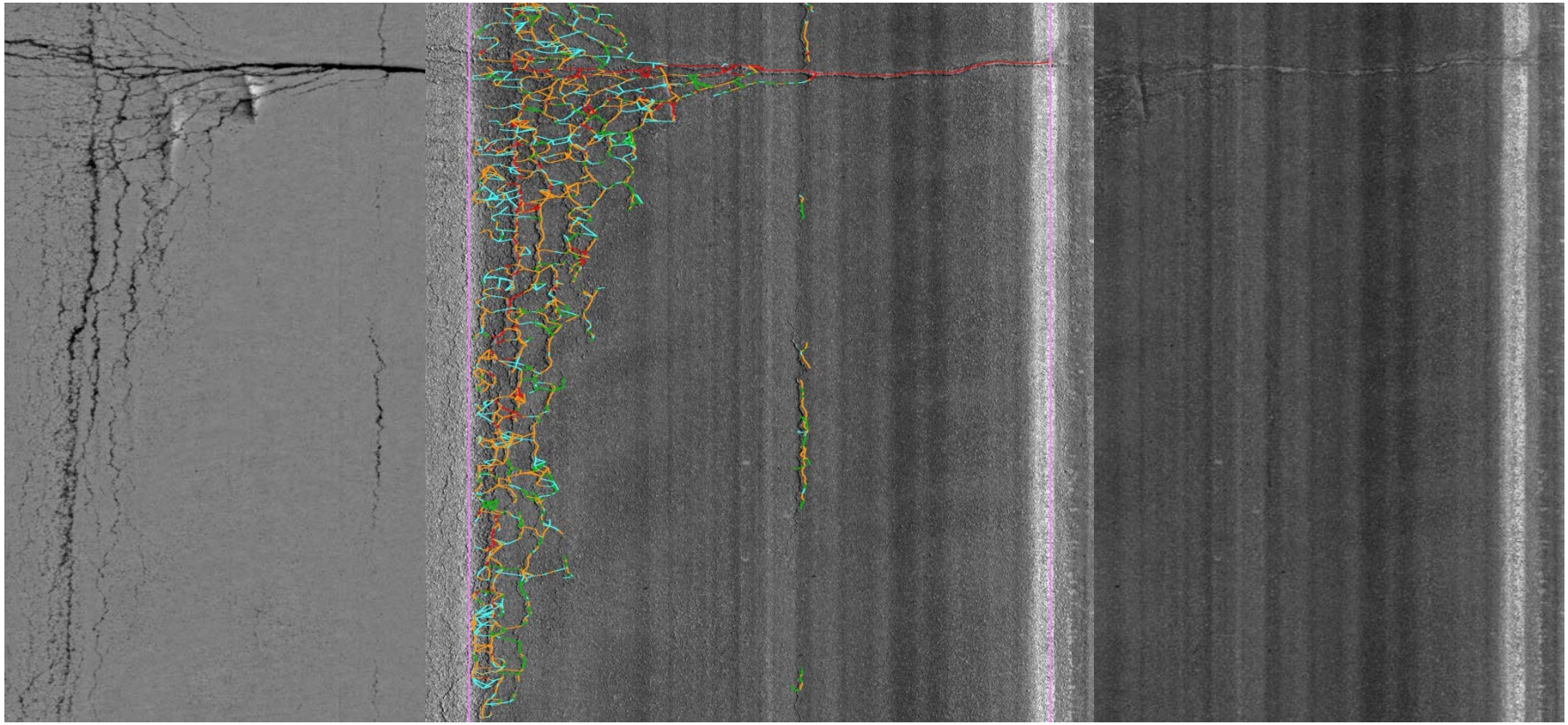
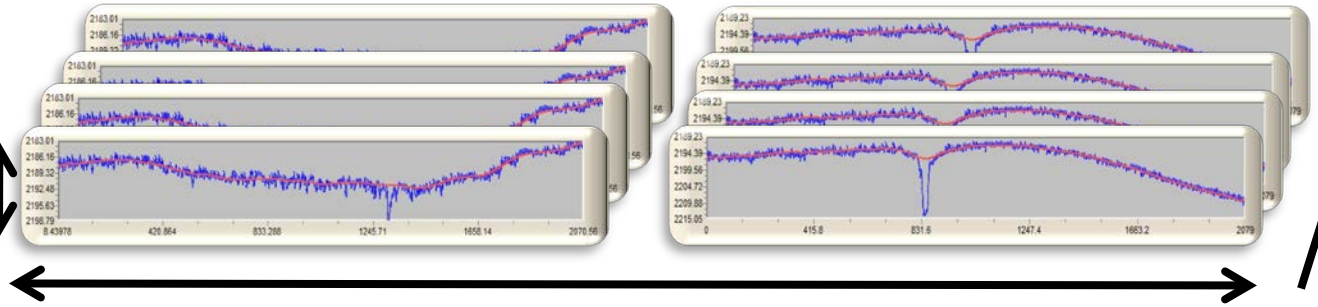
Understanding 3D Imaging



Range **Merged** **Intensity**

LCMS - Specifictions



LCMS Specifications	
Acquisition Rate	5,600-11,200 profiles/s
Range Accuracy	*0.5mm*
Lateral Resolution	1mm (FOV = 4m)

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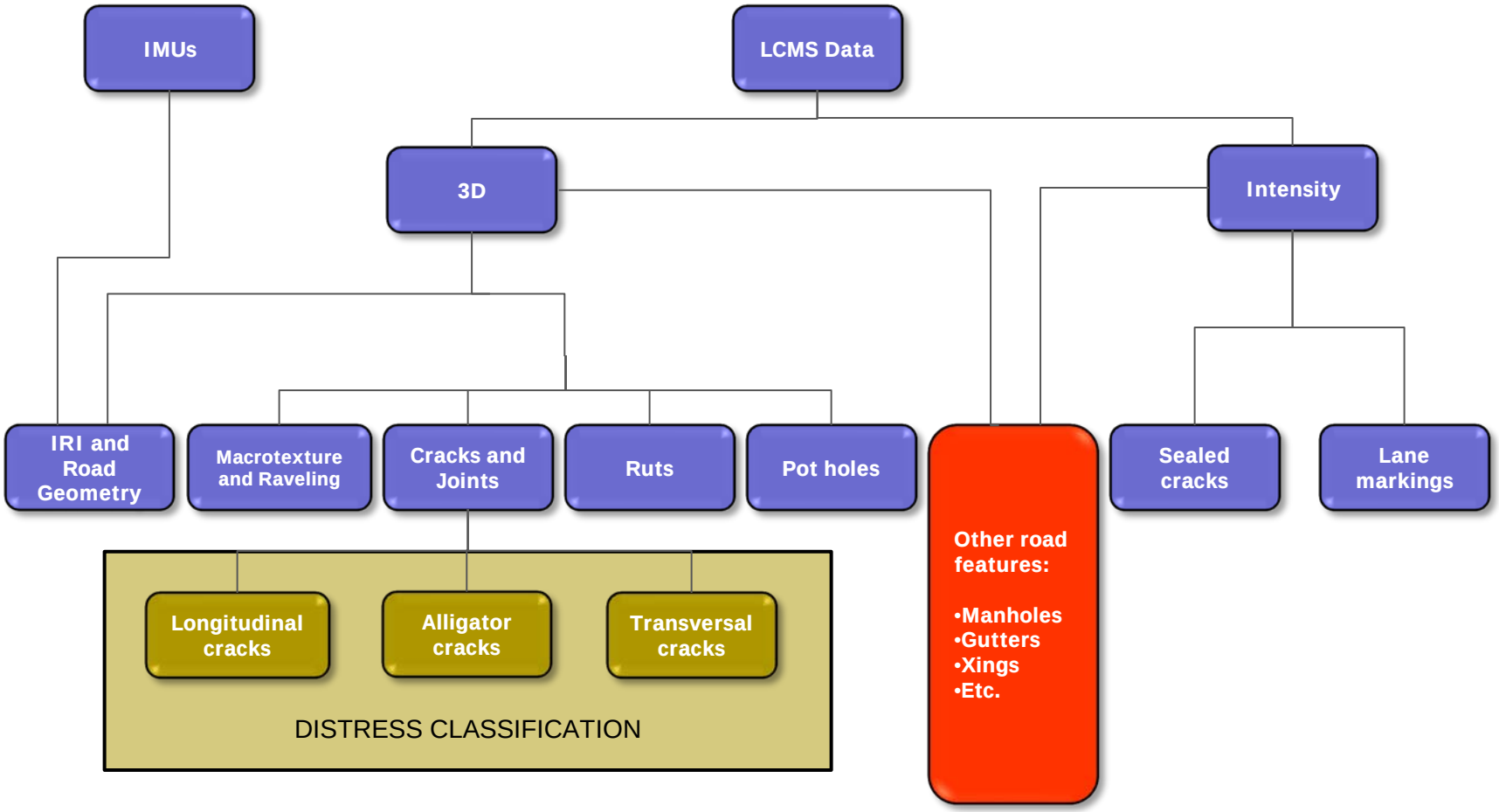
LCMS Data Processing Tree



