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Pavemetrics

3D road scanning and texture

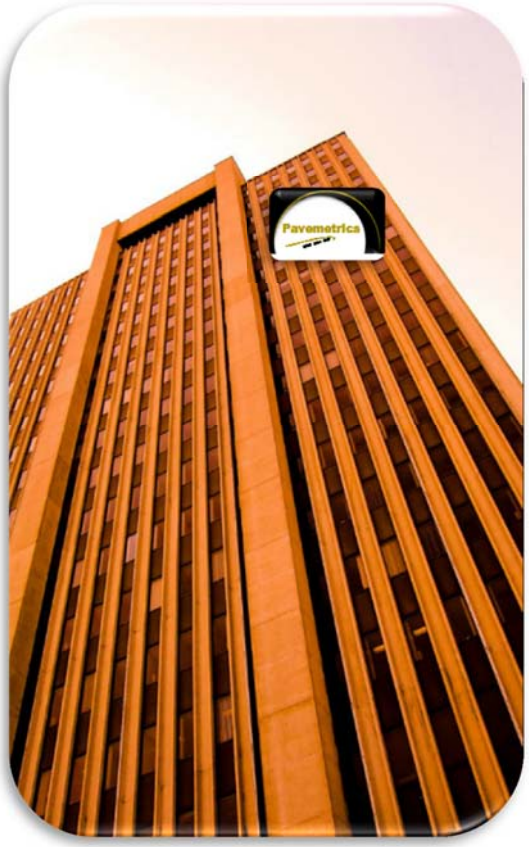
Vision Technology for Inspection of Transportation Infrastructures

PAVEMETRICS Systems Inc.

150 Boulevard René-Lévesque Est, Suite 1820
Québec, Québec, CANADA
G1R 5B1

www.pavemetrics.com

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 35+ countries**

Pavemetrics

The Sensor Technology Most Relied-on by DOTs worldwide

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Collect Your Own, or Contract-out

arrb GROUP

Stantec

FUGRO

RAMBOLL

MANDLI COMMUNICATIONS INC

INTERNATIONAL CYBERNETICS
Where technology meets the road

romdas

ECTRA FRANCE

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NUEVAS TECNOLOGÍAS

EnterInfo

Dynatest®
Pavement engineering specialists & equipment

LVM

SNC·LAVALIN

Pavemetrics

LCMS – Certified Technology

NOT a prototype

Certified AND proven around the world.

AASHTO THE VOICE OF TRANSPORTATION

ASTM INTERNATIONAL

INTERNATIONAL CERTIFICATIONS ISO 9001

CE

FC

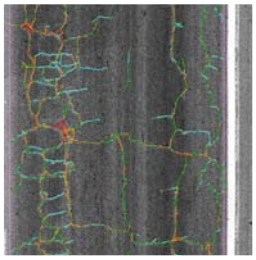
TÜV SÜD ISO 9001

DEPARTMENT OF HEALTH & HUMAN SERVICES • USA FDA

NEMA

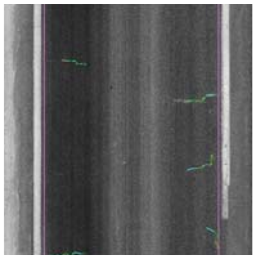
Pavemetrics

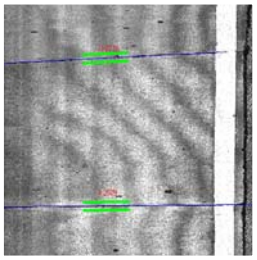
Any Paved Surface



Hotmix

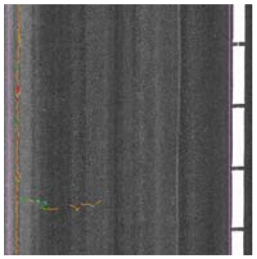
Chipseal





Concrete

Porous



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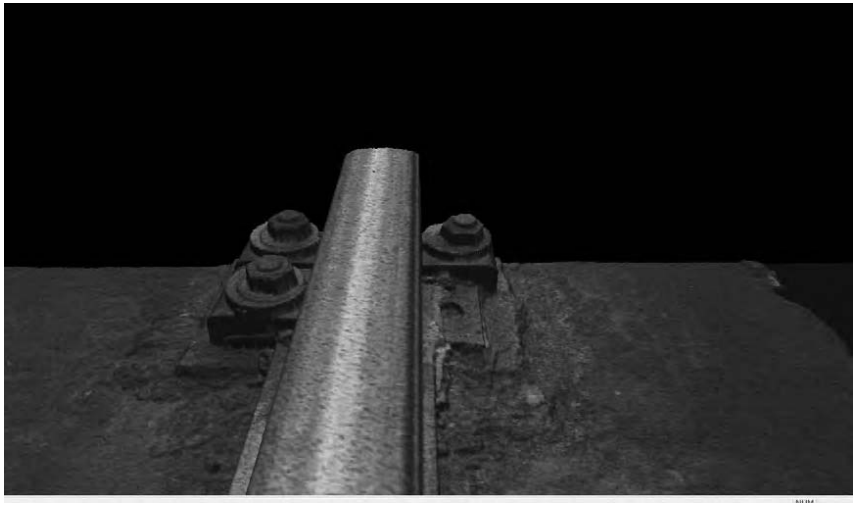
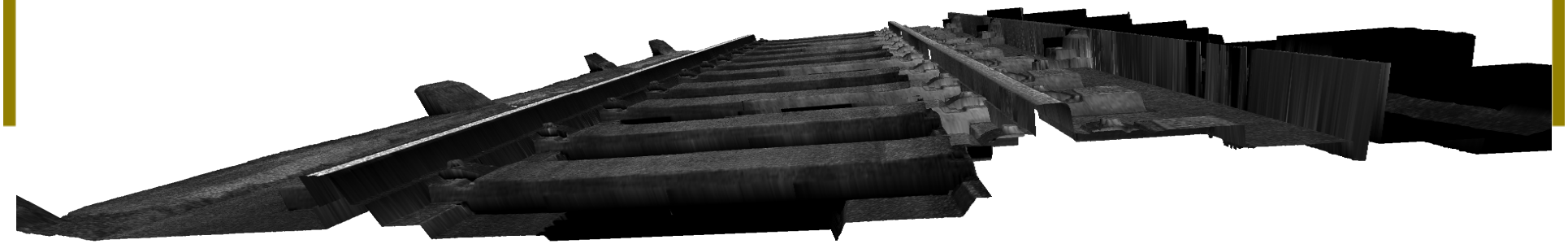
APPLICATION: Rails





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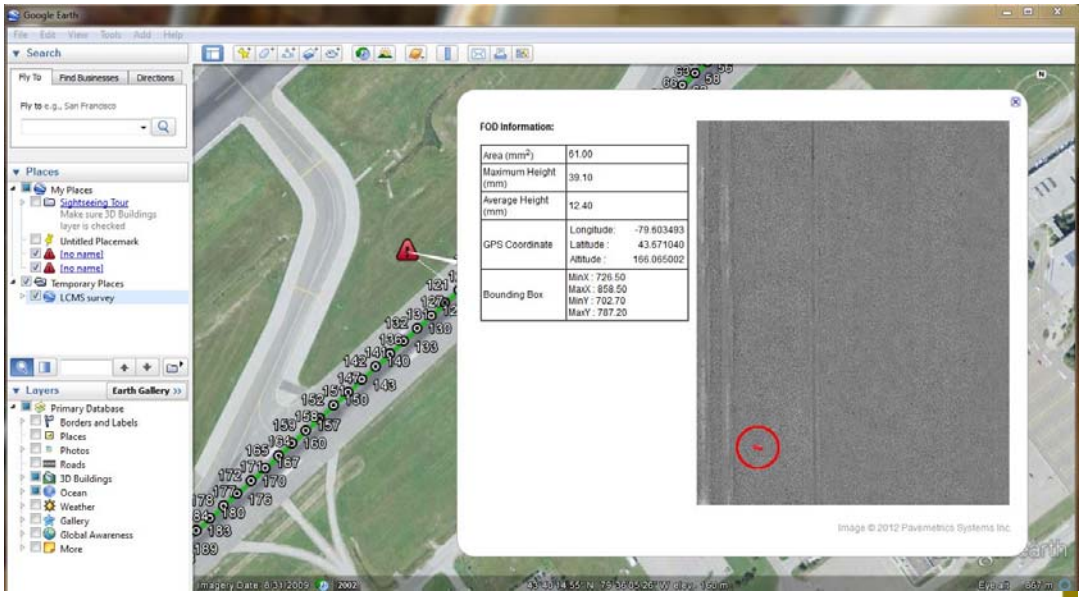
APPLICATION: Tunnels

Pavemetrics

Application: Airports - FOD



Runways currently scanned with Pavemetrics Technology

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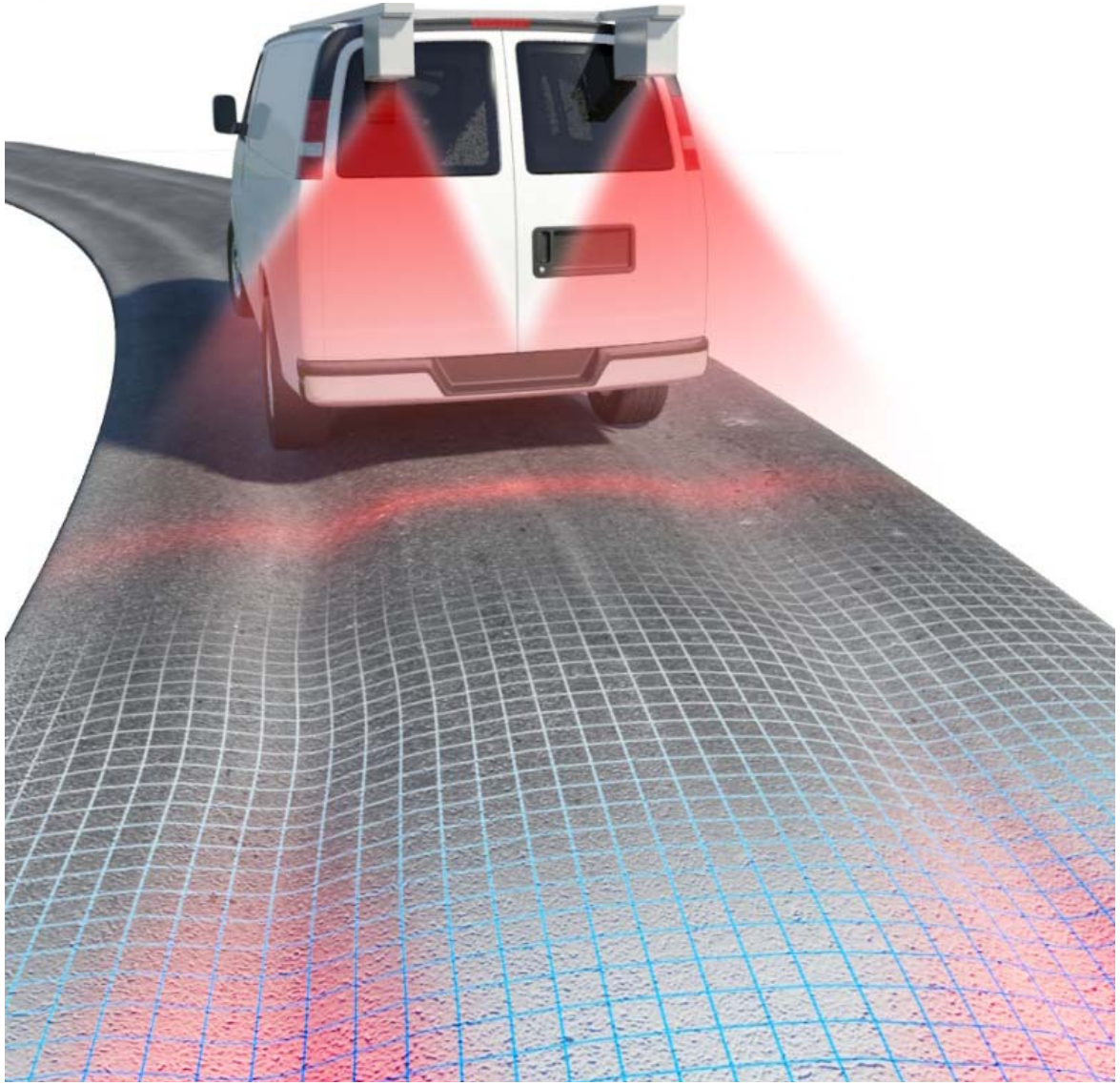
Application: ROADS distress and DTM



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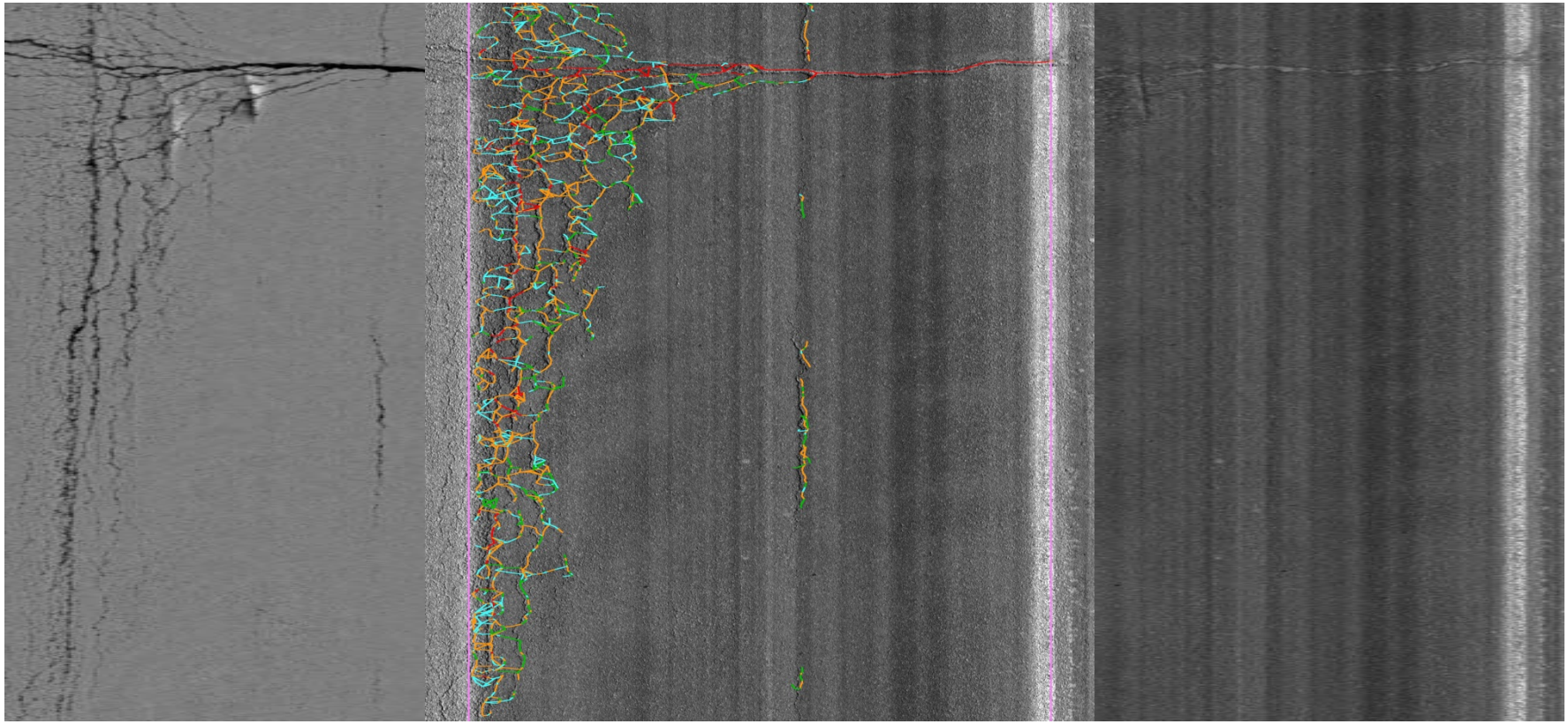
Understanding 3D Imaging



Range **Merged** **Intensity**

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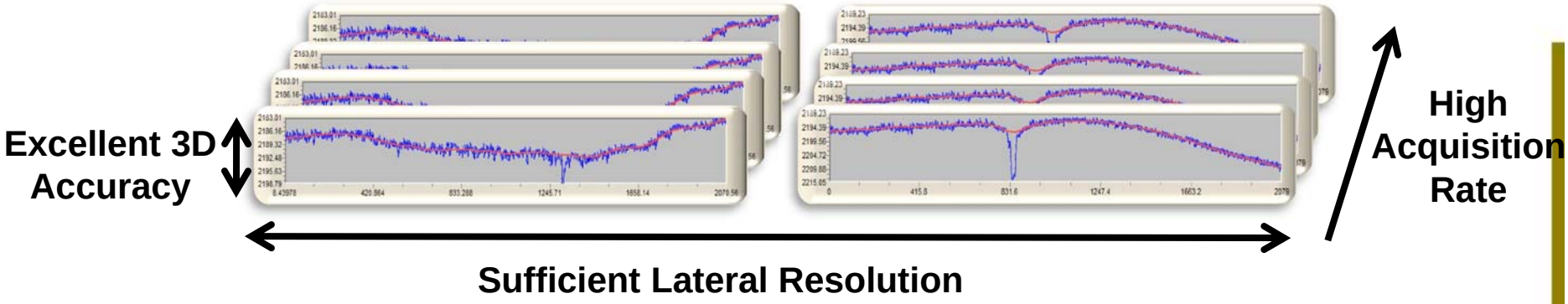
LCMS - Specifictions