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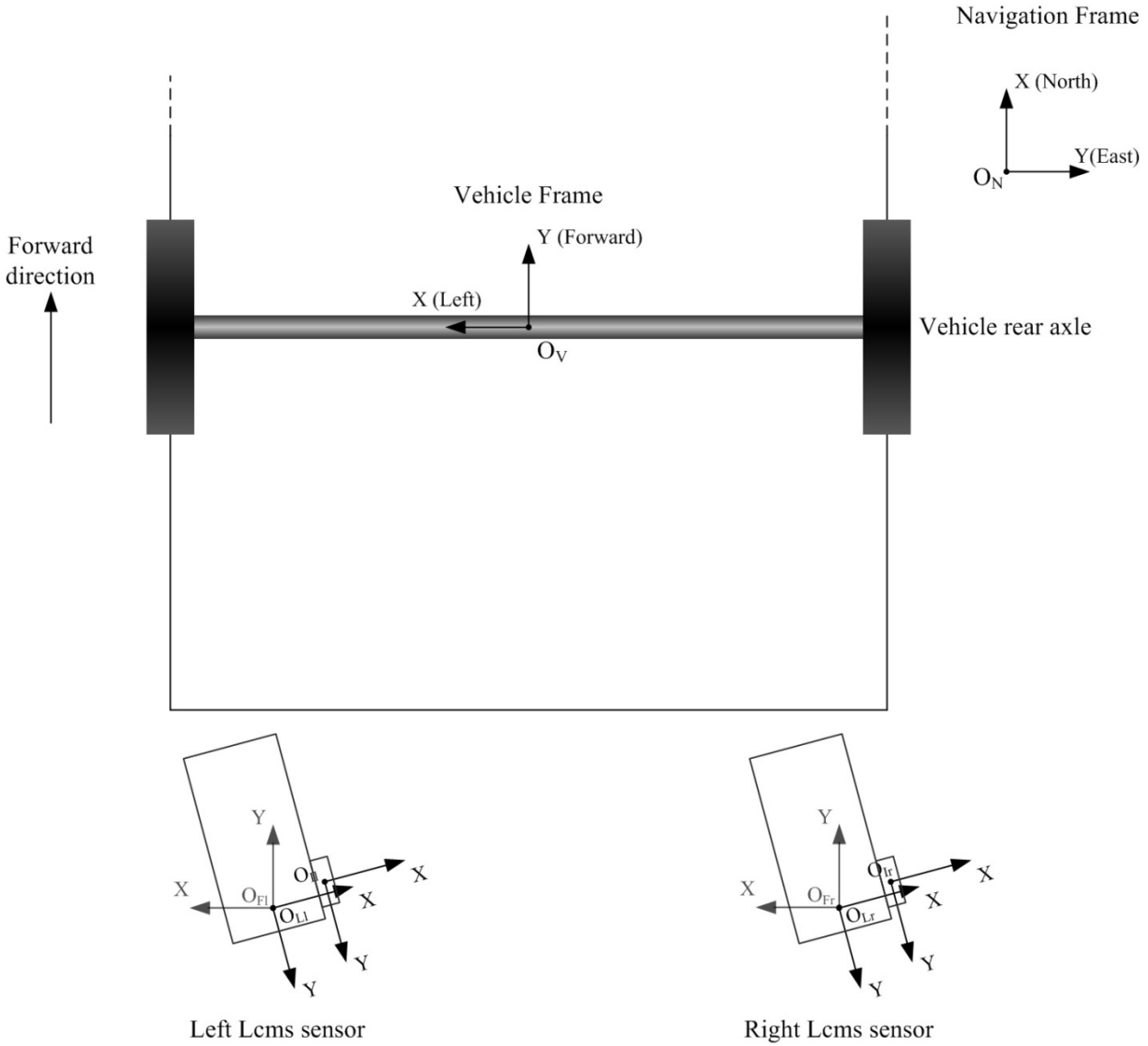
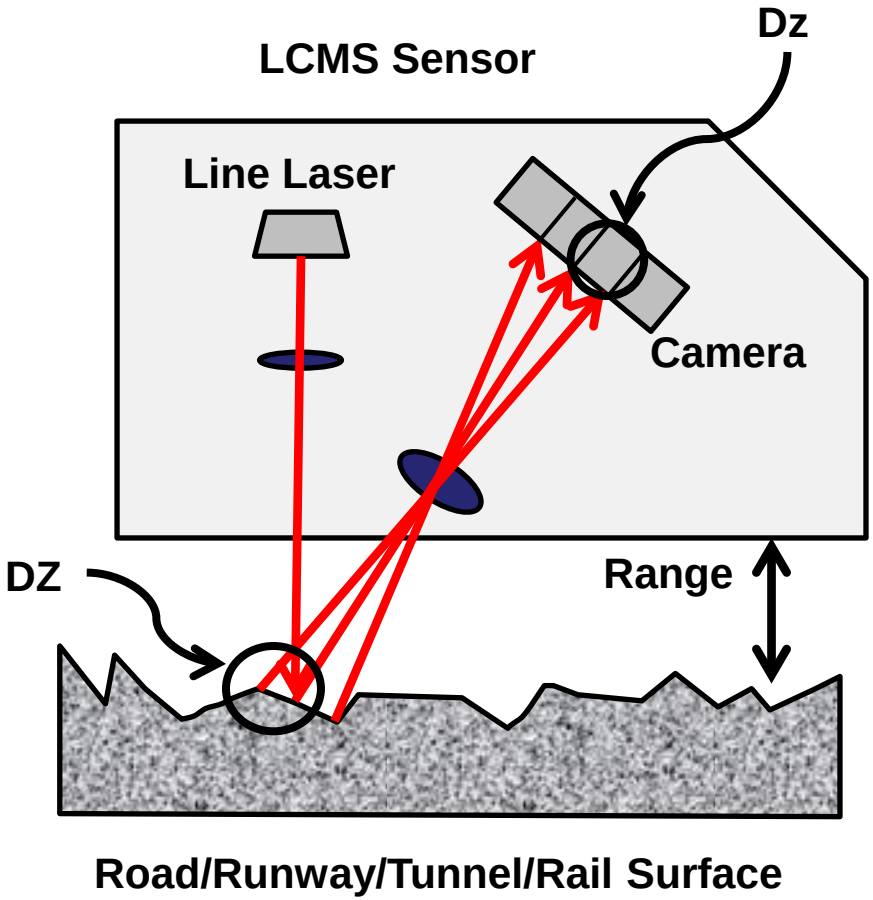
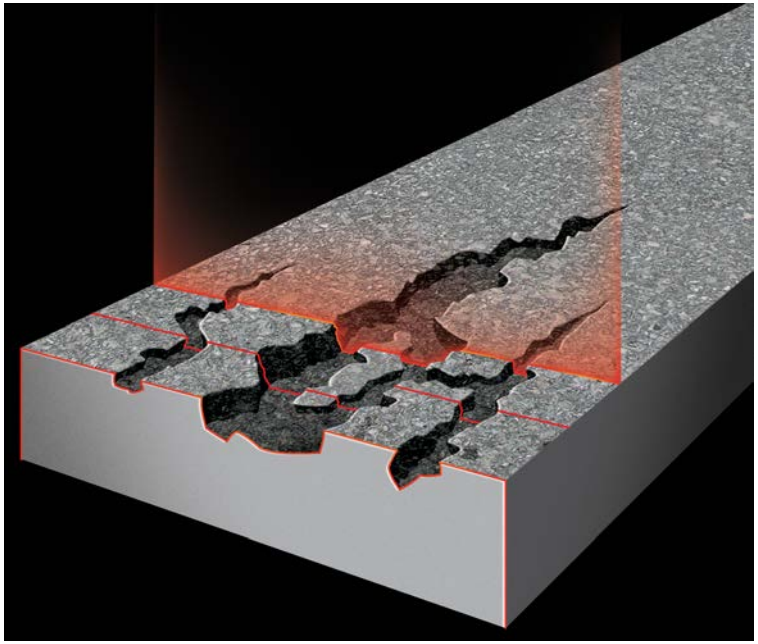
Road Geometry

Multiple Coordinate Systems



Camera/Laser calibration





Dz = k * DZ;

Where k is a factor for: distance between surface and lens, focal length of lens, refractive index of lens, distance between lens and sensor, etc…

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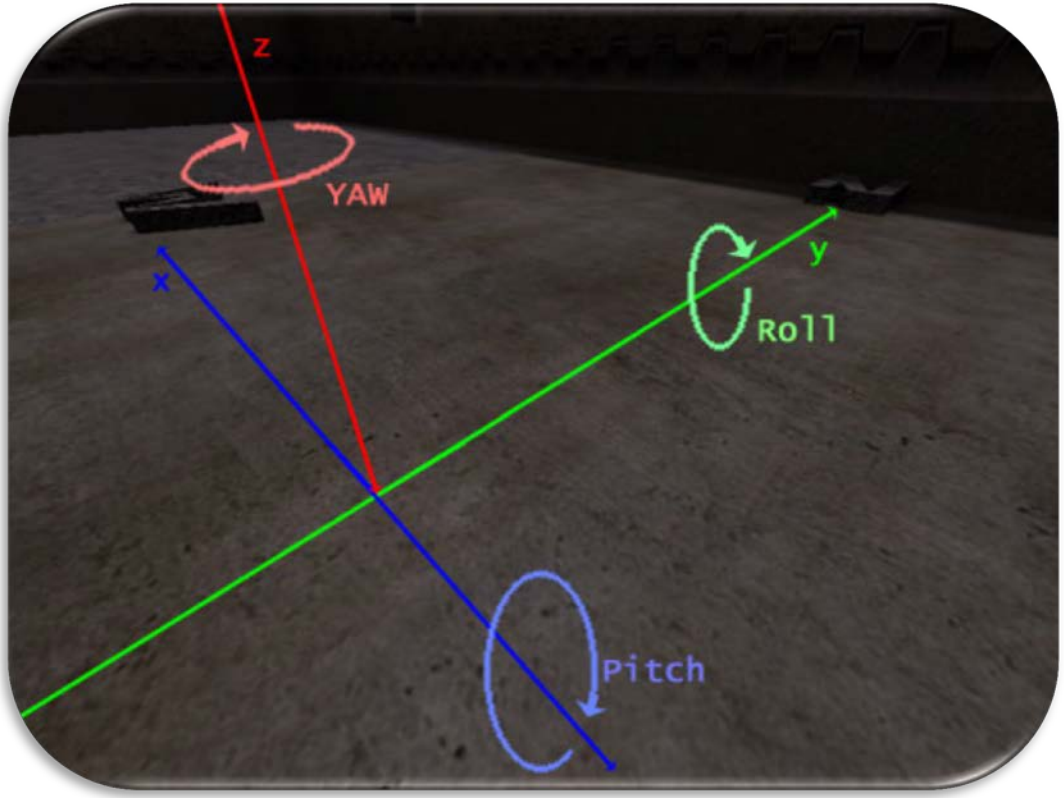
IMUs



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LCMS sensor/IMU coordinates transformation

Sensor to sensor and world (gravity) position calibration

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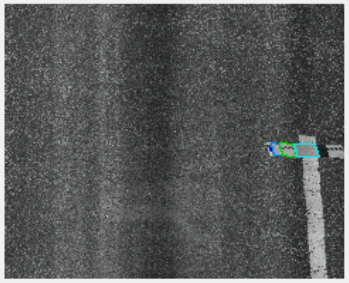
LcmsCalibrationTool

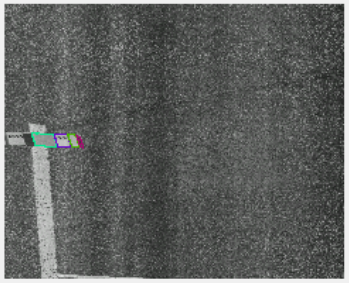
Step 1 | Step 2 | Step 3 | Step 4

Step 2 - 3D And Vehicle Level Calibration

Open Survey: D:\Temp\LcmsData\2013_07_31\Acqui0001\LcmsData_000004.fis

Process: Processing done





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Target Detection

First Profile 884 Last Profile 1056

3D Calibration Results

	Tx	Ty	Tz	
Translation L-R	-1614.8	34.86	6.14	mm

	L	R	
Sensor Angle L-R	16.47	14.51	deg

	Tx	Ty	Tz	
Target Position	-774.42	4622.34	2225.05	mm

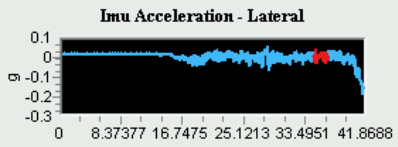
	Rx	Ry	Rz	
Target Rotation	0.29	-179.26	2.80	deg

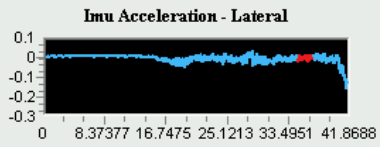
	Rx	Ry	Rz	
Lcms Orientation	-0.25	0.75	0.00	deg

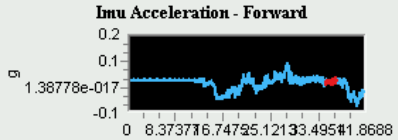
RMS Reprojection Error 0.76 mm

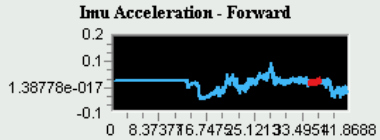
Imu Orientation - Leveled

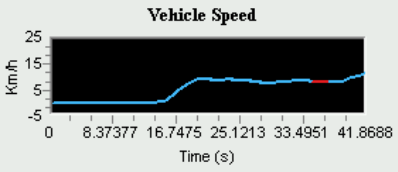
	Rx	Ry	Rz	
Left	1.43	0.14	163.32	deg
Right	1.06	-0.47	163.89	deg

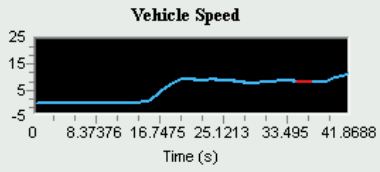












Calib Stop and Go : Success!
Calib Stop and Go - INS - : Success!
Step2: Loaded survey with 6 valid RoadSections
Calib 3D Target Detection : Success!
Calib Vehicle level : Success!
Calib Vehicle level Ins Platform: Success!
Calib 3D : Success!

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Sensor to sensor and world (gravity) position calibration

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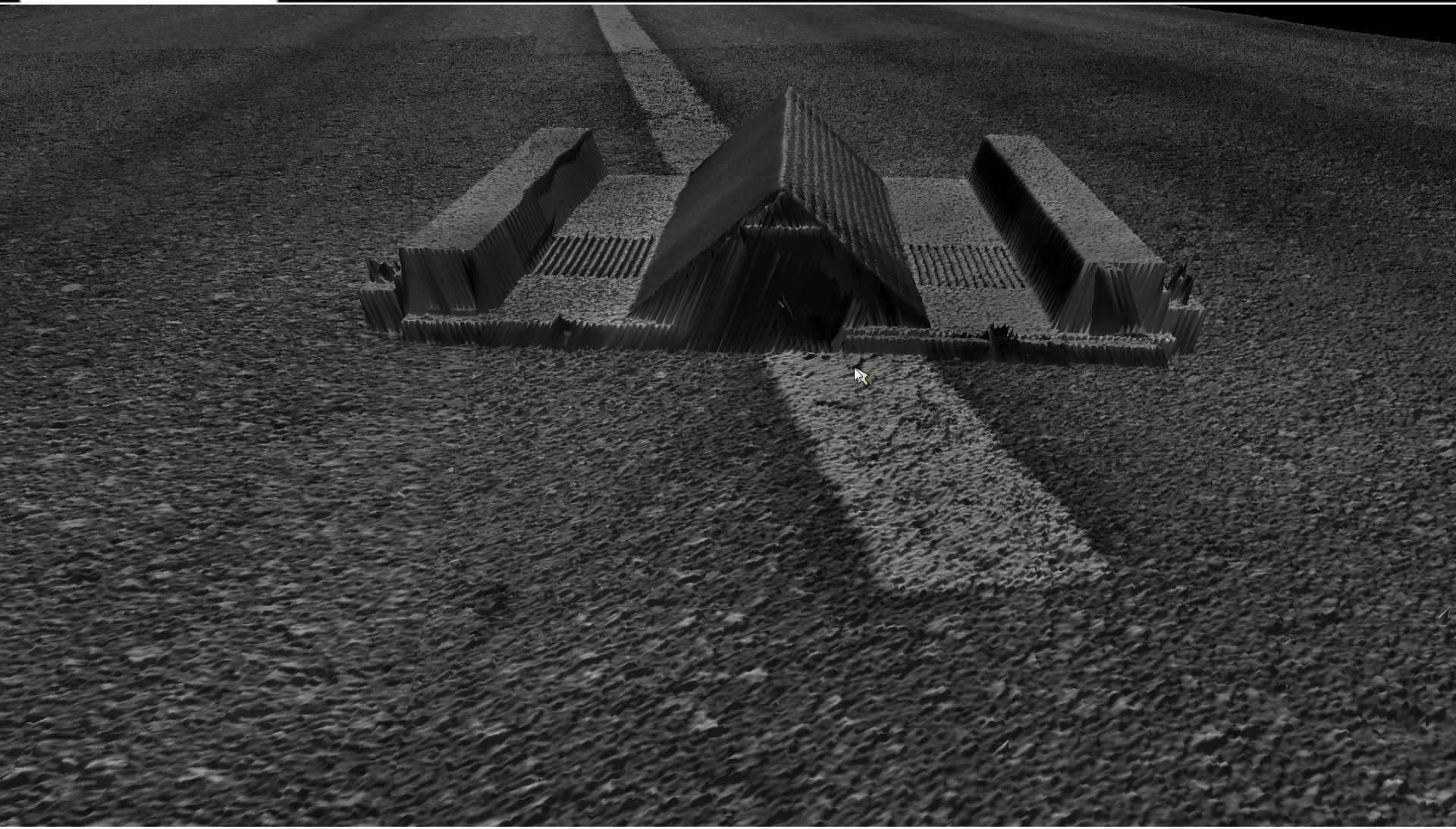
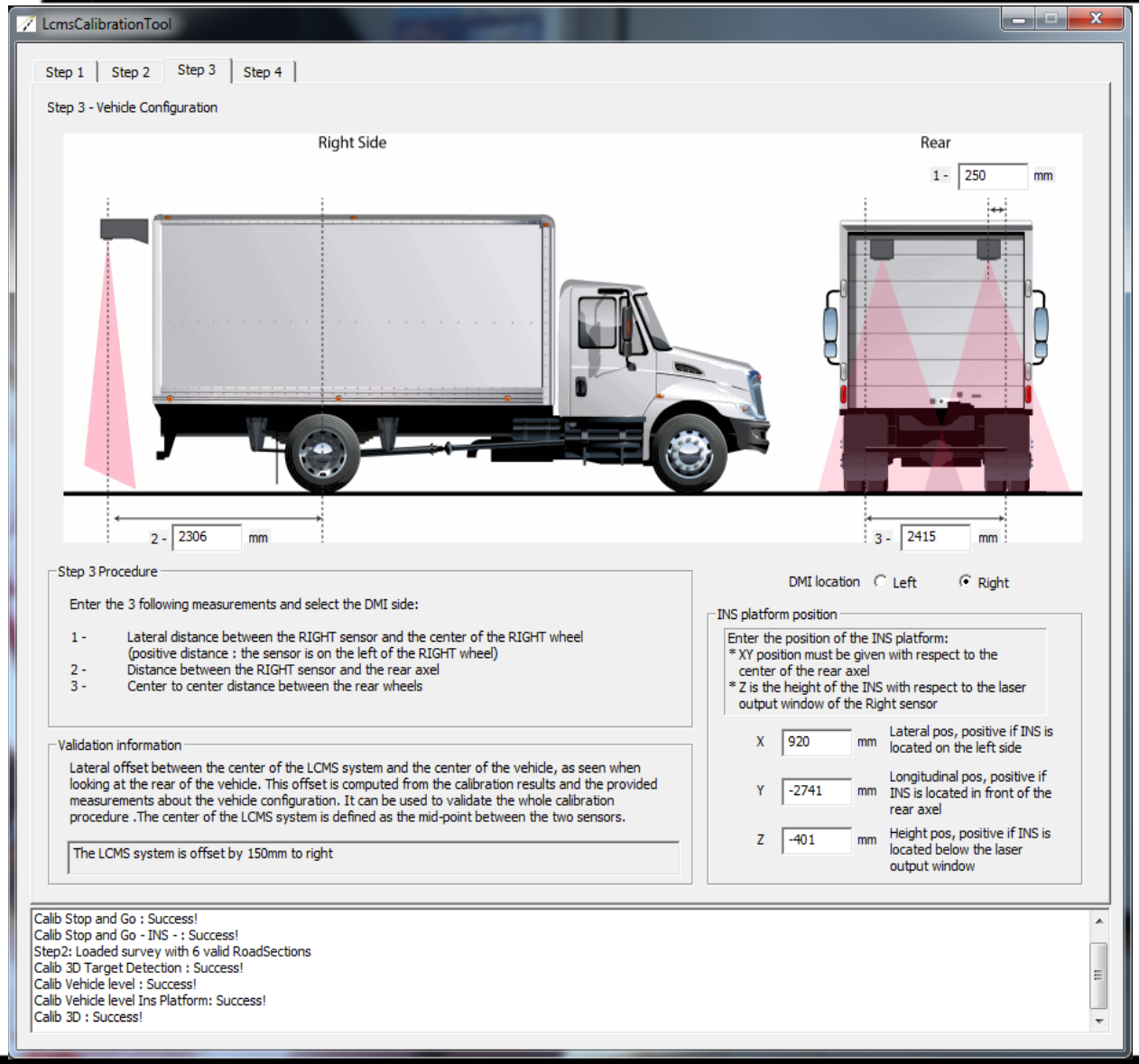
Sensor to sensor and world (gravity) position calibration



Wheel/encoder vs IMU coordinates transformation



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Field Validation Tests

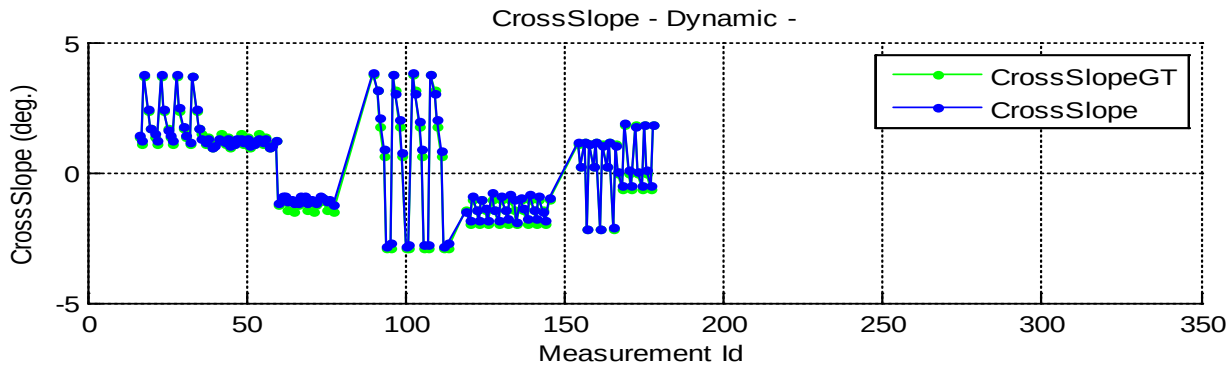
Slope/Xslope field validation

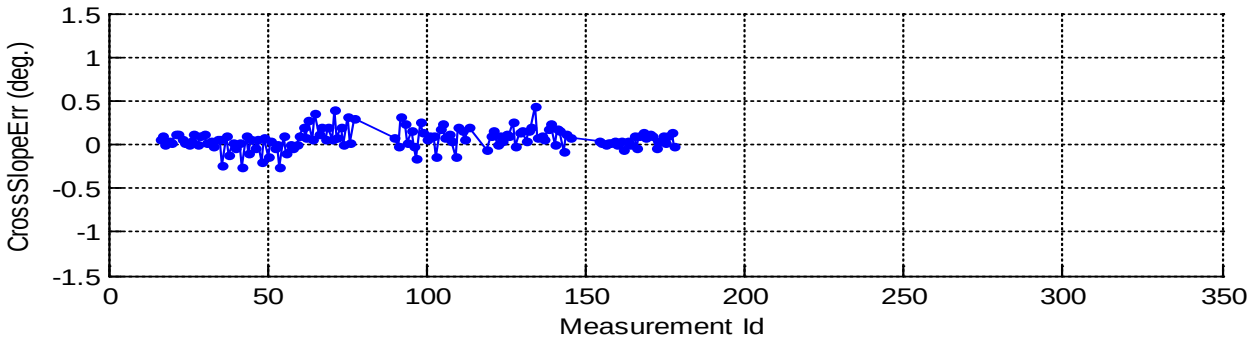
- Slope/Xslope was measured 50 different locations with digital inclinometer (0.1 degree accuracy)
- Xs were marked on road to identify measurement locations.
- Xs were identified in LCMS data and Slope/Xslope was determined from simulated reference beam location.