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

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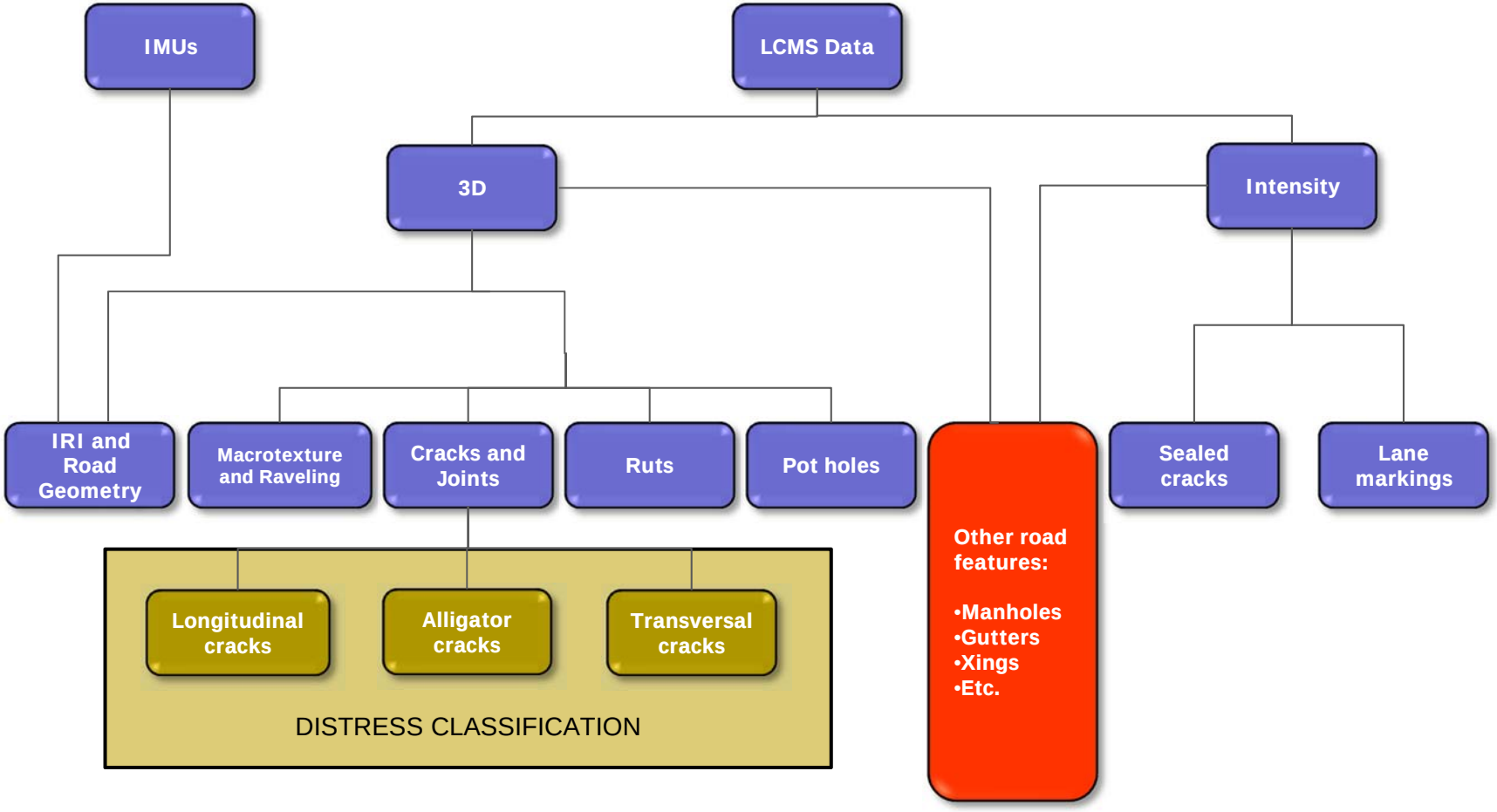
LCMS Data Processing Tree



Macrotexture : Mean Profile Depth (ASTM E1845-01)

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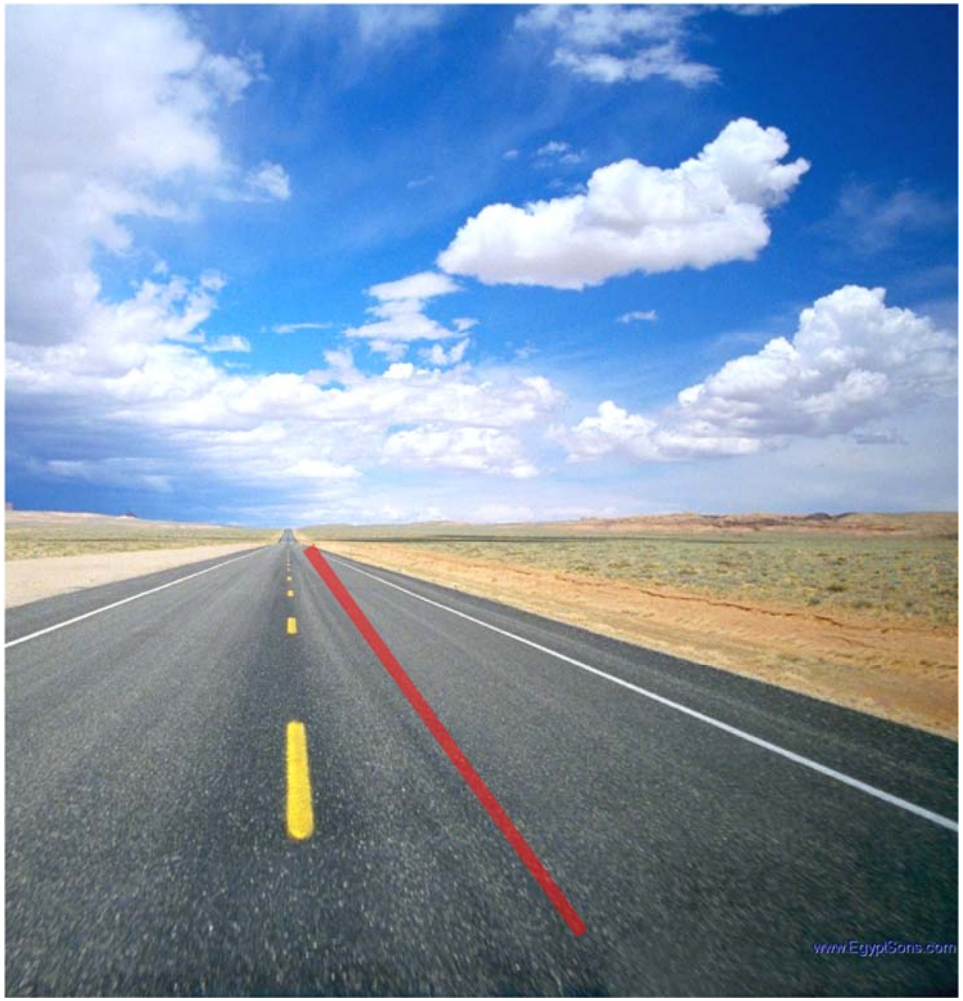
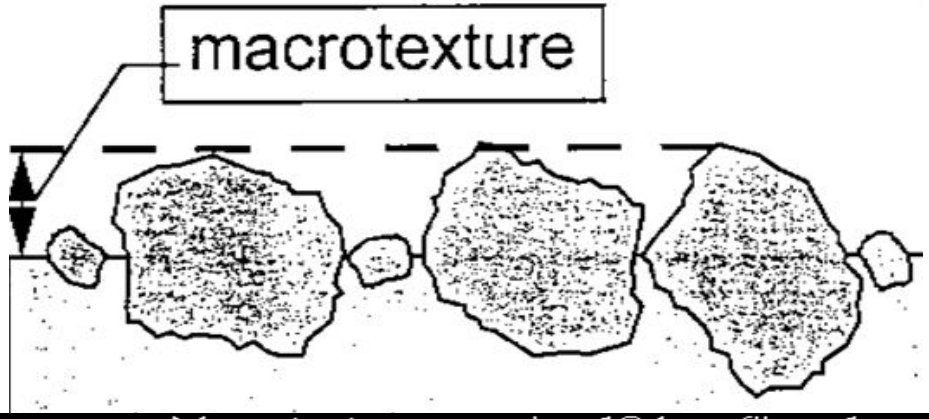
Specifications:

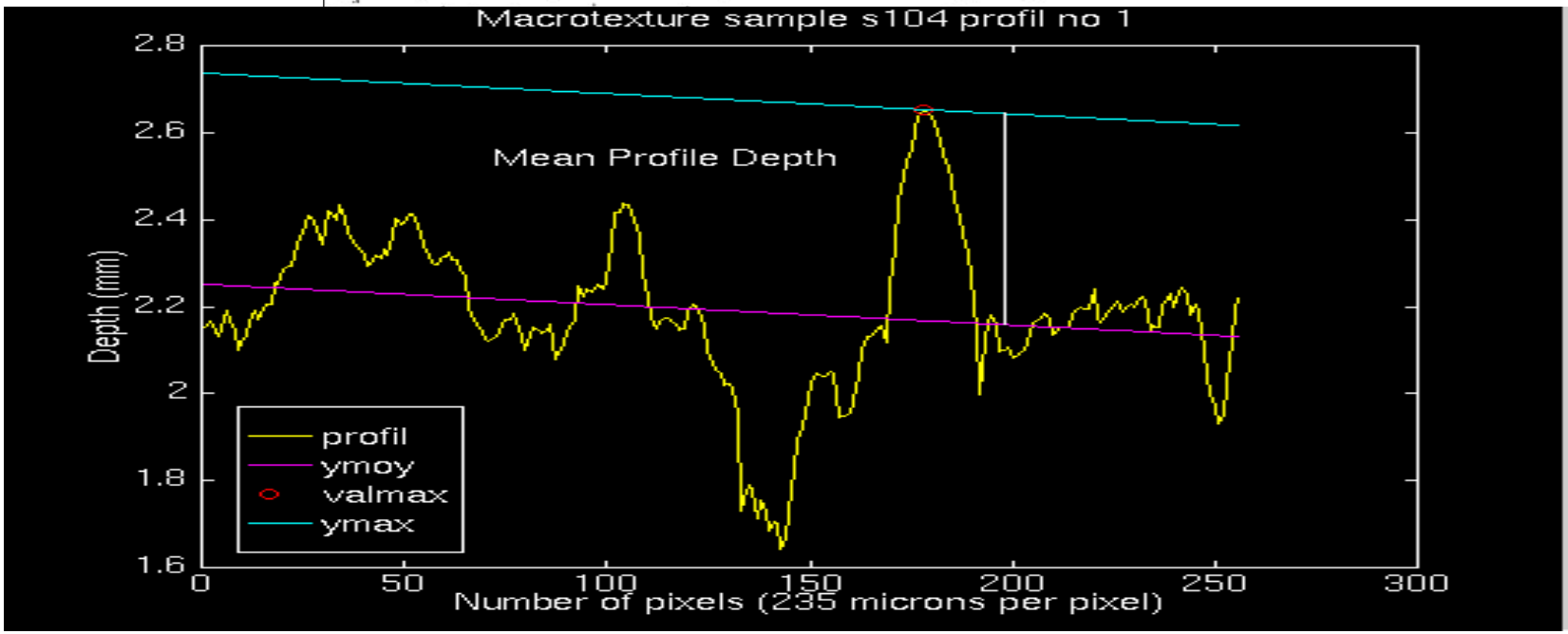
- 32kHz or 64kHz laser
- 1mm point spacing (minimum)
- 0.05 mm vertical resolution
- Low pass filtering 2.5mm features removed. 5mm+ features kept intact.



Pavemetrics

Macrotexture : Mean Profile Depth (ASTM E1845-01)





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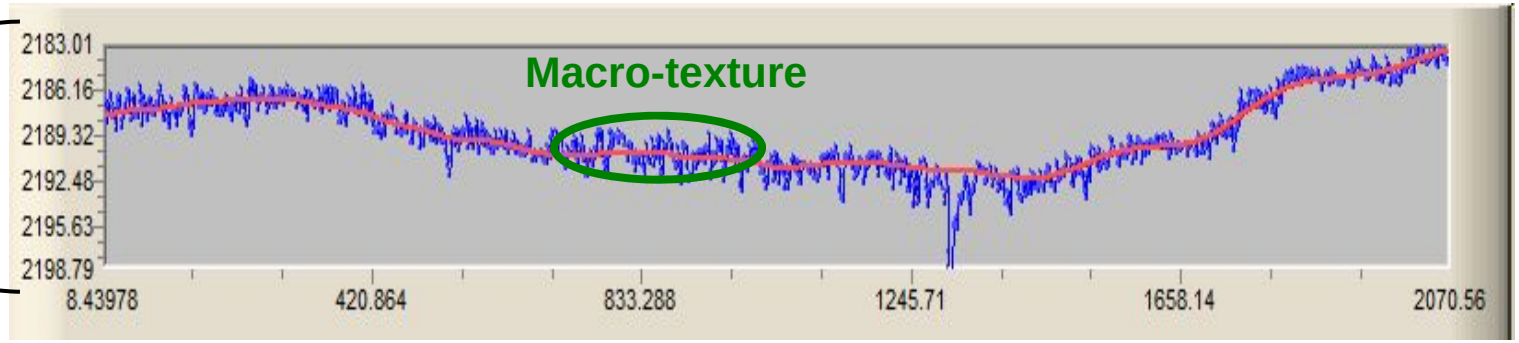
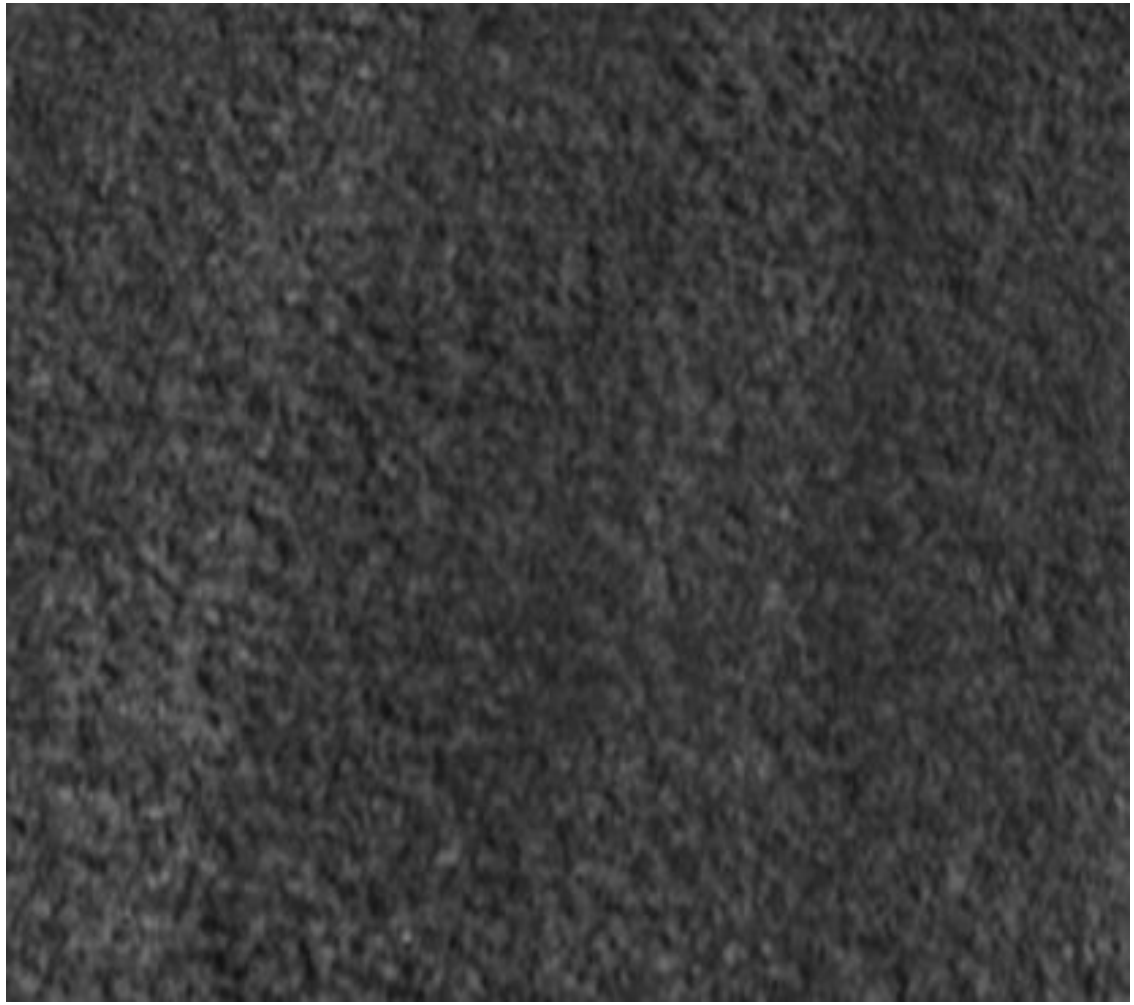
Single Road Profile (2 meter)