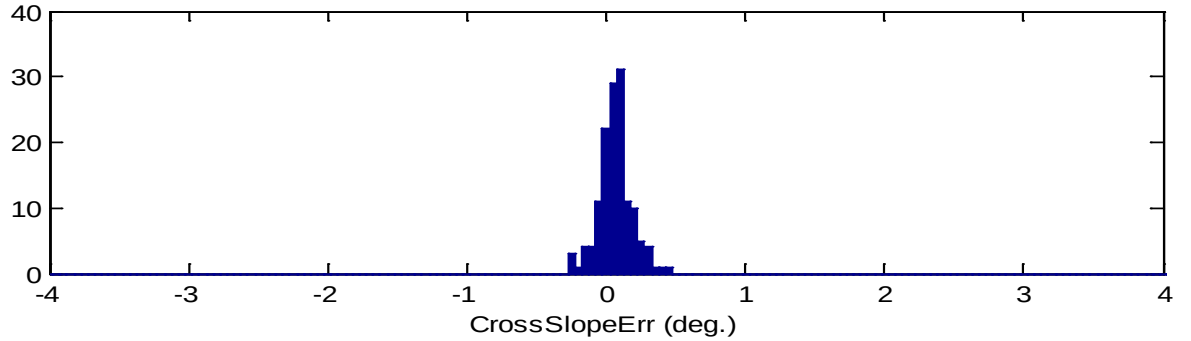
Cross-slope: Dynamic vs GT

Mean XSlopeErr = 0.07deg
Mean XSlopeErr = 0.13 %

Std Dev. XSlopeErr = 0.1 deg
Std Dev. XSlopeErr = 0.2%







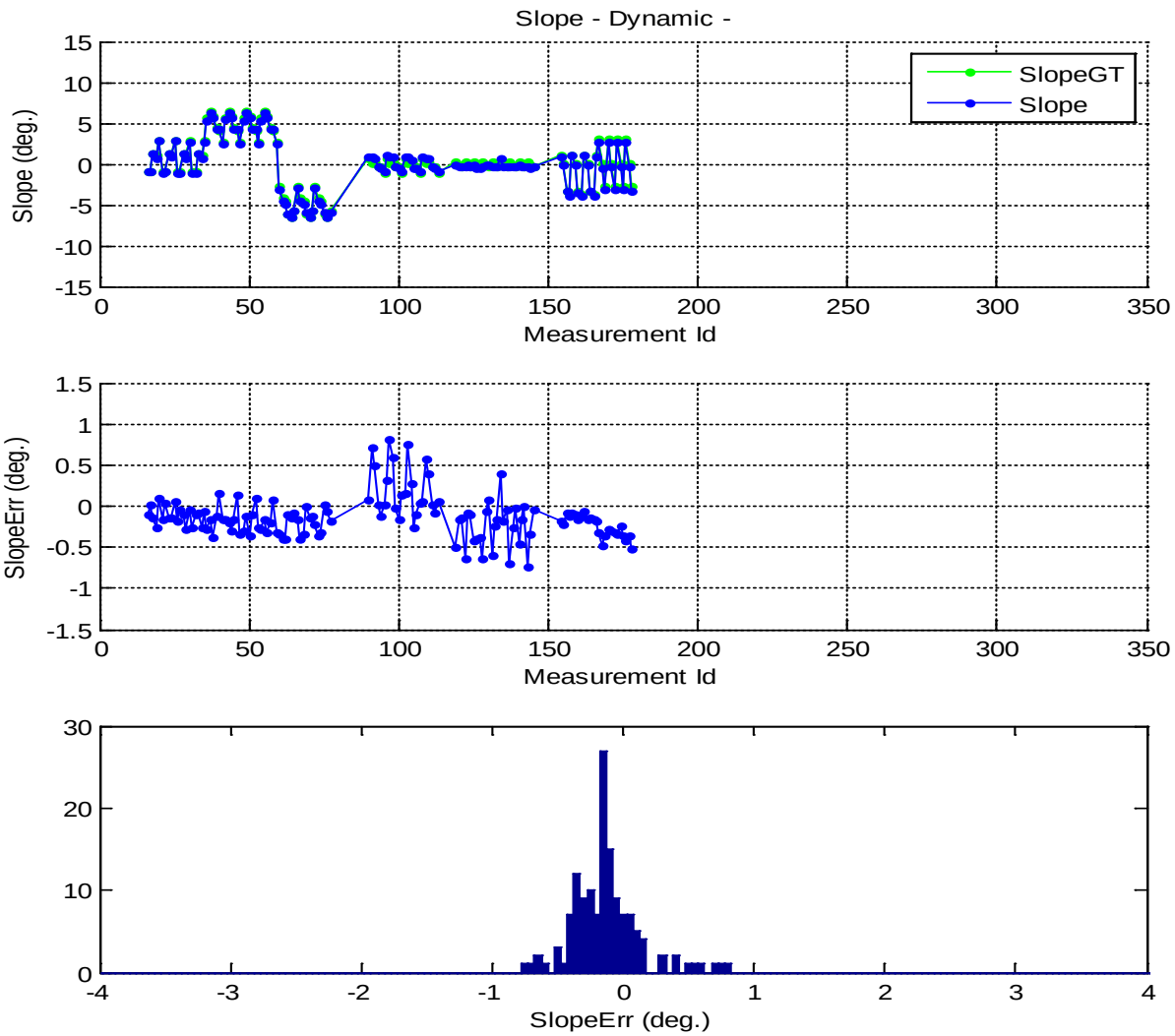
Slope: Dynamic vs GT

Mean SlopeErr = 0.13deg.

Mean SlopeErr = 0.25%

Std Dev. SlopeErr = 0.26deg.

Std Dev. SlopeErr = 0.46%



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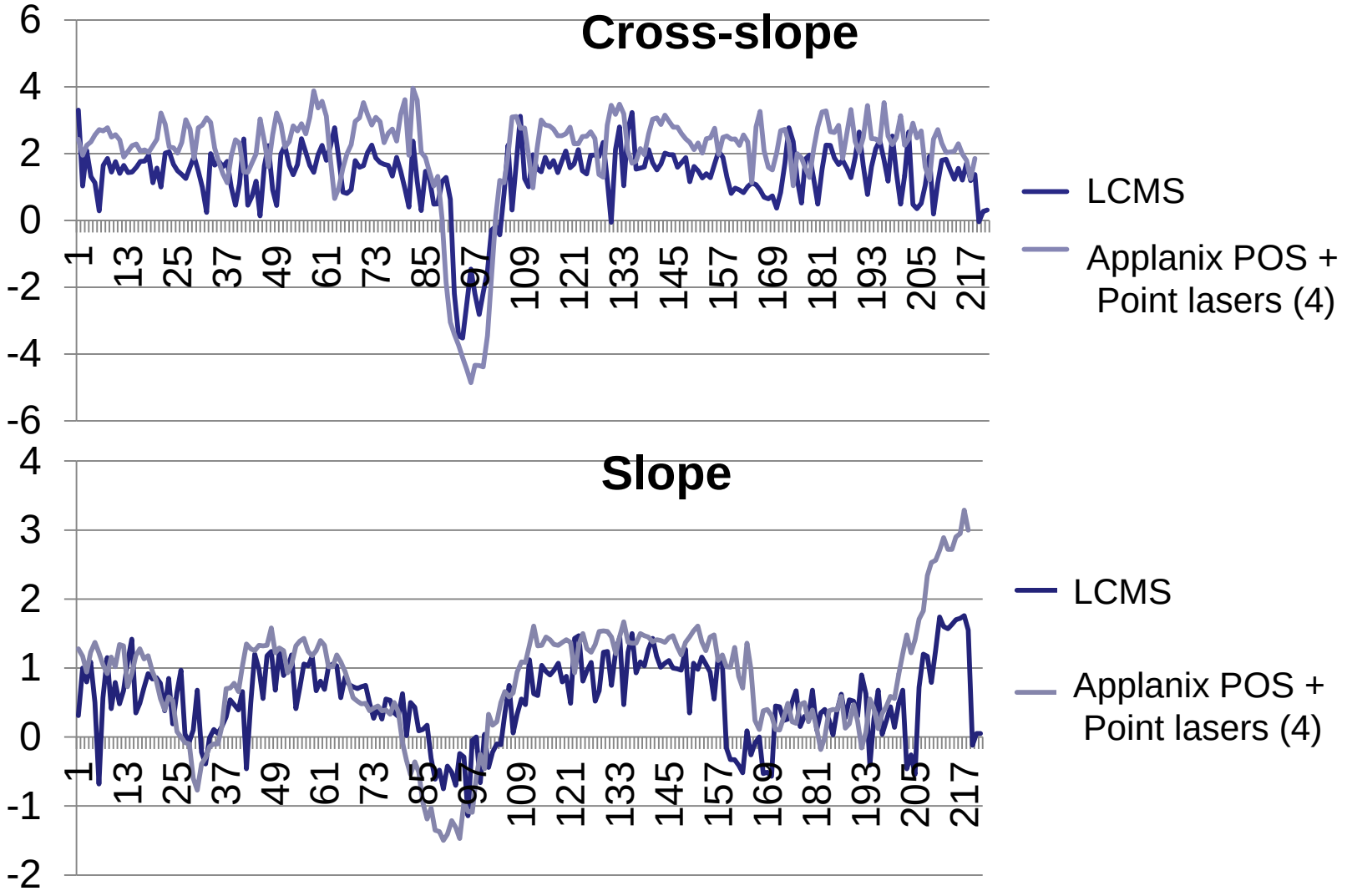
Road tests - Geometry



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Terrain Mapping

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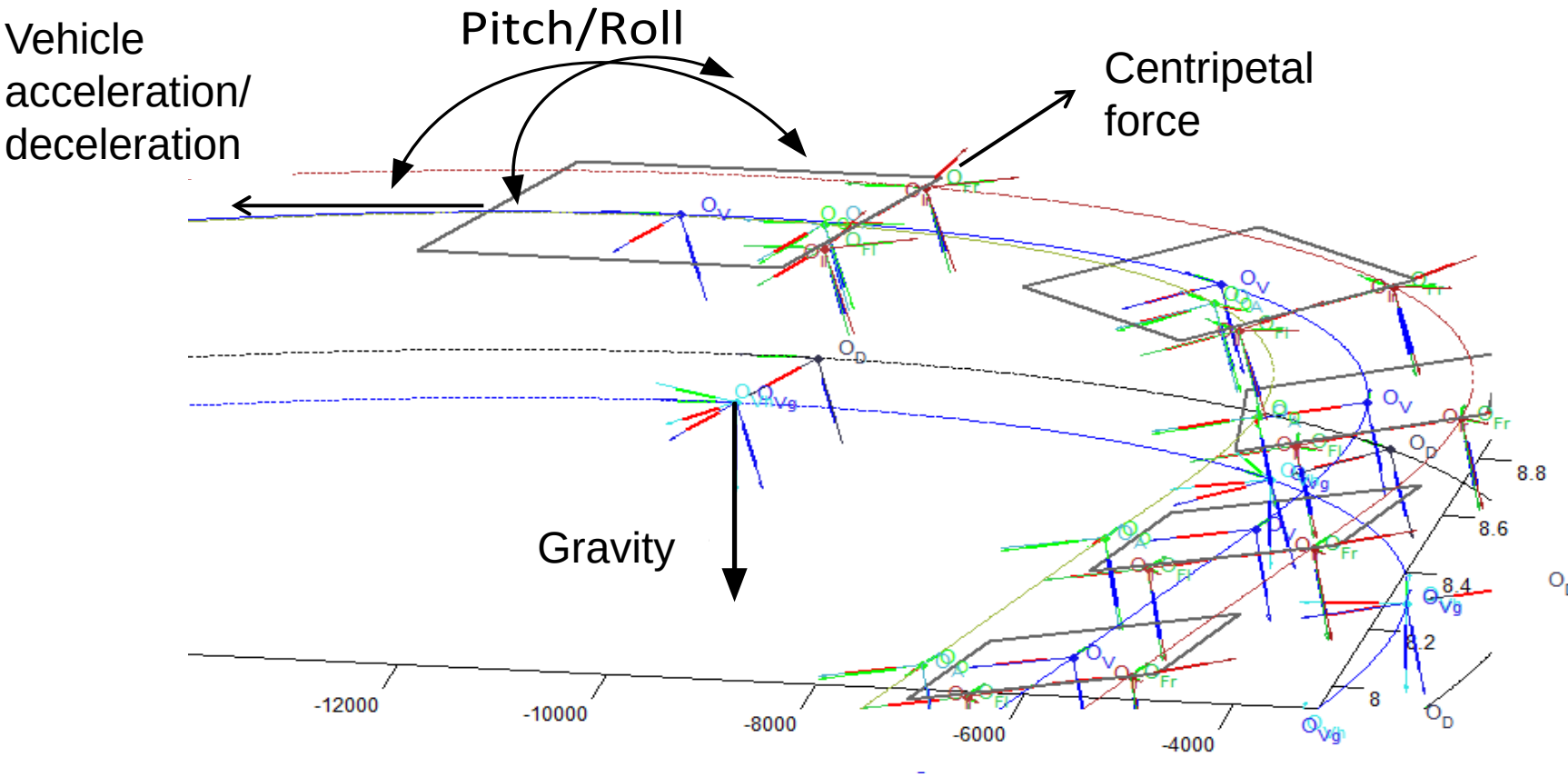
Complex Vehicle Dynamics



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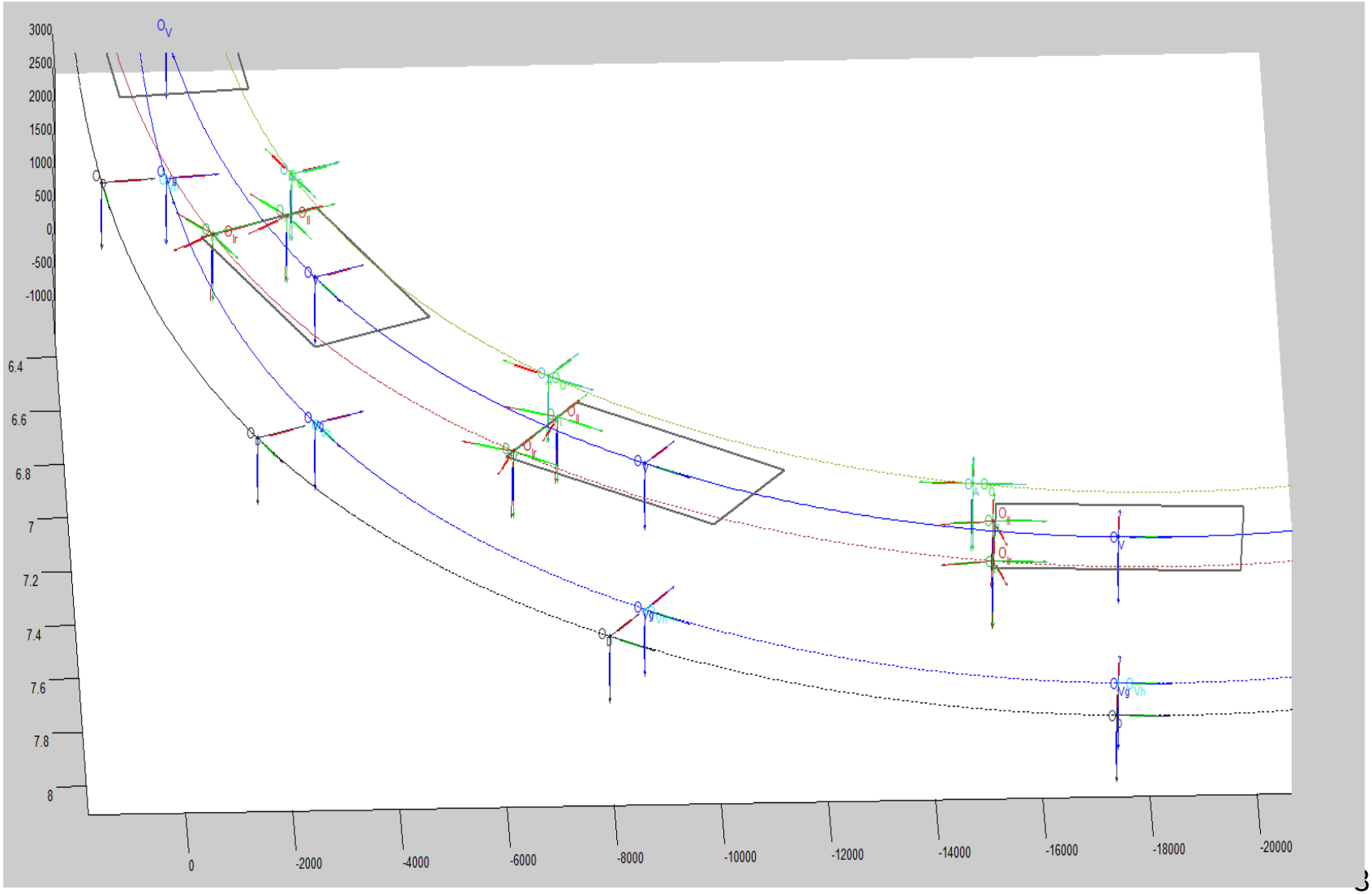
Final result – Vehicle track and DTM



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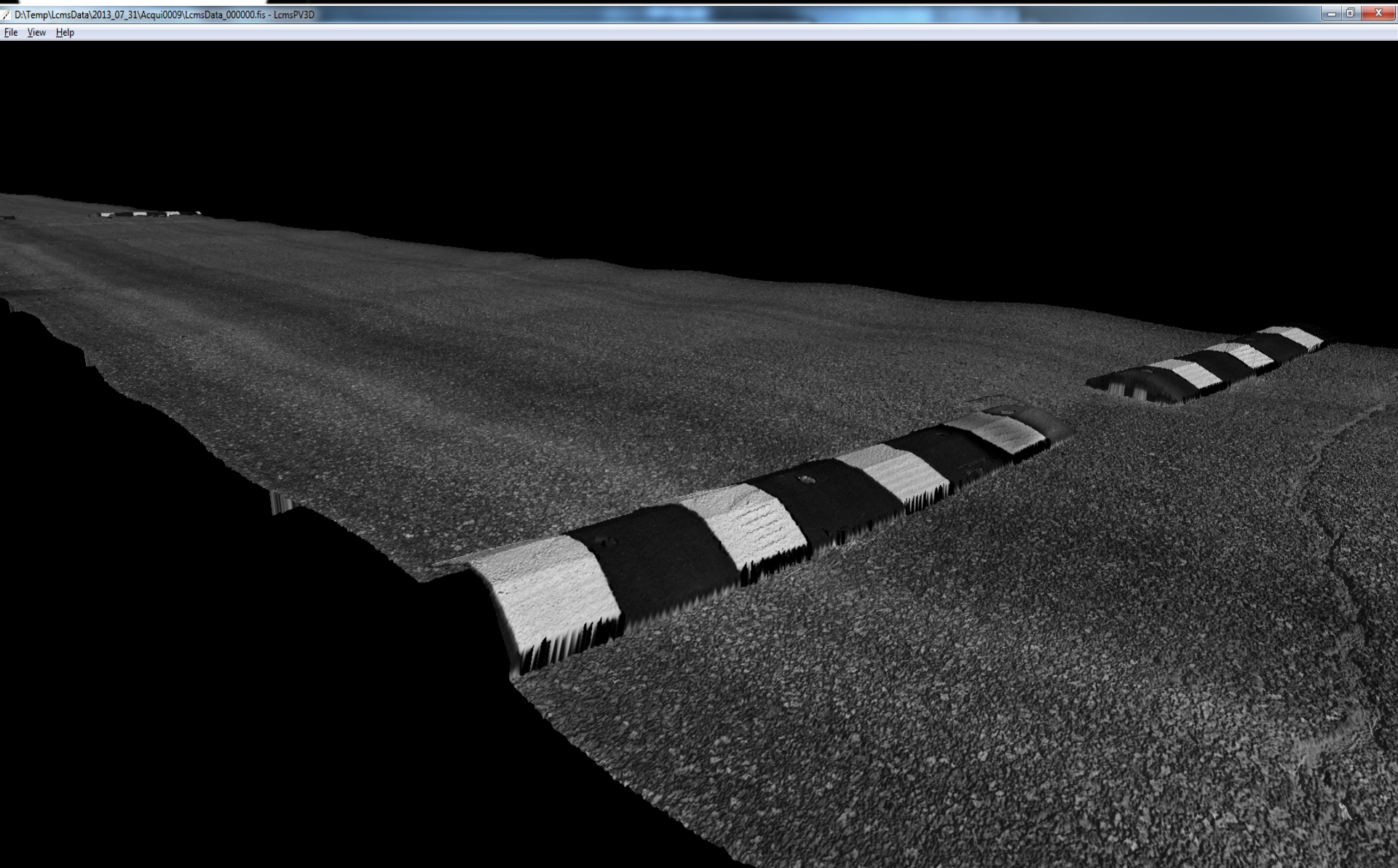
3D Road Profile Before Dynamic Corrections