Distance between Sensor and ground (in mm)



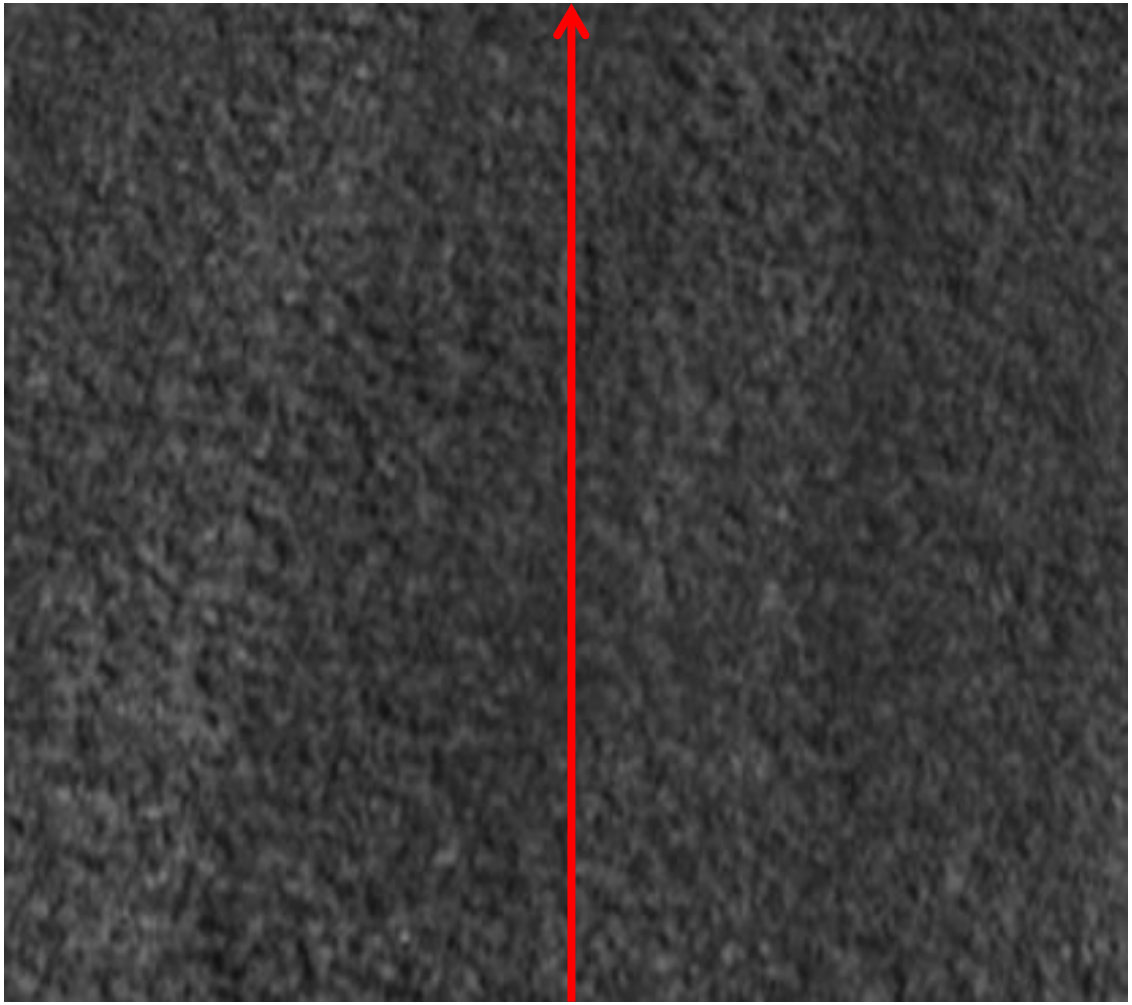
Pavemetrics

Macrotexture



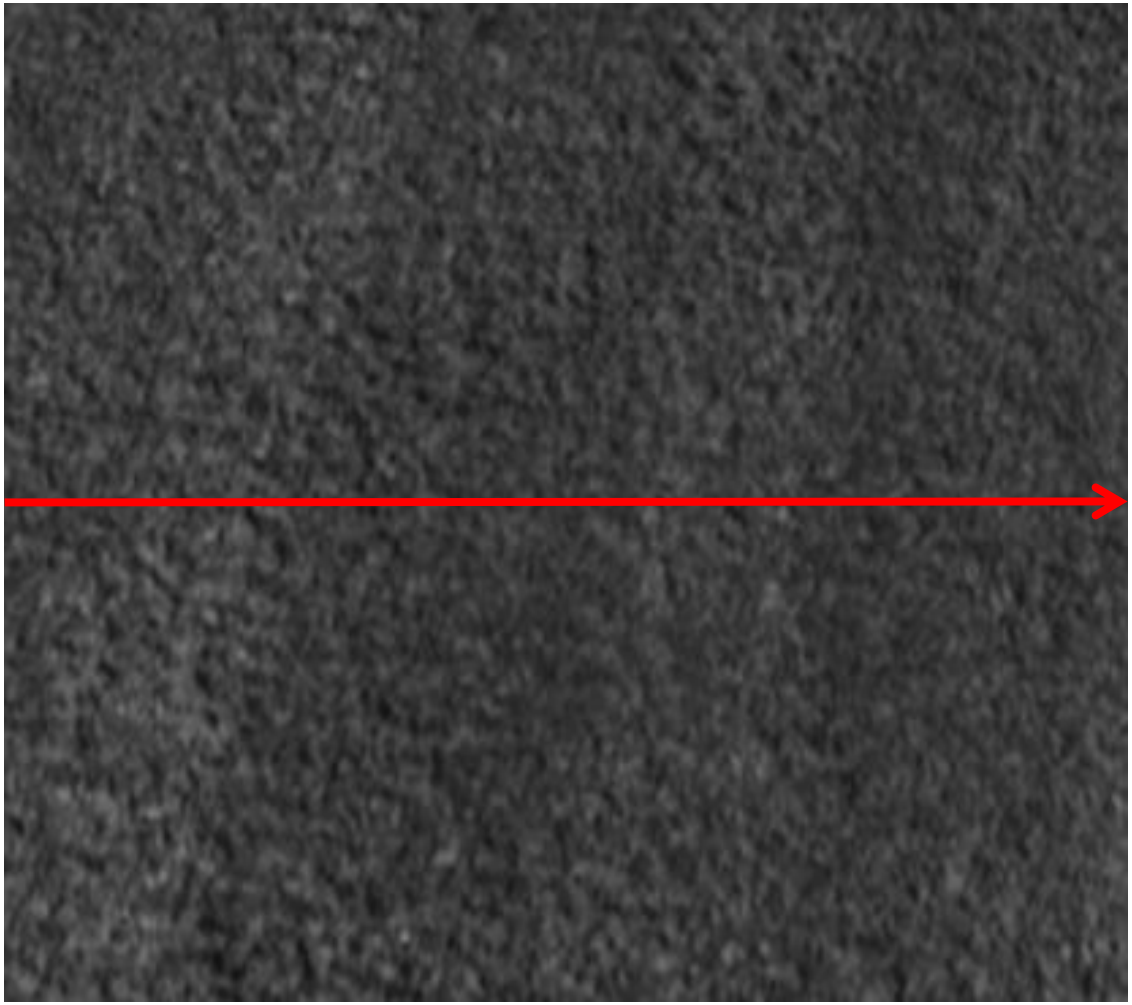
Pavemetrics

Macrotexture



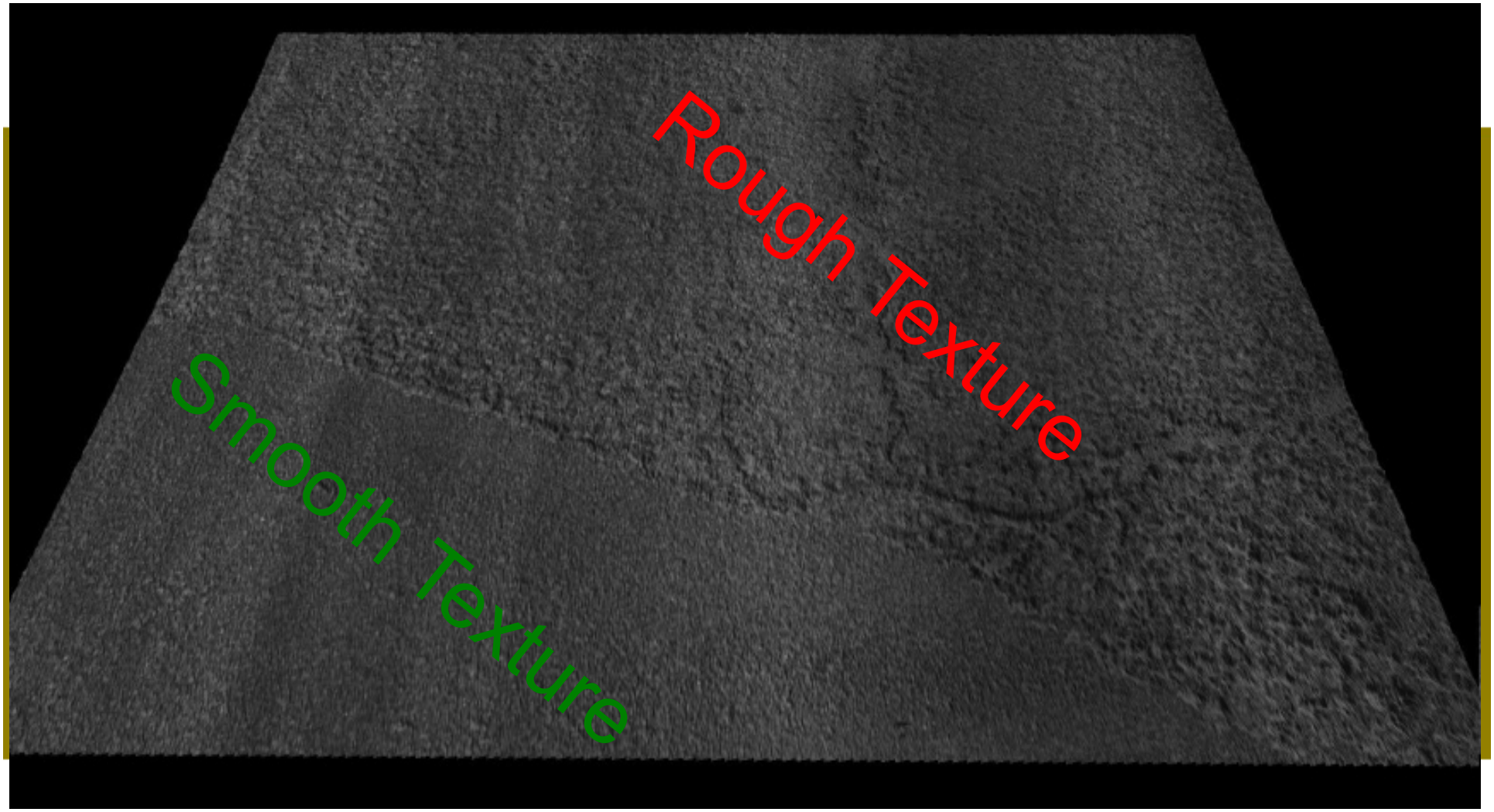
Pavemetrics

Macrotexture



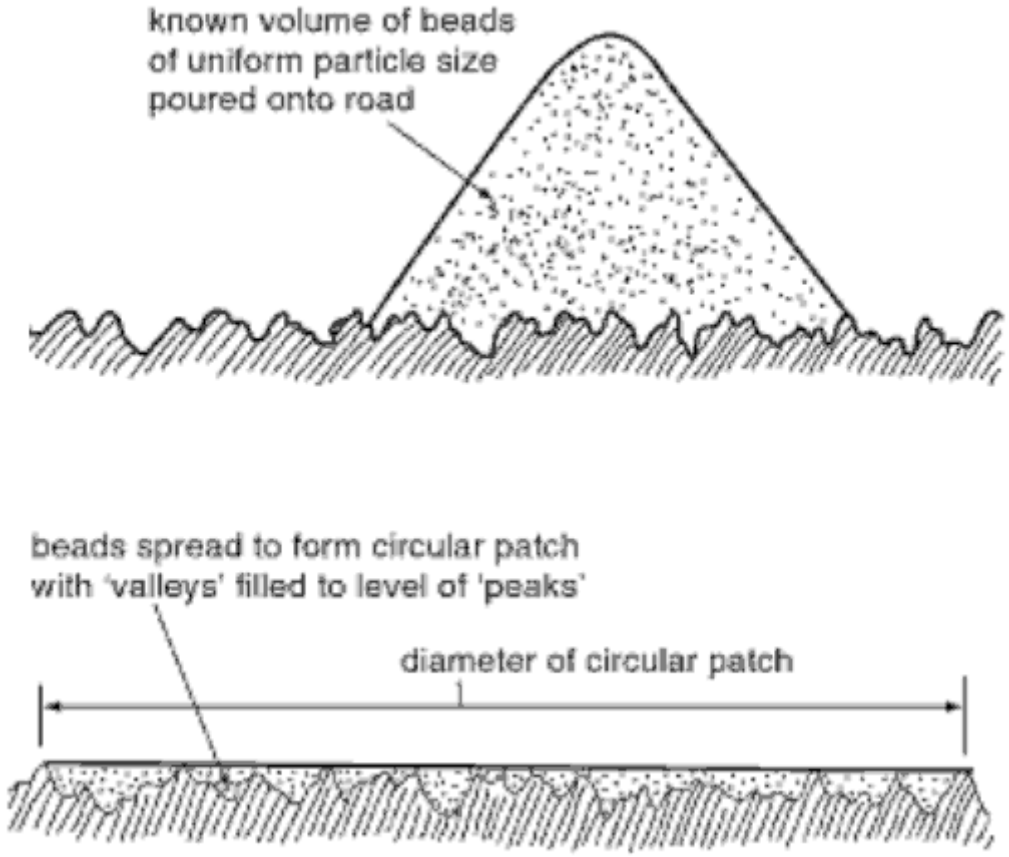
Pavemetrics

Macrotexture



Pavemetrics

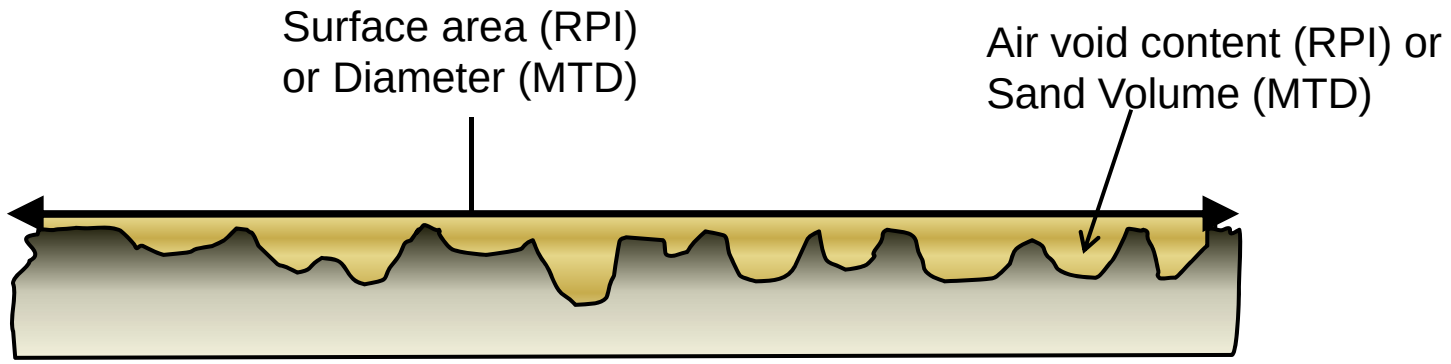
Macrotexture : Sand patch method (MTD) (ASTM E965)



Pavemetrics

Macrotexture – RPI
Digital Sand Patch Method

RPI - Road Porosity Index = (Volume under the surface – Ravelling - Cracks) divided by a surface area



$$RPI = \frac{(Vol_{air\ void} - Vol_{ravelling} - Vol_{cracks})}{Area_{Total}}$$

Pavemetrics

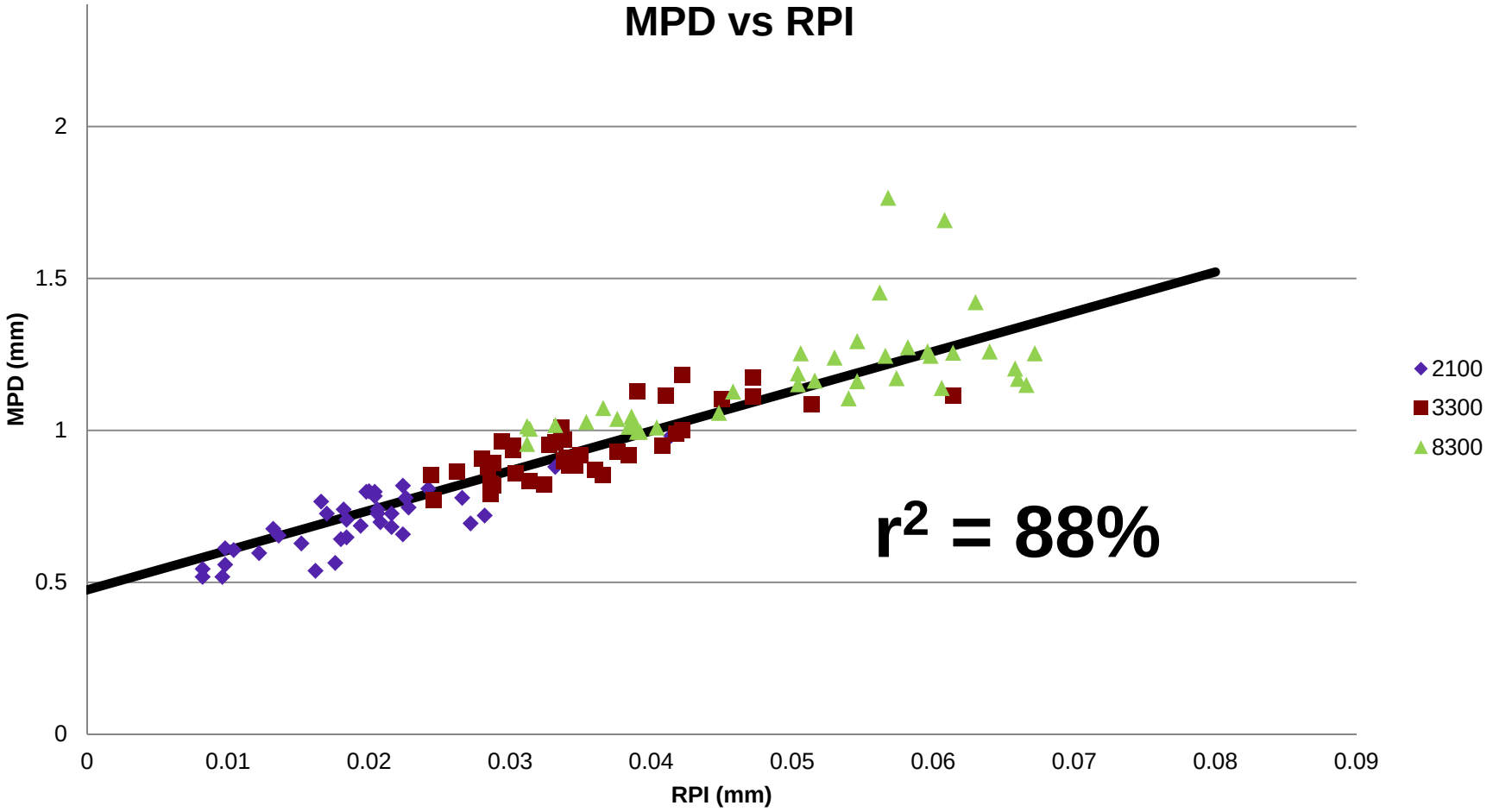
Macrotexture – LCMS Digital Sand Patch Method

Pros:

- Network survey is possible at 100kmh
- Full lane width is measured
  - 5 AASHTO bands
- Great repeatability
  - Automatic lane marking detection