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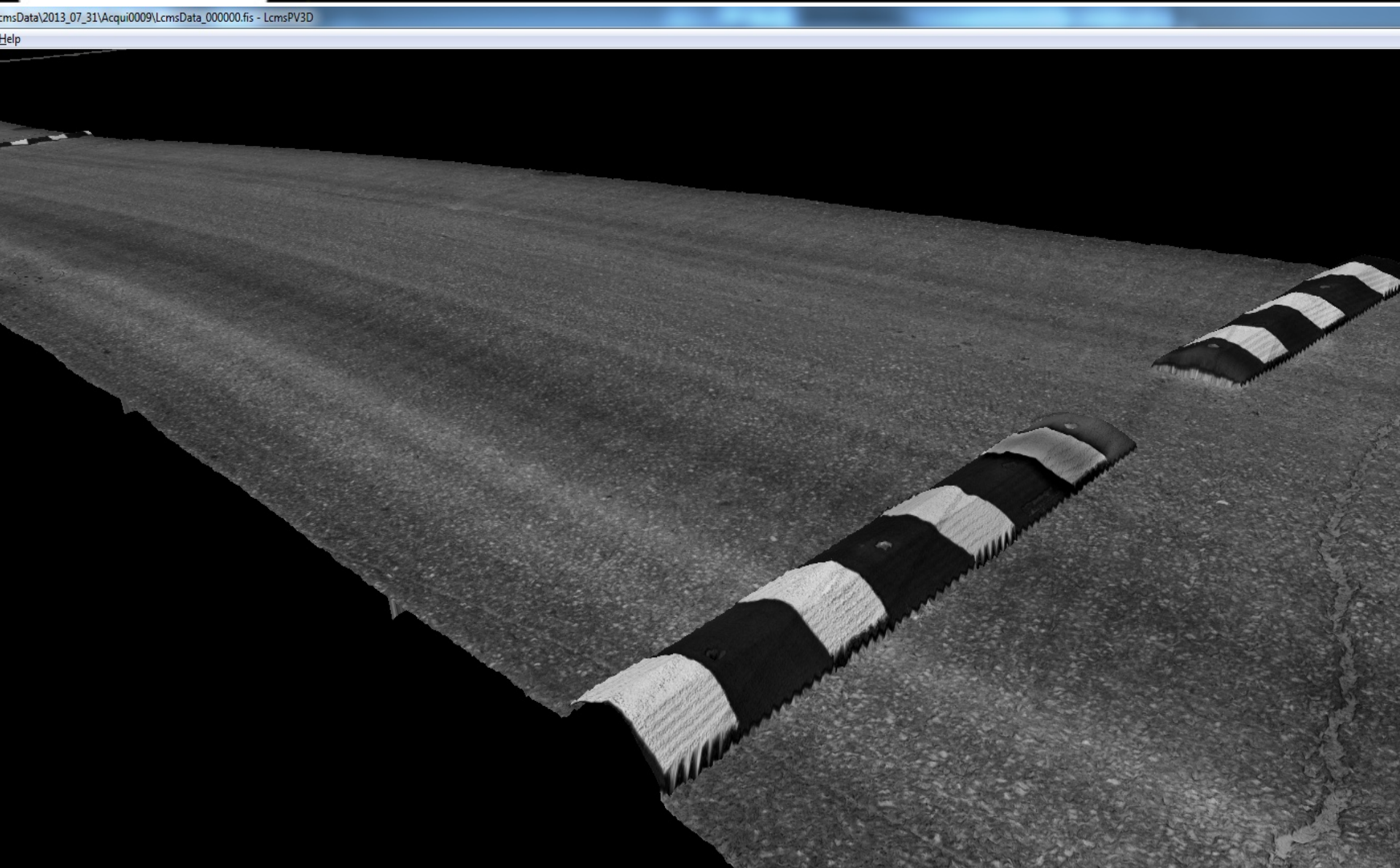

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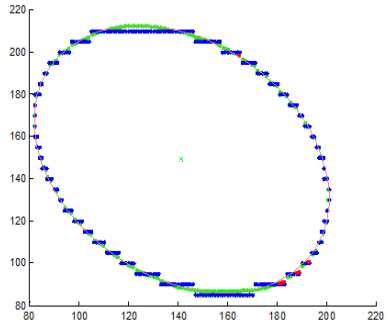
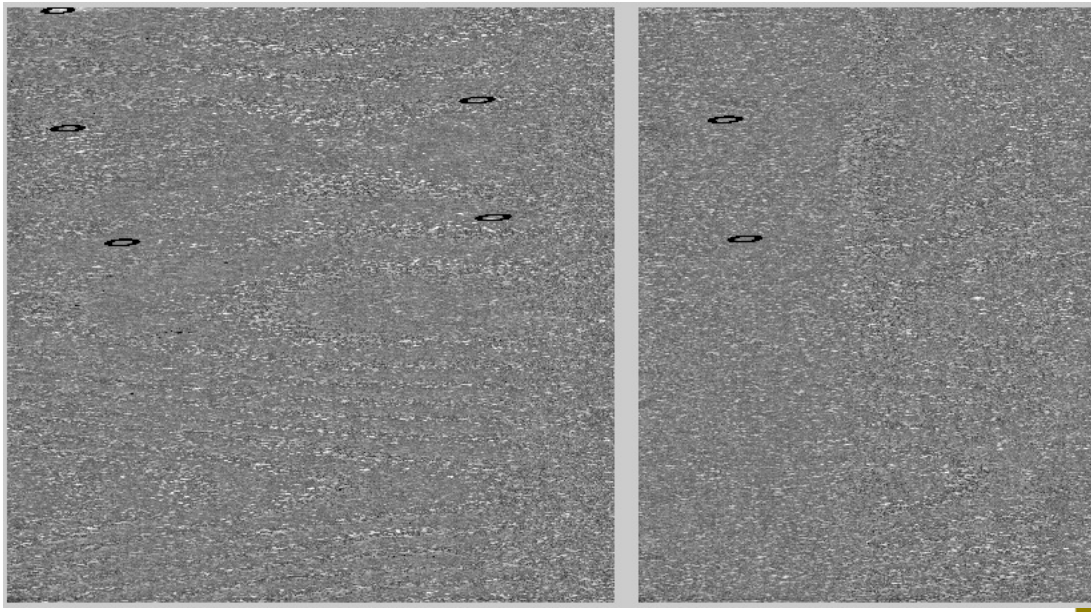
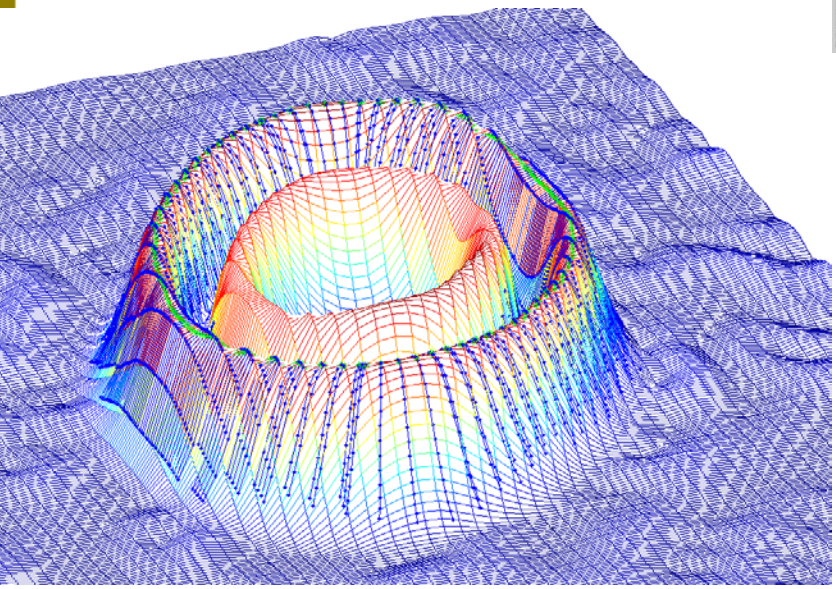
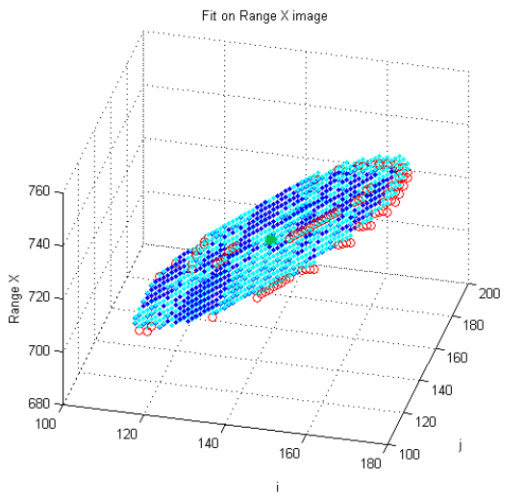
Field validation

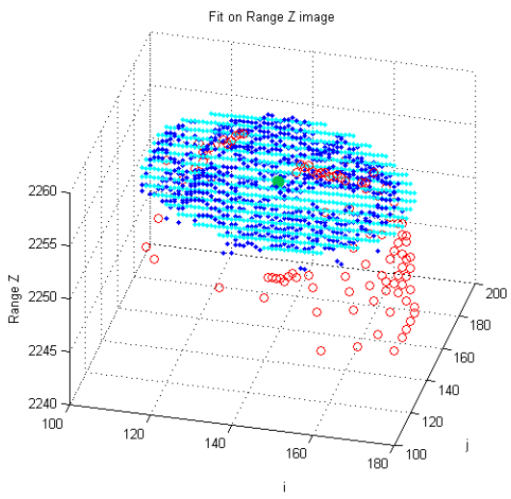
Field validation – Puck center evaluation