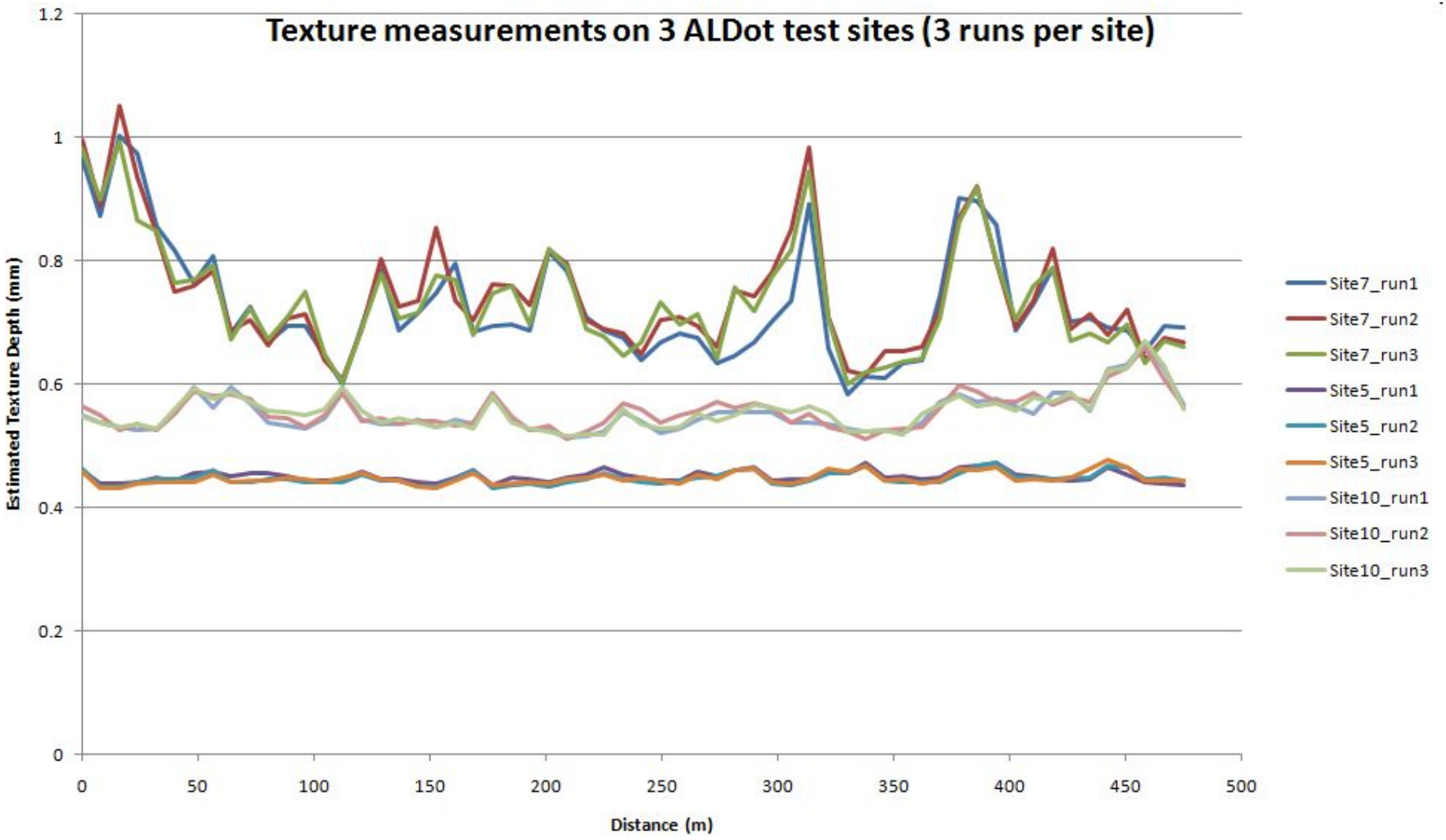
Pavemetrics

Macrotexture – Correlation between MPD and RPI



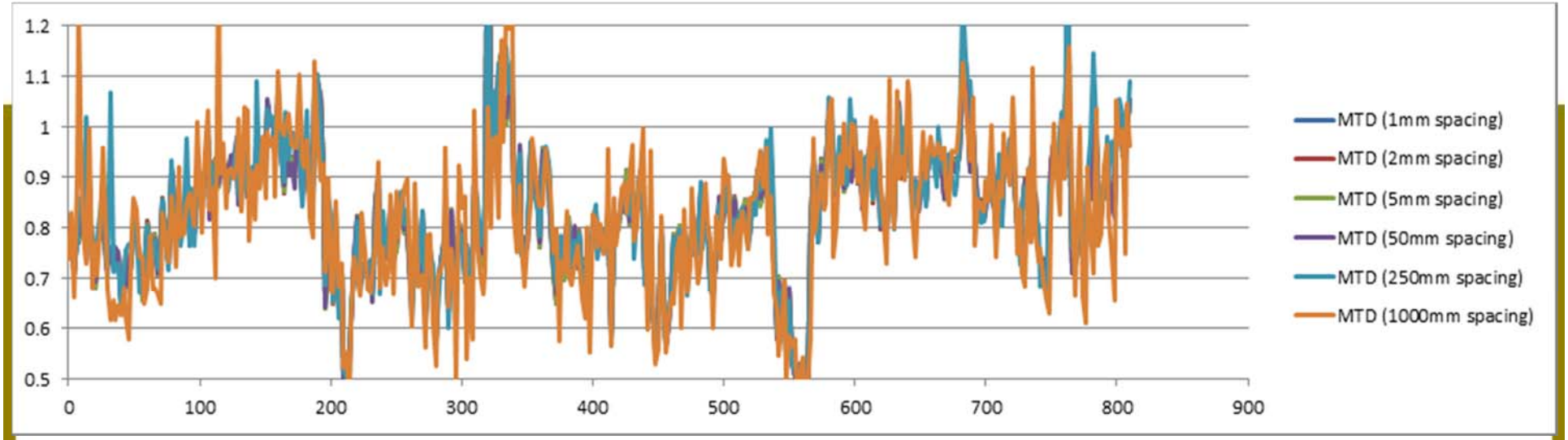
Pavemetrics

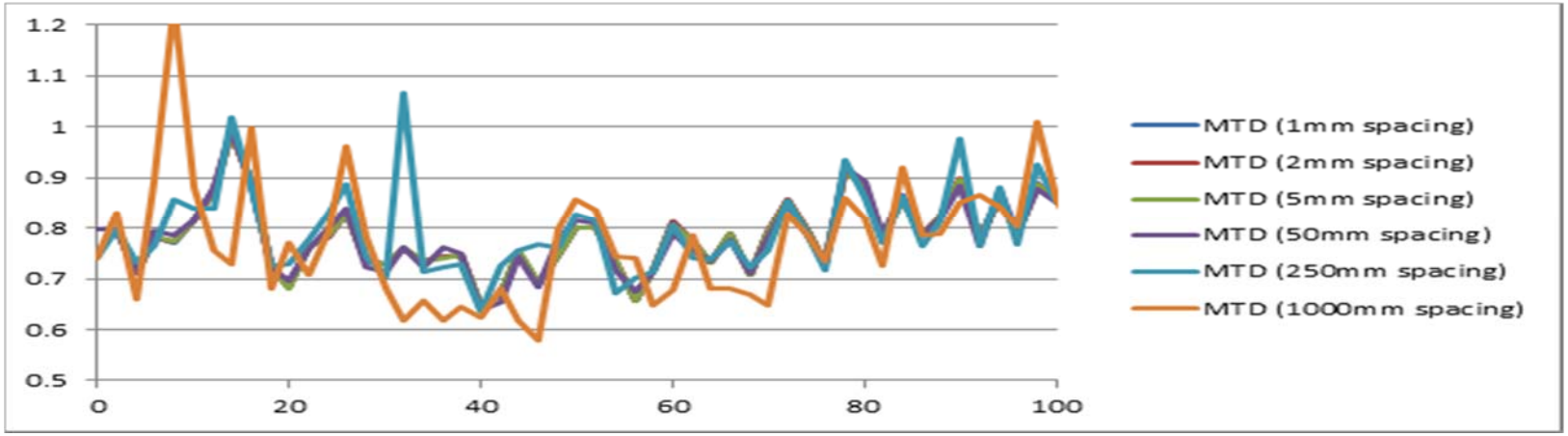
Repeatability – RPI measurement



Pavemetrics

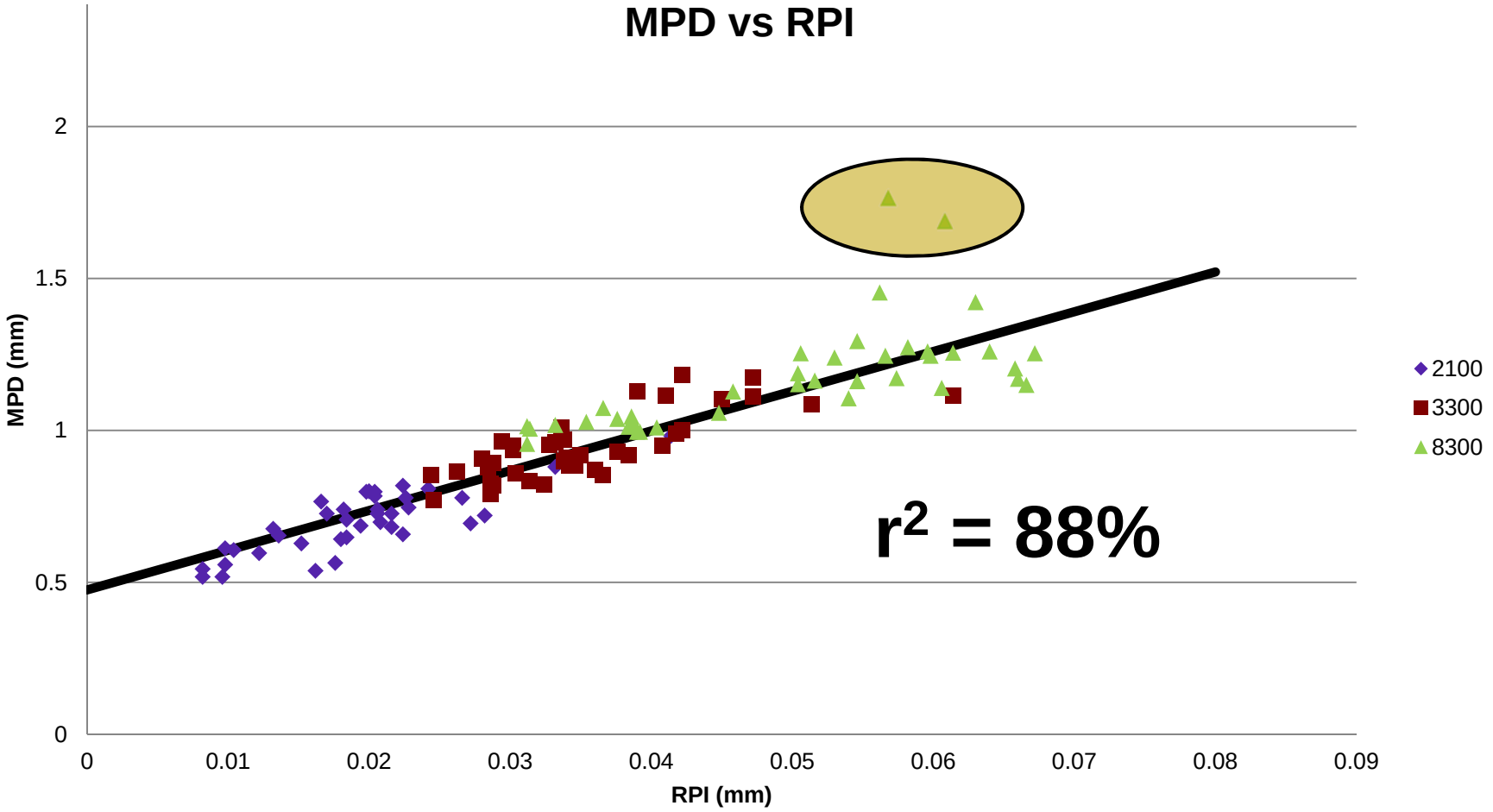
MPD single profile vs spacing



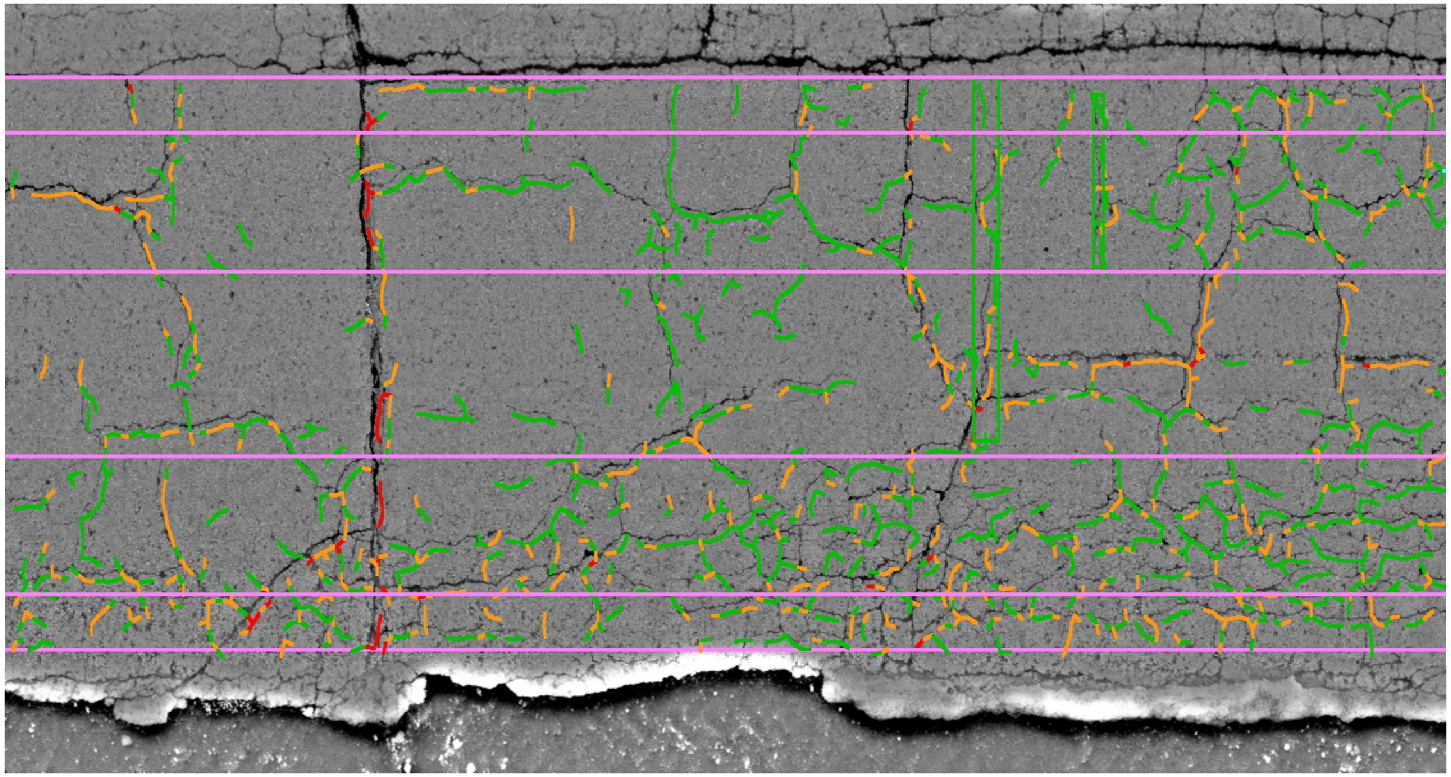


Pavemetrics

Macrotexture – Correlation between MPD and RPI

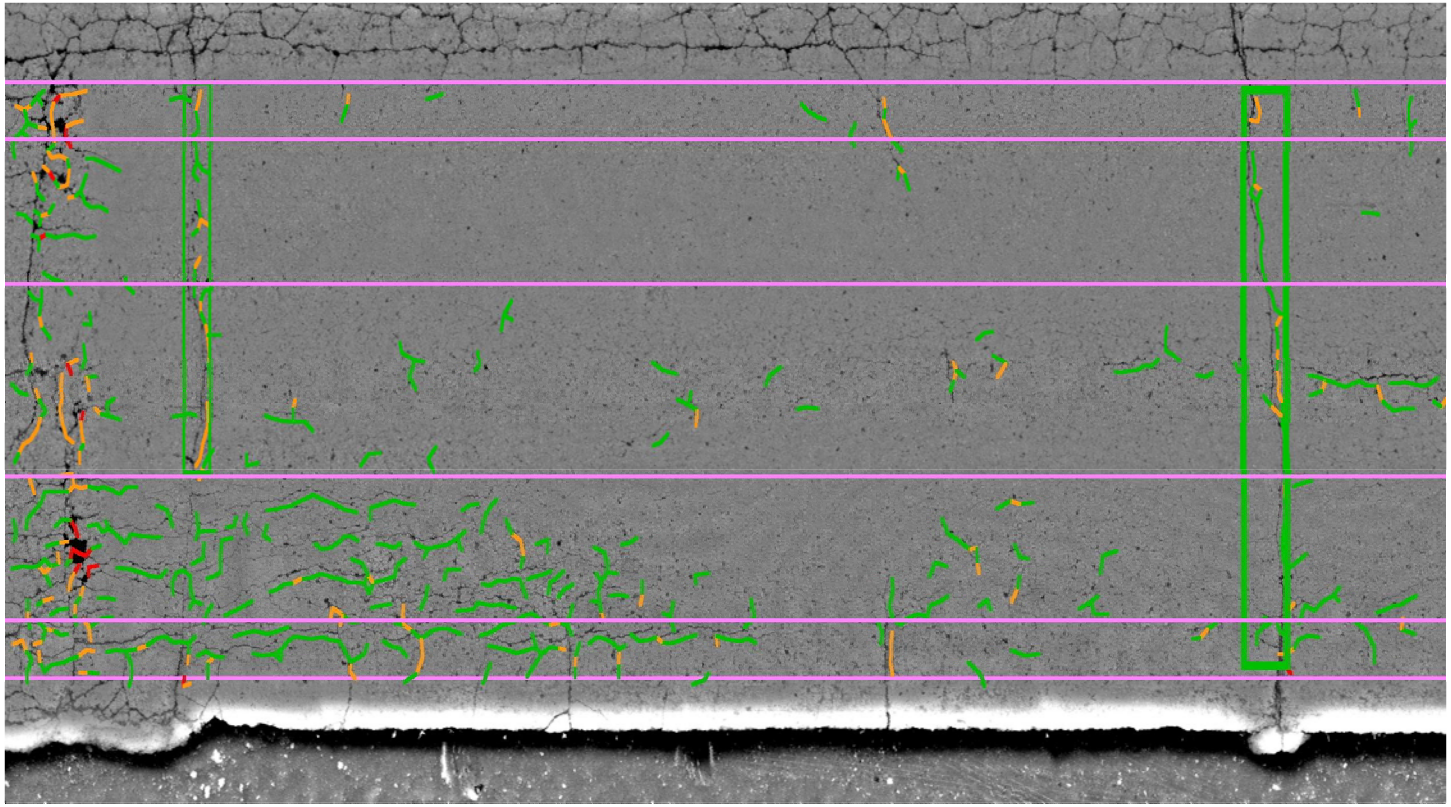


Macrotexture – Results for Section 08300



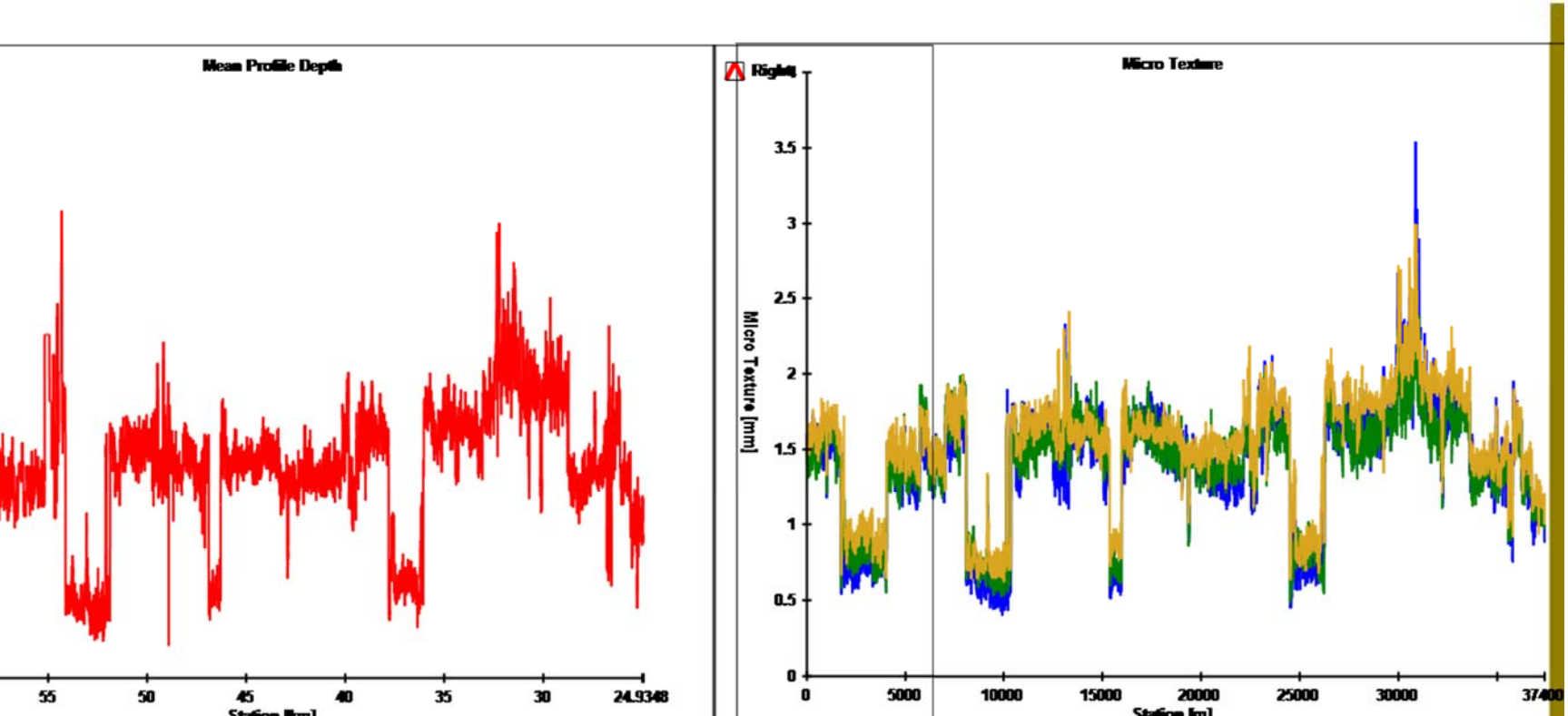
Pavemetrics

Macrotexture – Results for Section 08300

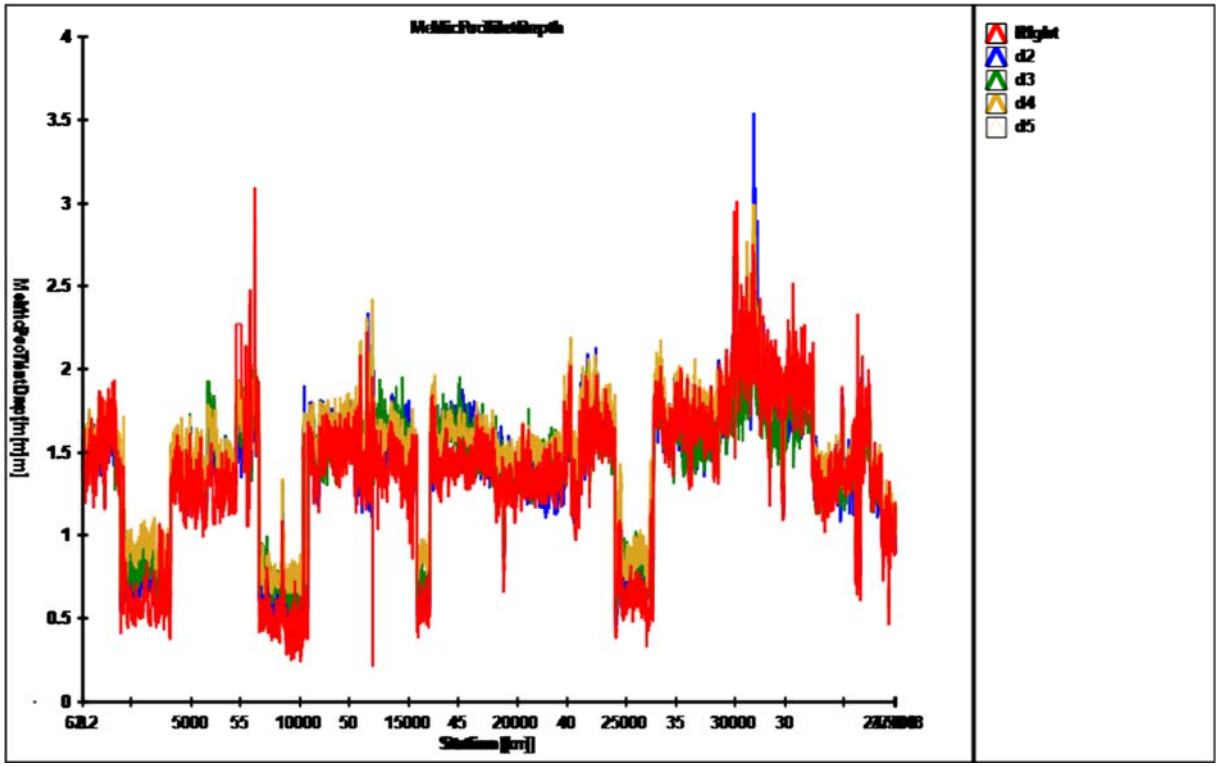


Right wheel path
(20-30m)

LCMS vs 64 KHz laser



LCMS vs 64 KHz laser



Raveling tests Netherlands

ghways; 5,010 km (~20,000 lane km)

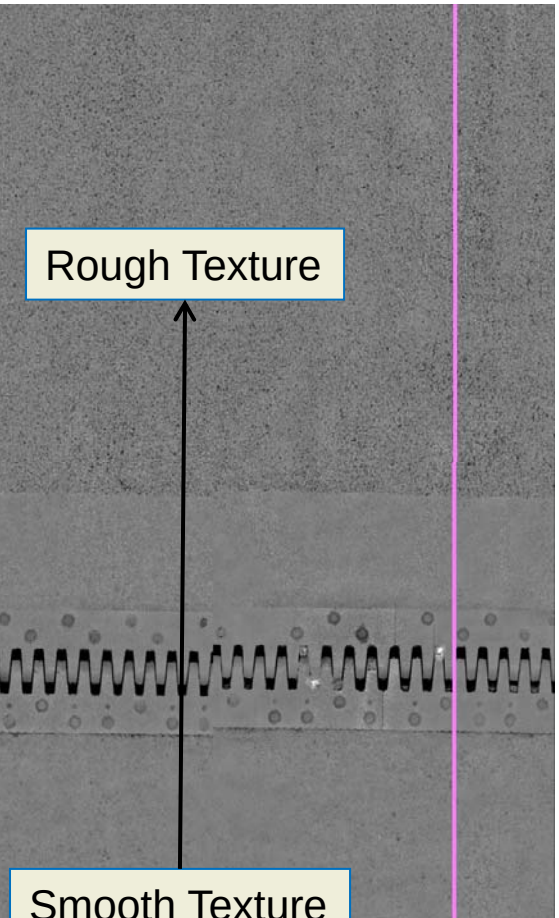
- 10% DAC and SMA
- 90% Porous Asphalt

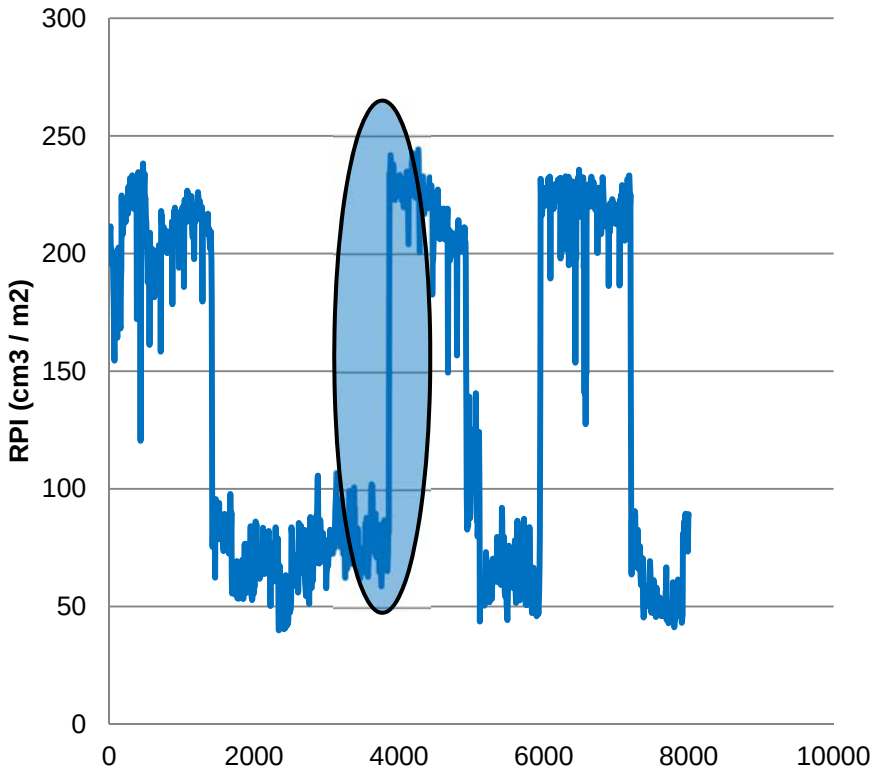
sing LCMS to detect raveling

- Development of algorithms
- Matching of severity levels with manual evaluators

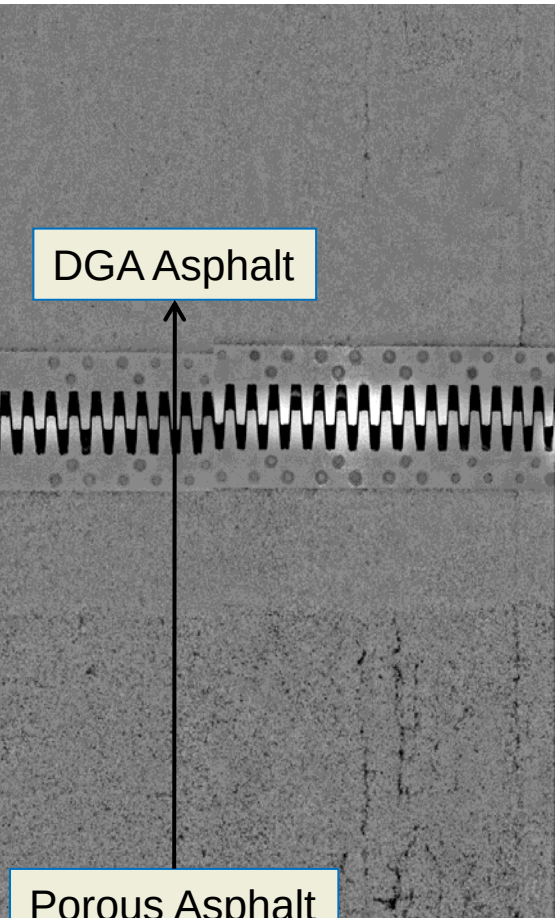
Rijkswaterstaat vehicle

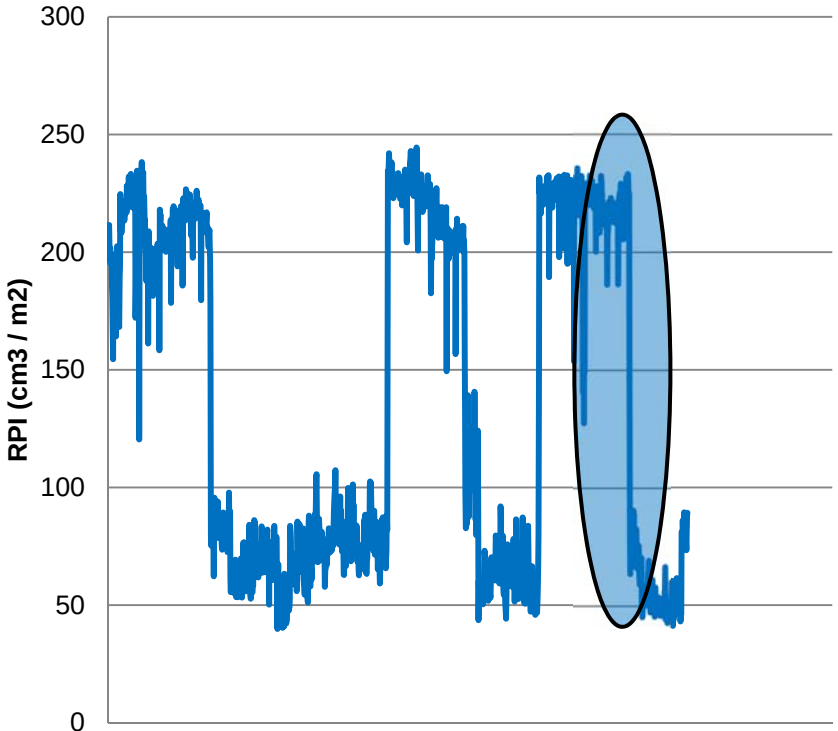
Texture Transition: DGA to Porous asphalt





TextureTransition: Porous to DGA asphalt

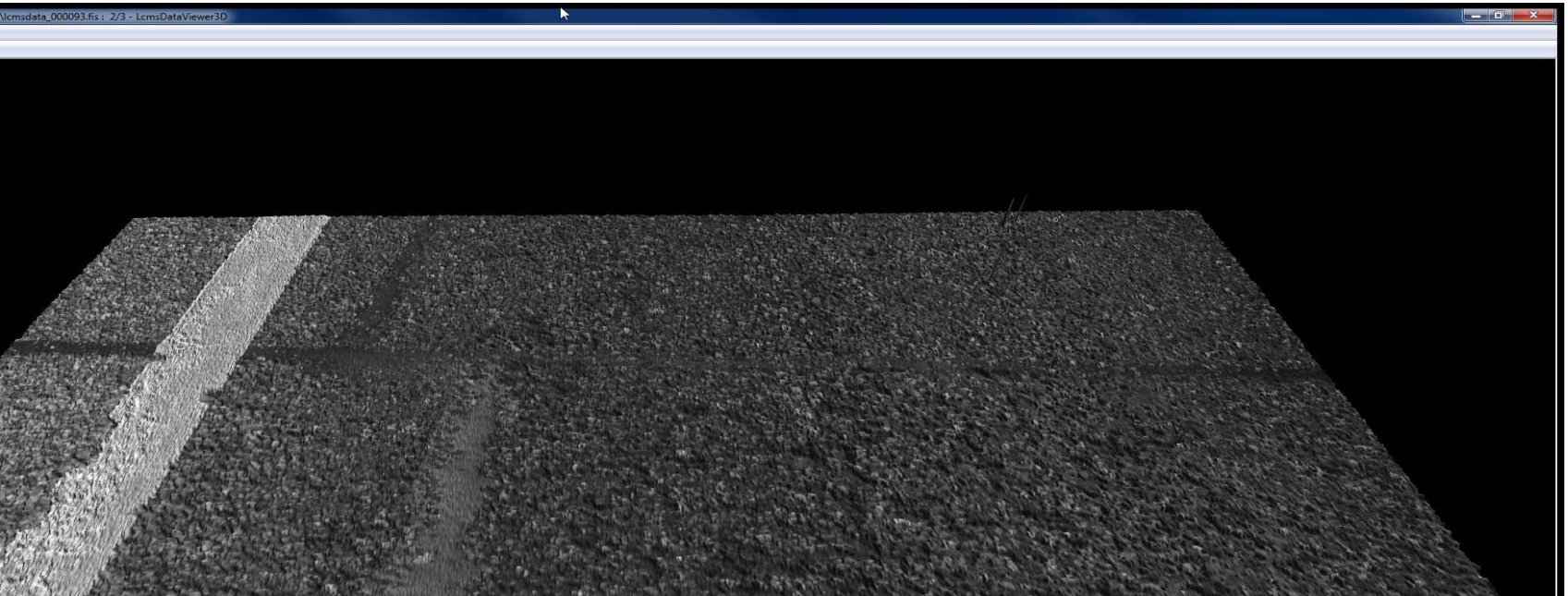




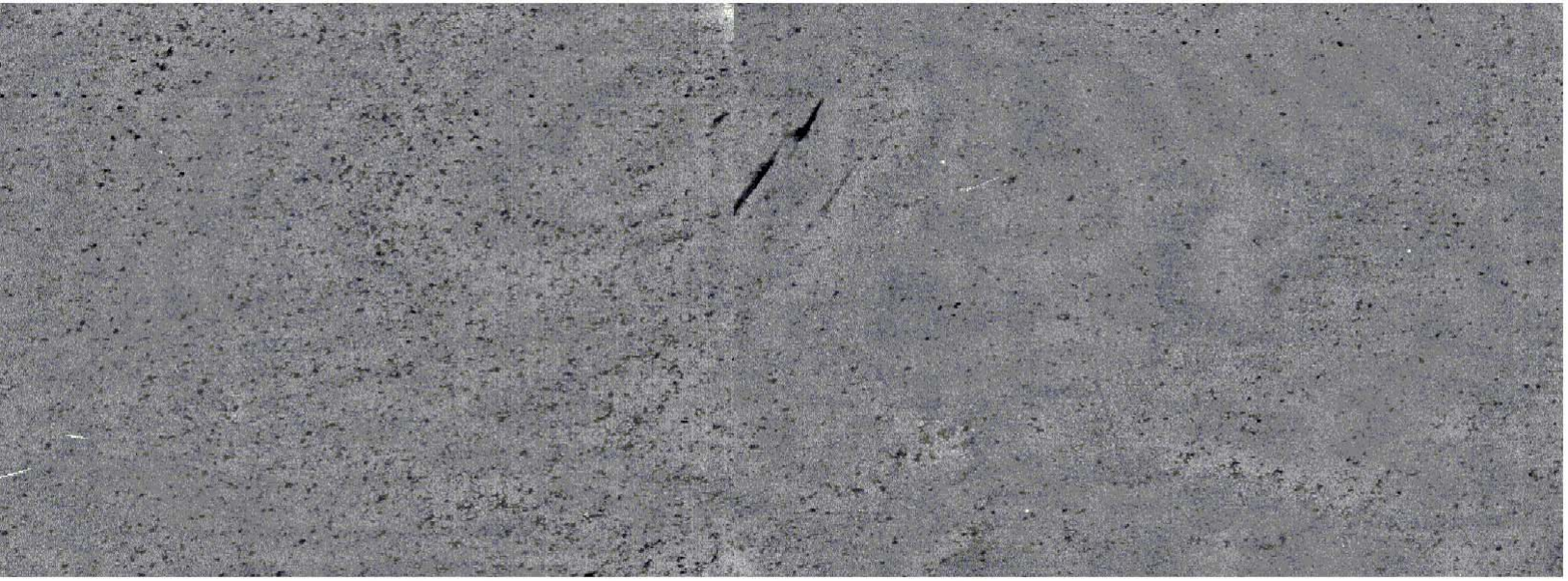
Ravelling Index - RI

elling Index (RI) = The volume of aggregate loss per surface area

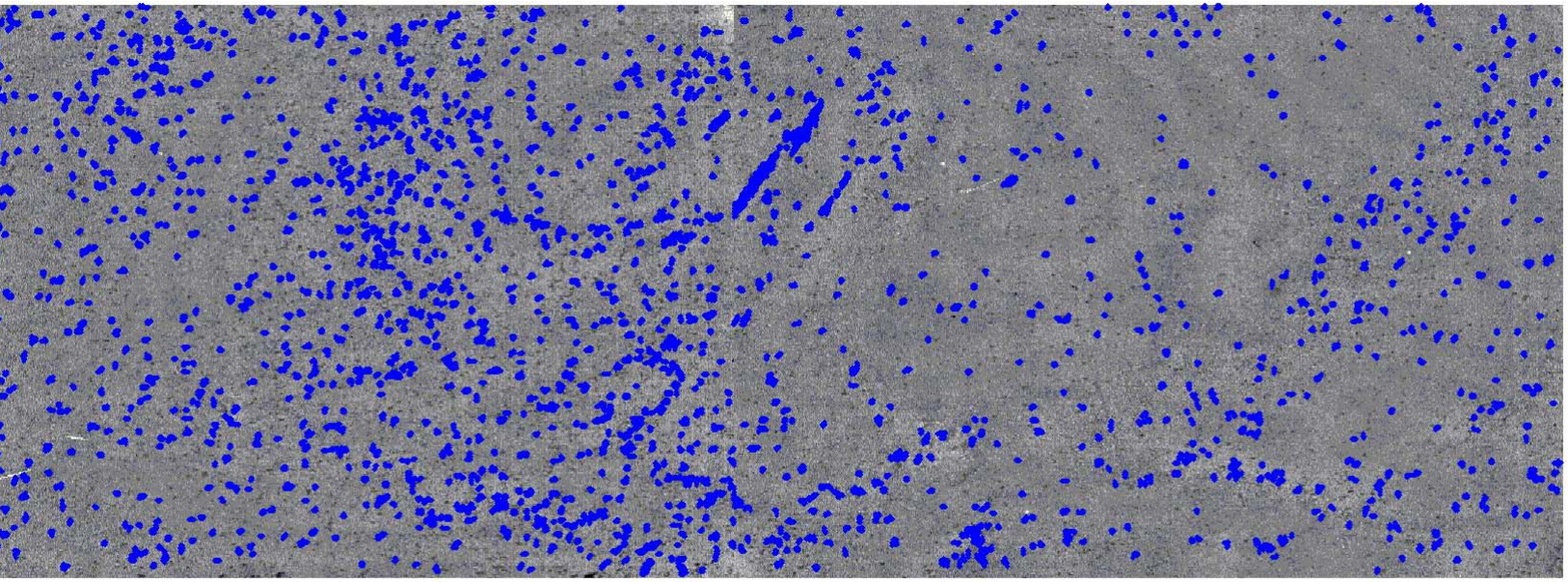
$$RI = V_{aggregate\ loss} / A_{Total}$$