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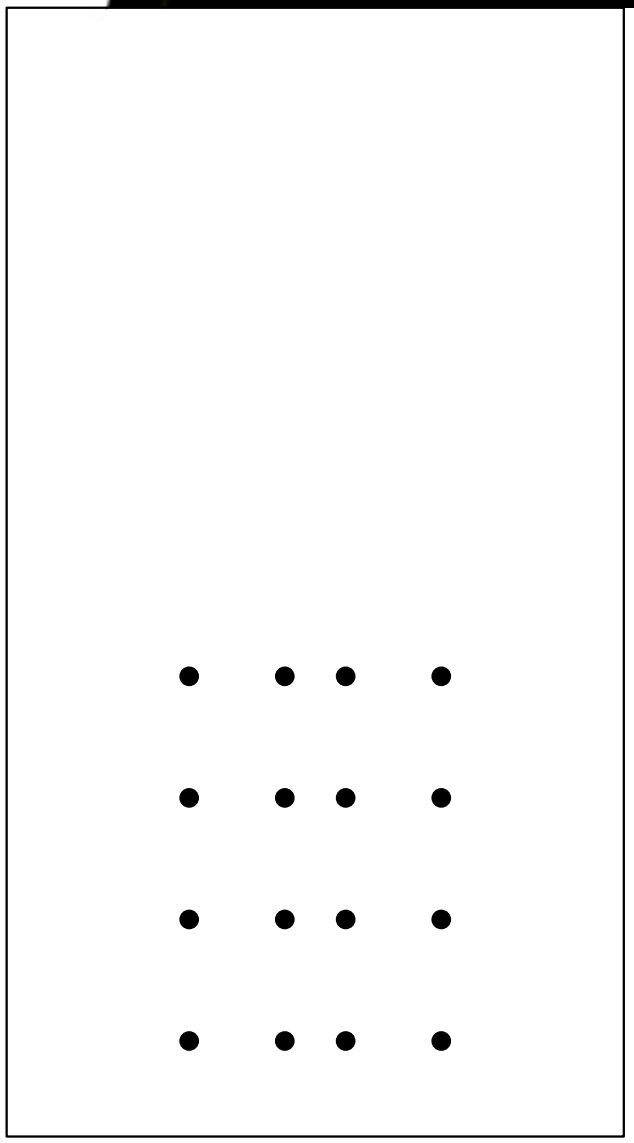
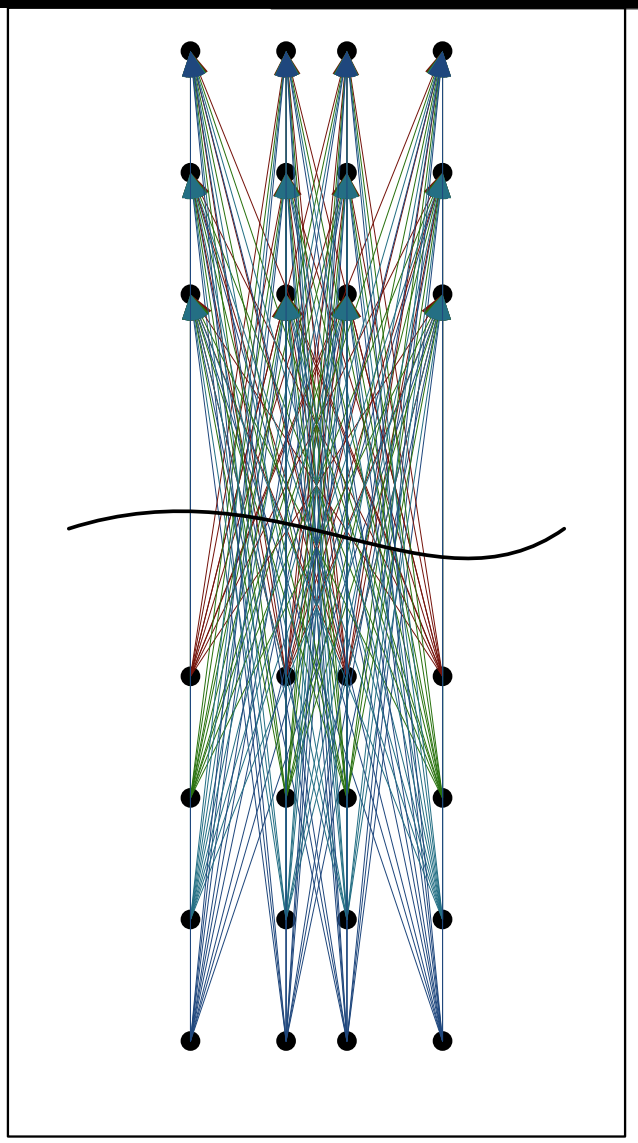
Field validation





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Accuracy tests - RMS error

100% Inertial - 4m

Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	3.32	2.28	3.06	4.51	5.91
3	3.53	2.42	2.88	5.30	6.50
4	3.89	3.01	5.34	2.79	6.74
5	4.65	3.63	5.09	5.40	8.26
6	2.92	1.59	4.02	3.07	5.30
Mean	**3.66**	**2.59**	**4.08**	**4.21**	**6.54**

100% Inertial - 84m

Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	9.89	2.08	21.76	2.42	21.99
3	8.65	2.08	16.15	5.36	17.14
4	15.87	5.18	31.59	4.15	32.28
5	13.56	3.37	27.28	3.64	27.73
6	12.38	2.00	25.52	2.68	25.73
Mean	**12.07**	**2.94**	**24.46**	**3.65**	**24.98**

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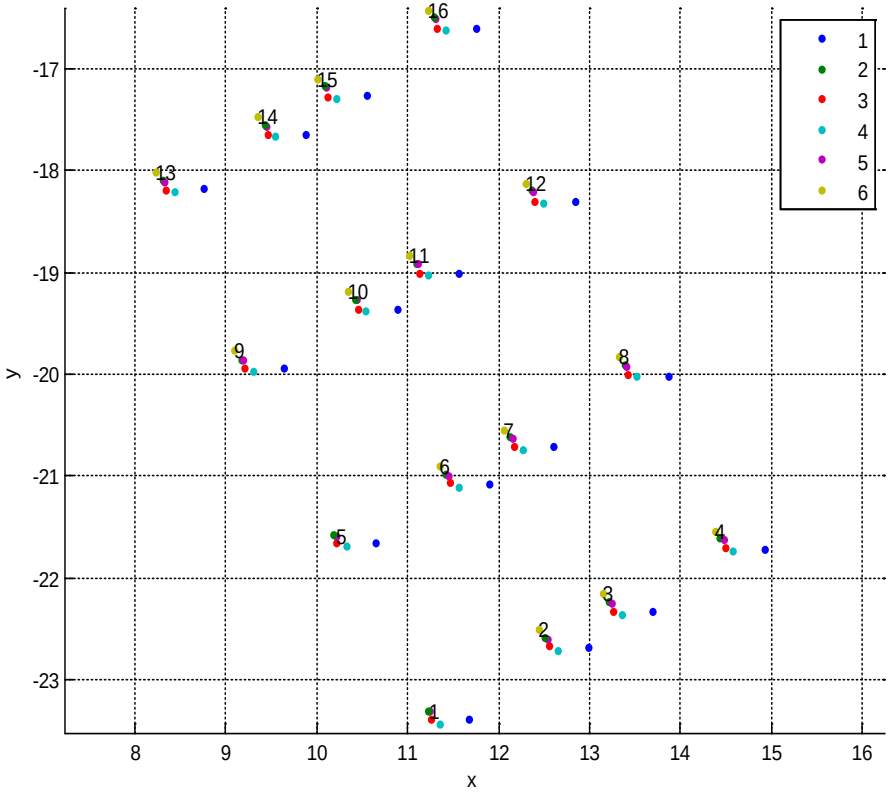
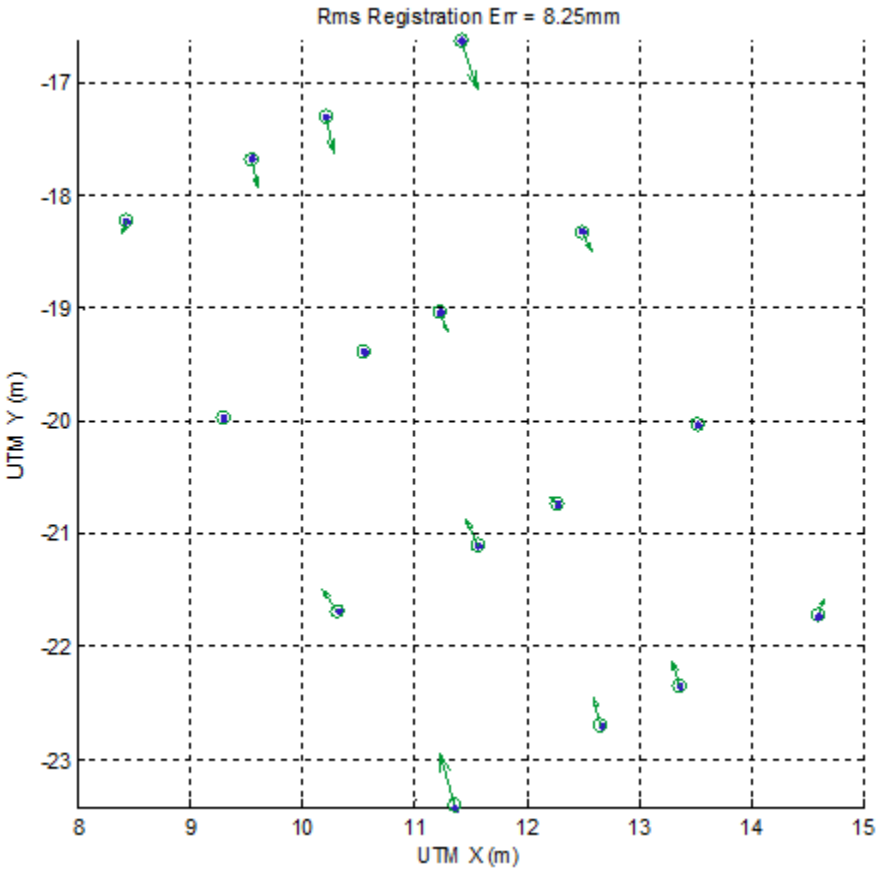
Accuracy tests - RMS error





Pavemetrics

Accuracy tests - RMS error

100% Inertial - 4m

Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	3.32	2.28	3.06	4.51	5.91
3	3.53	2.42	2.88	5.30	6.50
4	3.89	3.01	5.34	2.79	6.74
5	4.65	3.63	5.09	5.40	8.26
6	2.92	1.59	4.02	3.07	5.30
Mean	**3.66**	**2.59**	**4.08**	**4.21**	**6.54**

100% Inertial - 4m 2 known points

Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	3.11	2.30	2.09	4.50	5.47
3	3.33	2.42	2.07	5.27	6.16
4	3.34	3.02	3.89	2.78	5.65
5	4.26	3.63	3.77	5.38	7.51
6	2.45	1.59	2.75	3.02	4.38
Mean	**3.30**	**2.59**	**2.91**	**4.19**	**5.83**