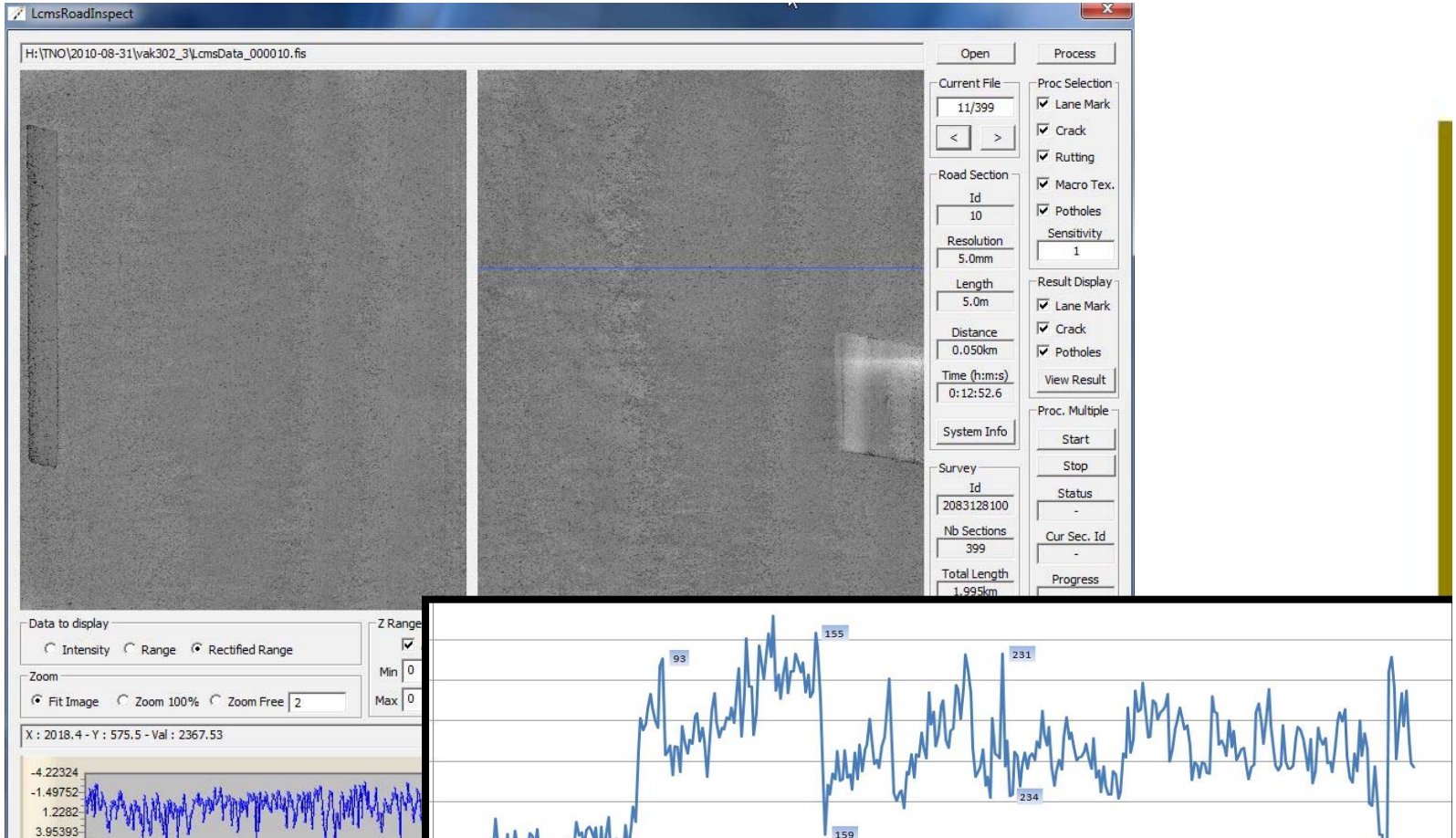
Aggregate loss detection



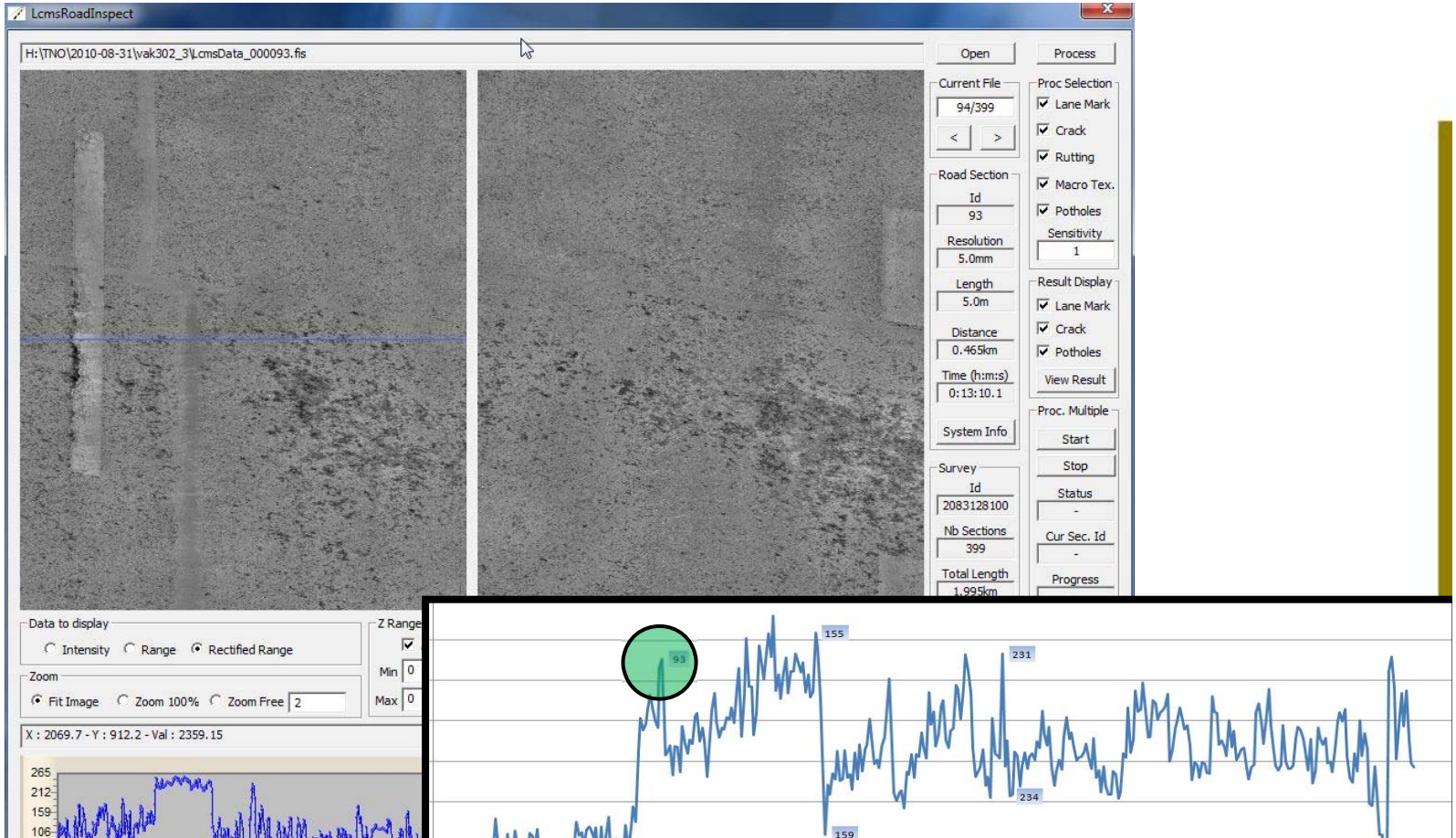
Aggregate loss detection



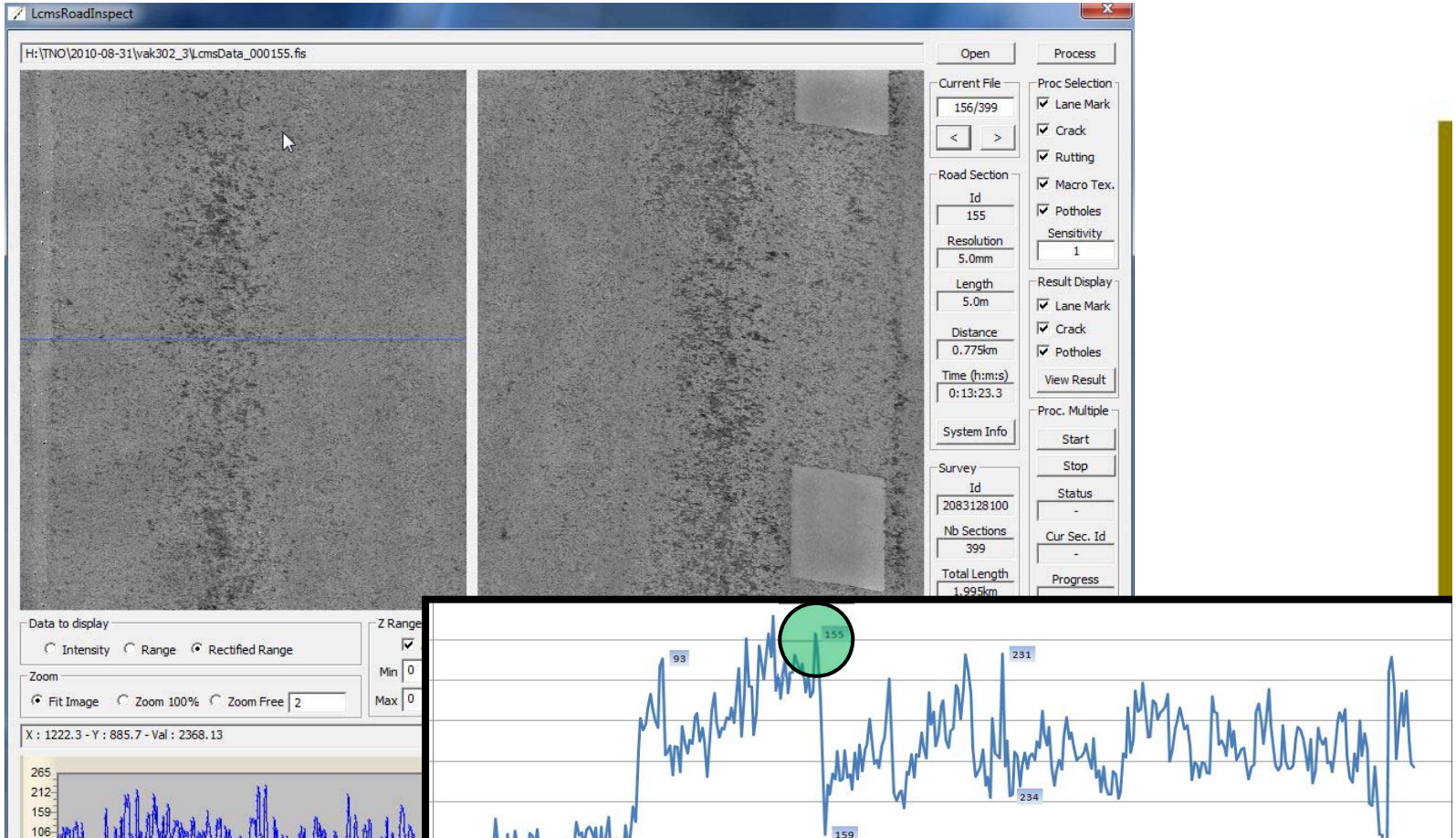
RI – Road test – Porous Asphalt in the Netherlands



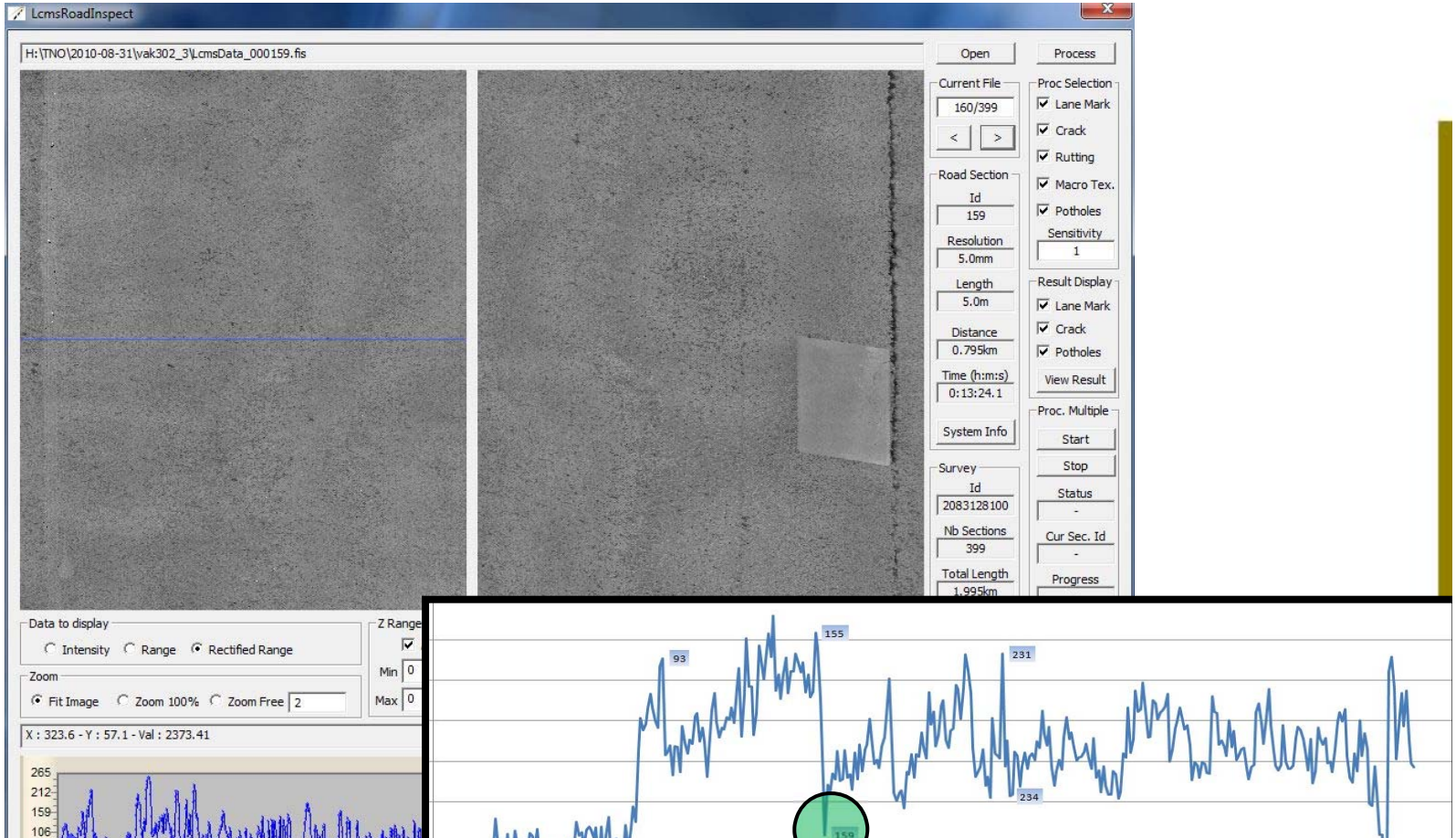
Road Section #93 : Transition between Ravelling and new pavement (Range)



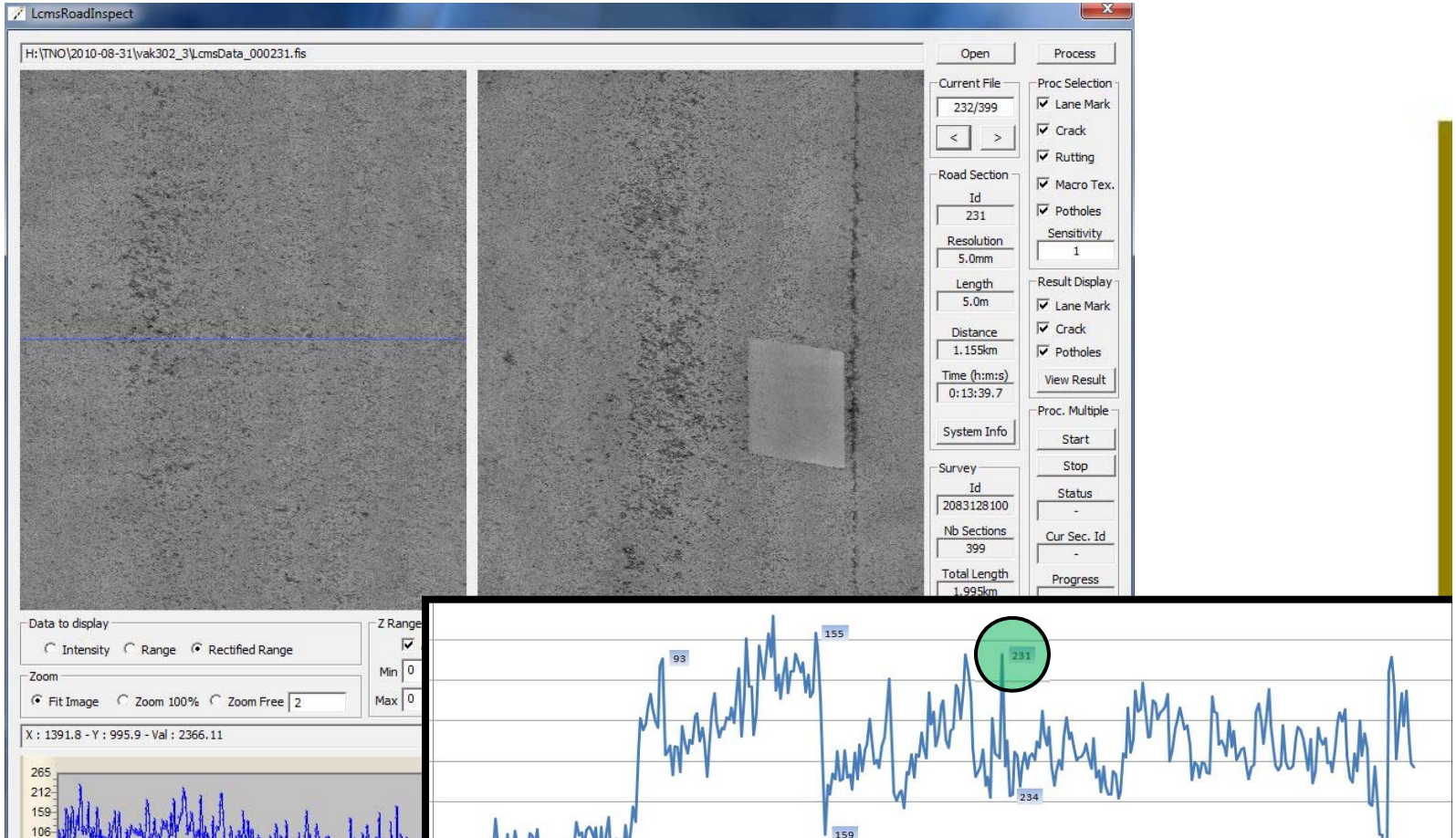
Road Section #155 : Raveling patch



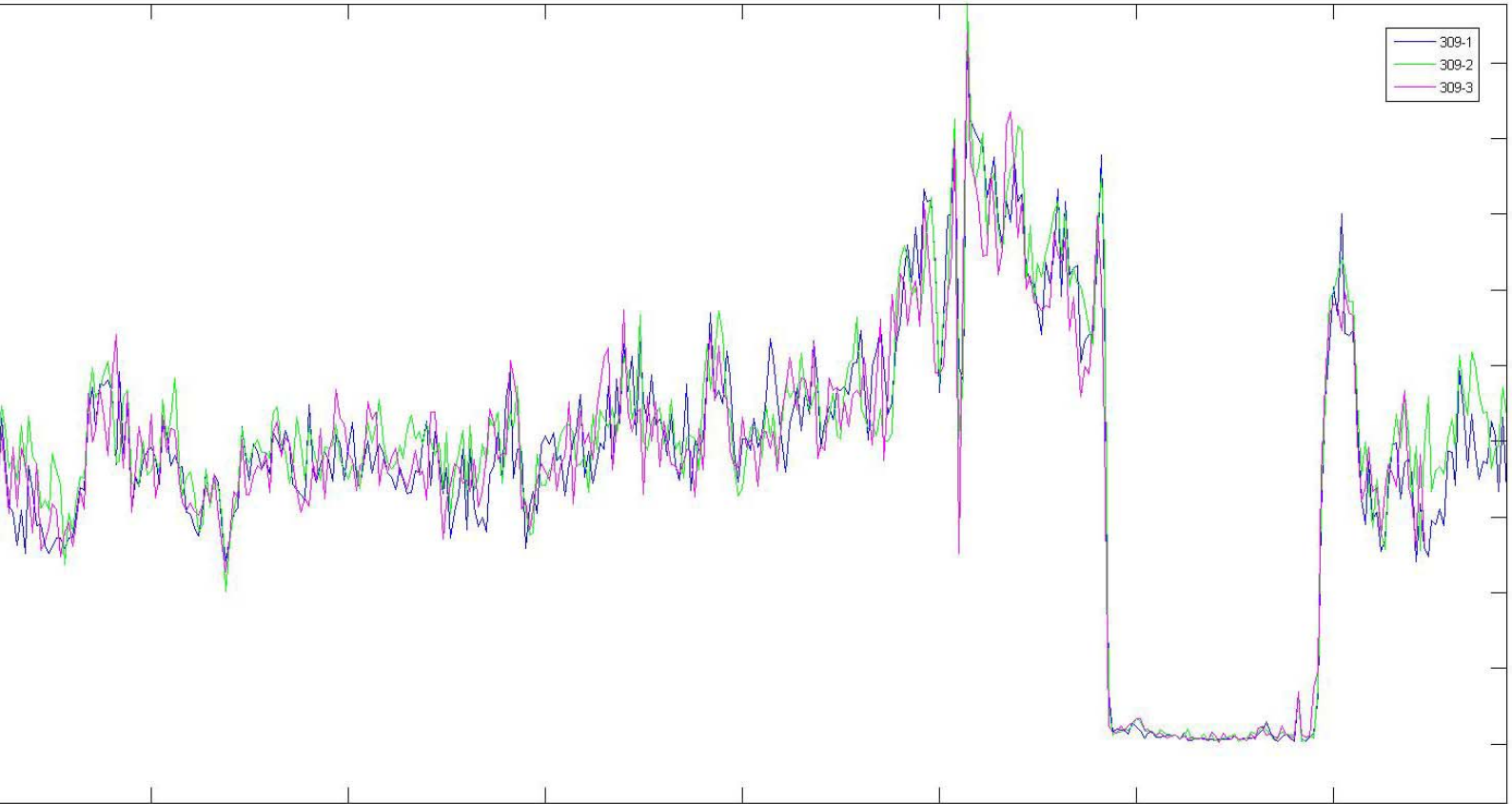
Road Section #159 : Smooth texture



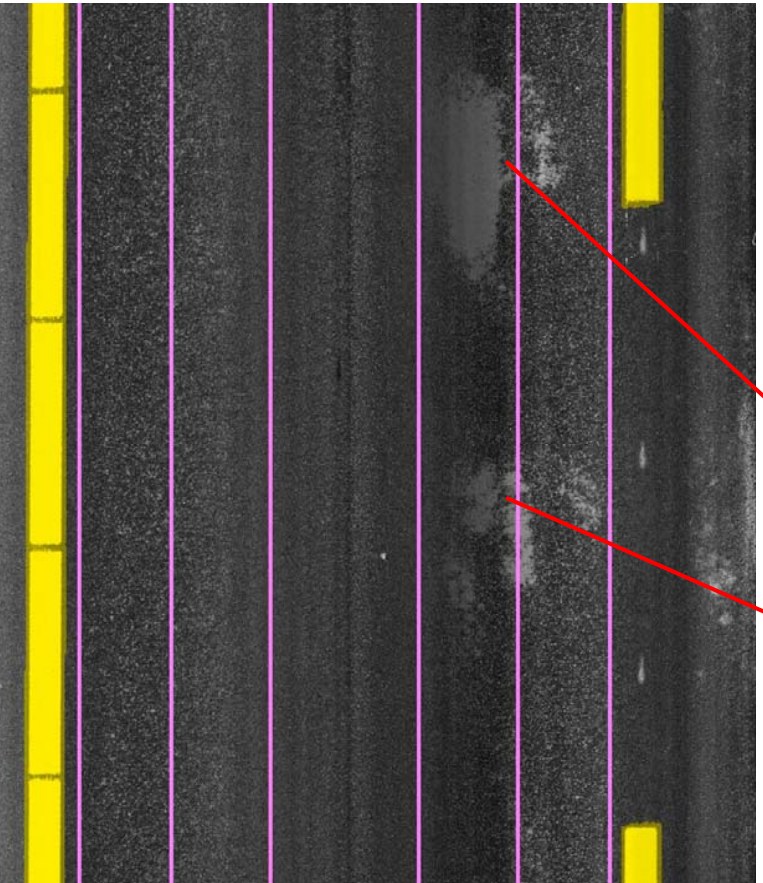
Road Section #231 : Raveling patch

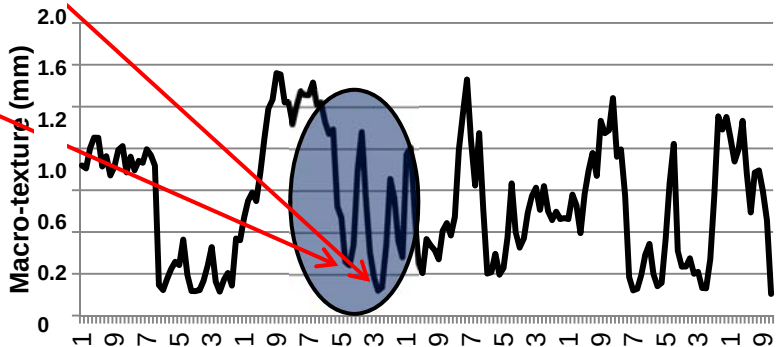


Ravelling Index - Repeatability (Porous asphalt Netherlands)