100% Inertial - 84m

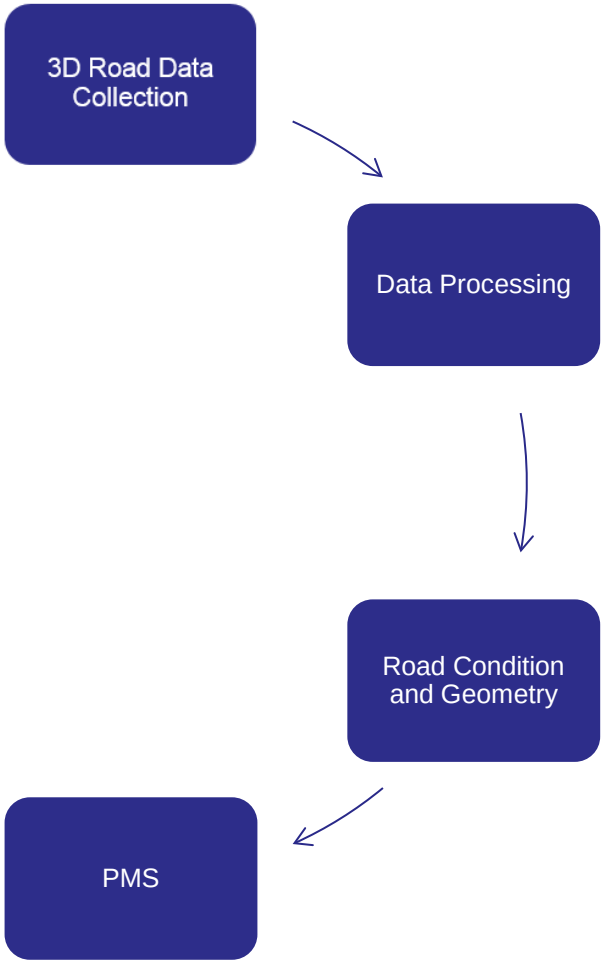
Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	9.89	2.08	21.76	2.42	21.99
3	8.65	2.08	16.15	5.36	17.14
4	15.87	5.18	31.59	4.15	32.28
5	13.56	3.37	27.28	3.64	27.73
6	12.38	2.00	25.52	2.68	25.73
Mean	**12.07**	**2.94**	**24.46**	**3.65**	**24.98**

100% Inertiel - 84m 2 known points

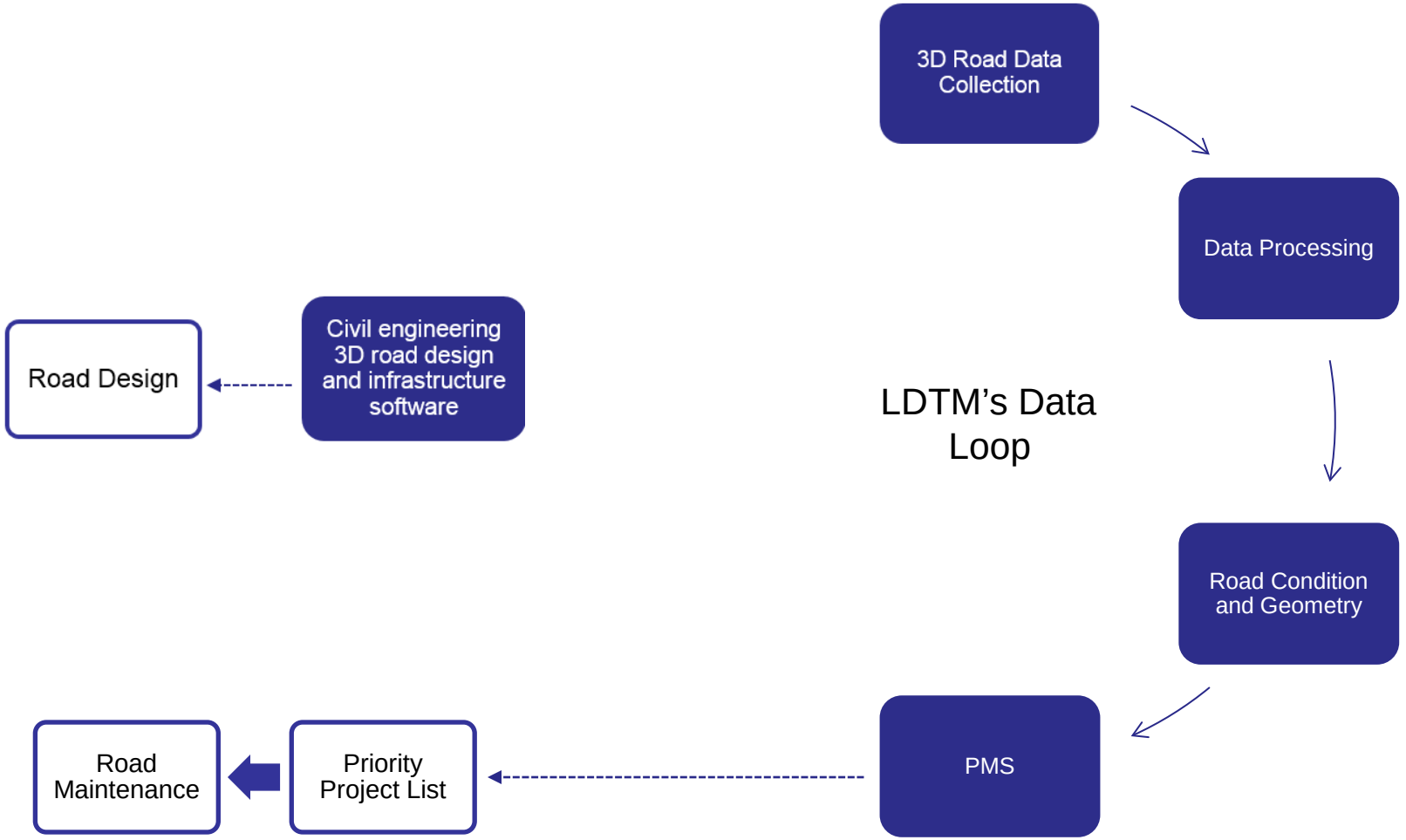
Scan	RMS Registrati	RMS Geometry preservation error (mm)			
		X	Y	Z	Module
2	3.12	2.07	3.07	2.38	4.40
3	4.26	2.08	3.09	5.30	6.48
4	5.73	5.18	4.63	4.14	8.09
5	4.51	3.37	4.03	3.62	6.38
6	3.21	2.00	3.80	2.66	5.05
Mean	**4.17**	**2.94**	**3.72**	**3.62**	**6.08**

Pavemetrics

LDTM – Closing the Loop



LDTM – Closing the Loop



Pavemetrics

Road Profile Before Corrections

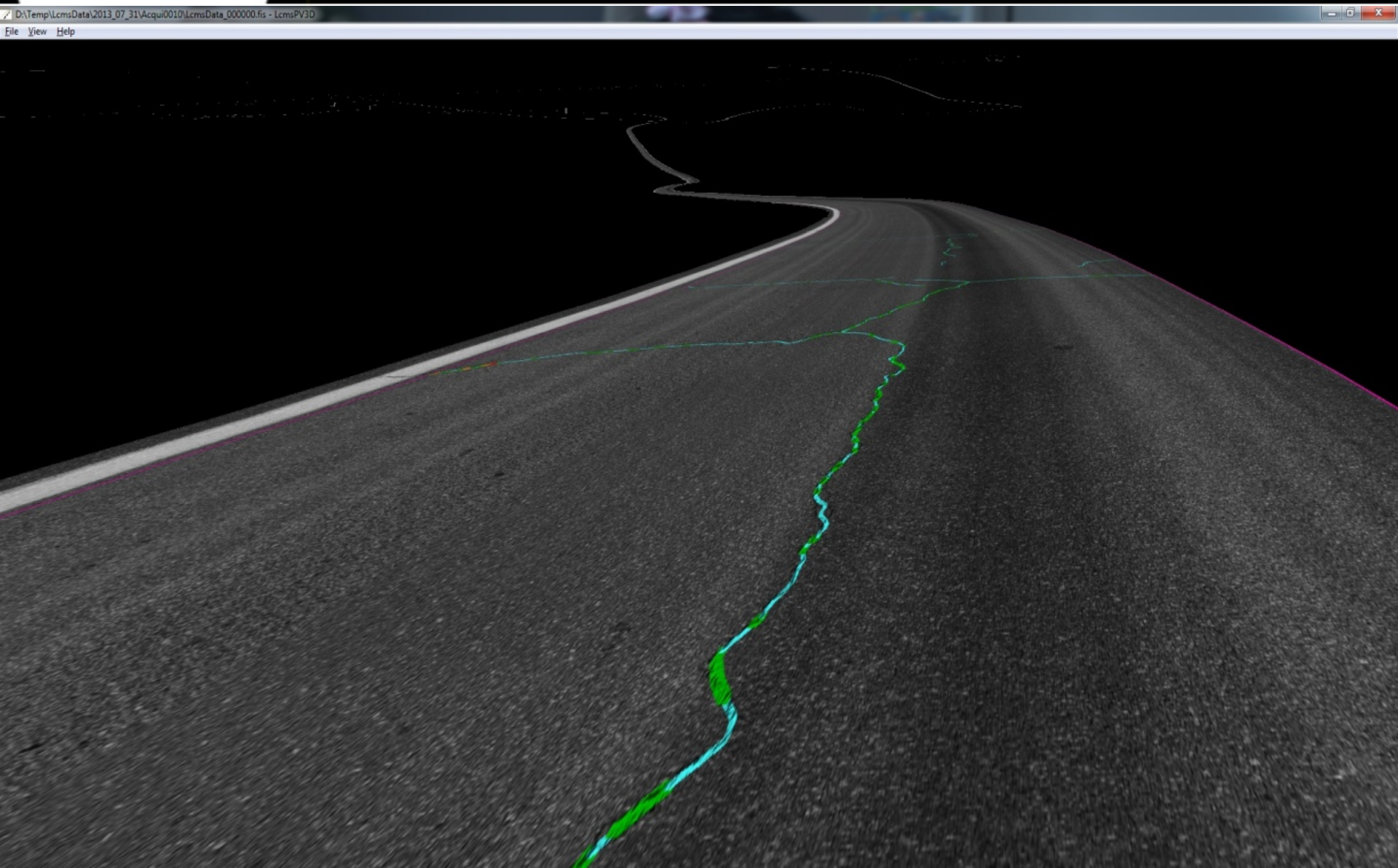
Pavemetrics

Road Profile After Geometric and Dynamic Corrections

Pavemetrics

One Sensor; Many Outputs

- Pavement Management
  - Transverse Profile
  - Joint Faulting
  - Sealed cracks
  - Alligator Cracking
  - Transverse Cracks
  - Longitudinal Cracks
  - Rutting
  - Raveling
  - Potholes
  - Macro Texture
  - IRI
  - Pavement Images
- Inventory
  - Pavement Width
  - Pavement Length
  - Pavement Type
  - GPS Tagging
  - Linear Referencing
- Safety
  - Foreign Object Debris
  - Pavement Markings
  - Horizontal Curvature
  - Cross Fall
  - Longitudinal Grade
- Design
  - Automatic Breaklines
  - Digital Terrain Models

Pavemetrics

Any Questions?