Bleeding

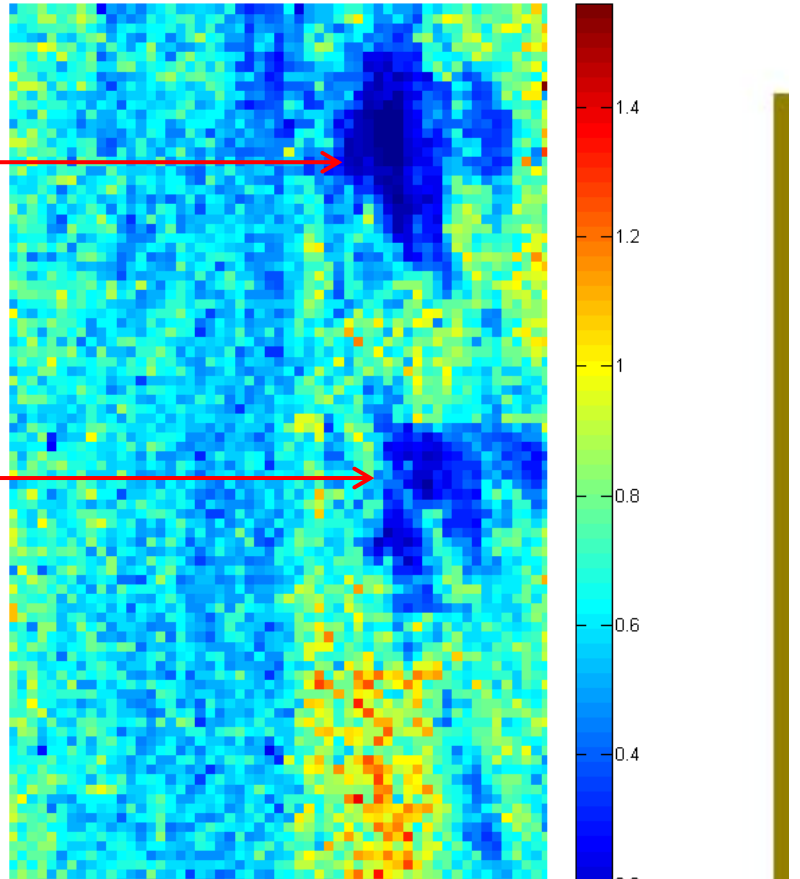




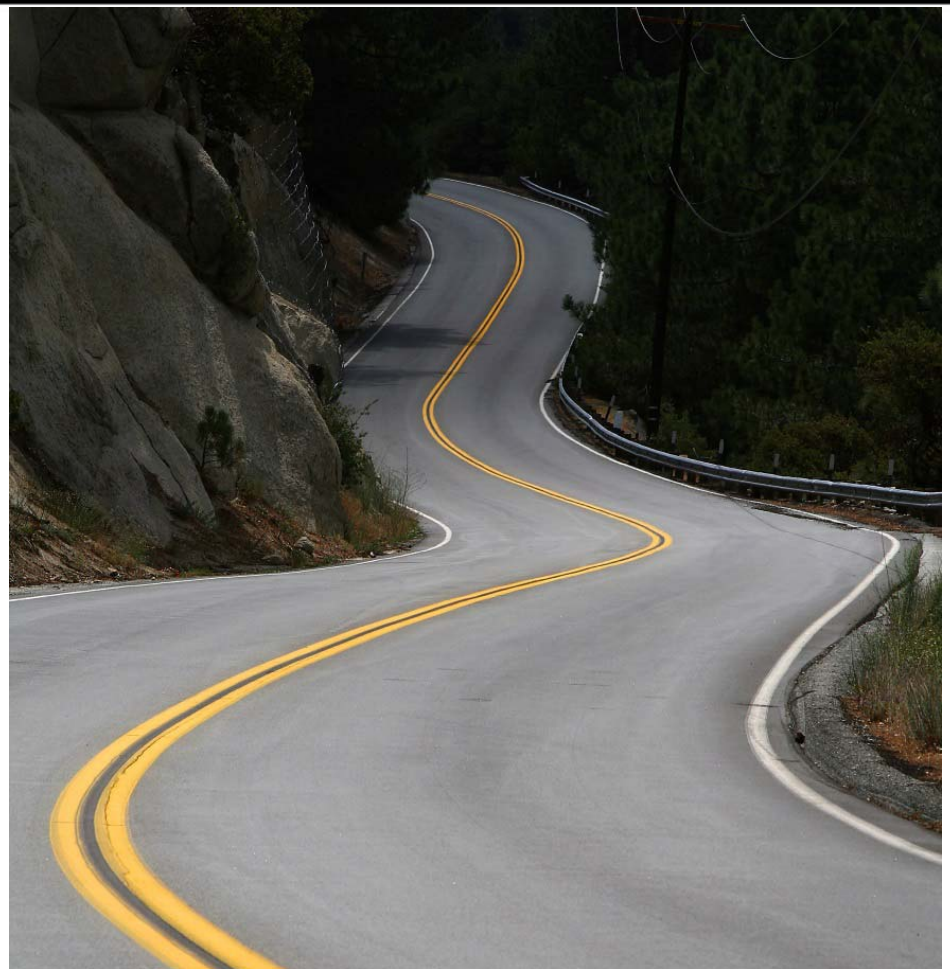
Macrotexture: bleeding

Intensity image

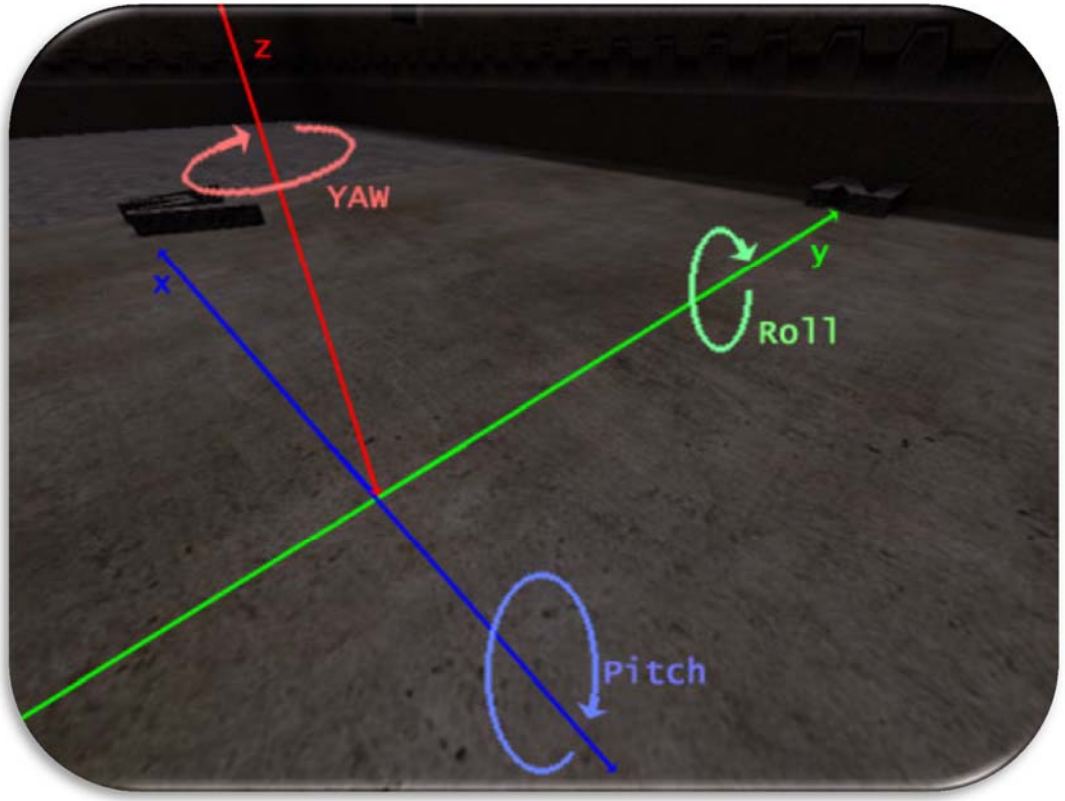
Texture image (MTD, mm)



Road Geometry



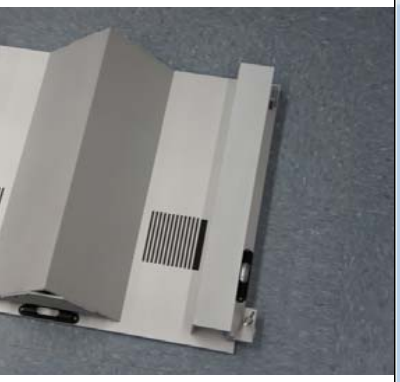
IMUs



LCMS sensor/IMU coordinates transformation

IU

Sensor to sensor and world (gravity) position calibration



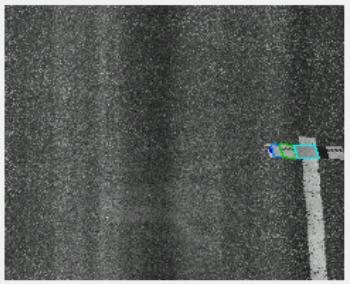
LcmsCalibrationTool

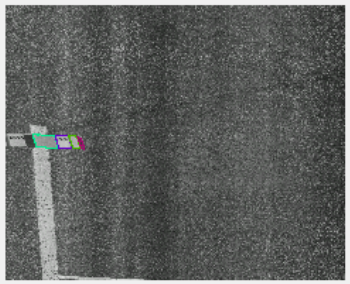
Step 1 | Step 2 | Step 3 | Step 4

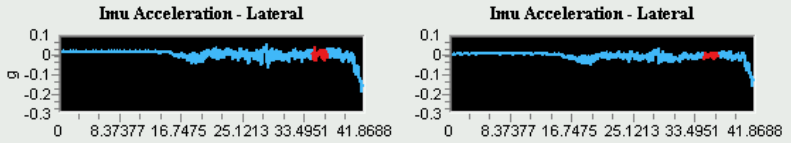
Step 2 - 3D And Vehicle Level Calibration

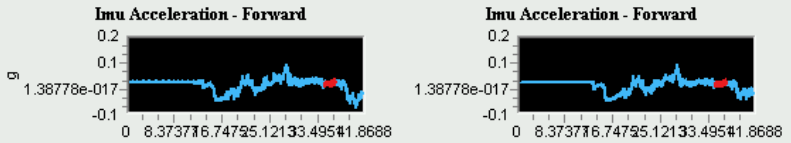
Open Survey | D:\Temp\LcmsData\2013_07_31\Acqui0001\LcmsData_000004.fis

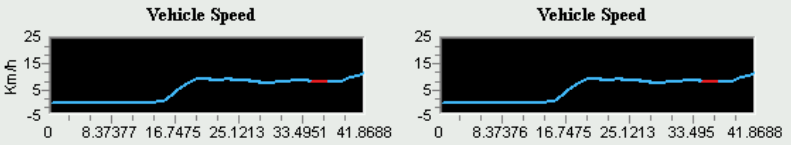
Process | Processing done











<< | < | > | >>

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

Sensor to sensor and world (gravity) position calibration

Sensor to sensor and world (gravity) position calibration

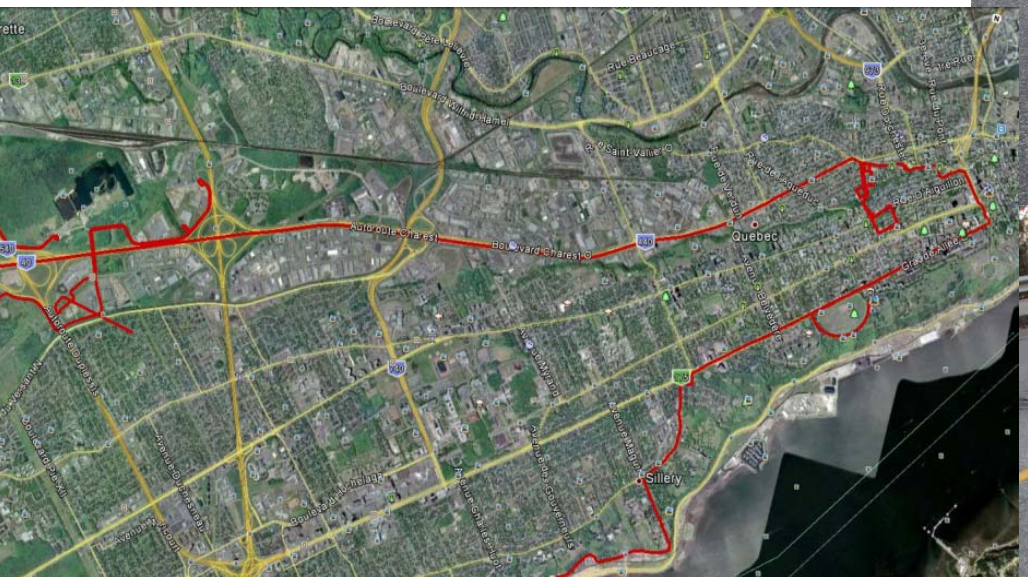
Field Validation Tests

Slope/Xslope field validation

slope was measured 50 different locations with digital ter (0.1 degree accuracy)

marked on road to identify measurement locations.

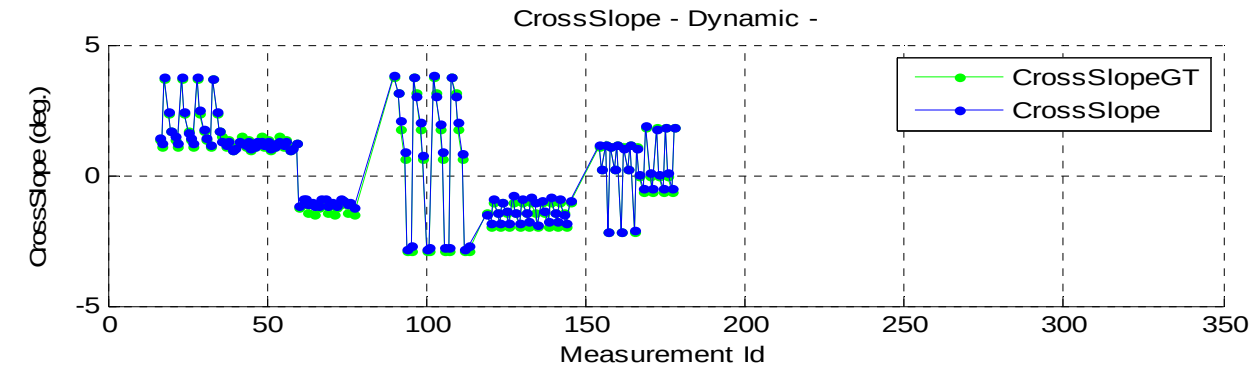
identified in LCMS data and Slope/Xslope was ed from simulated reference beam location.

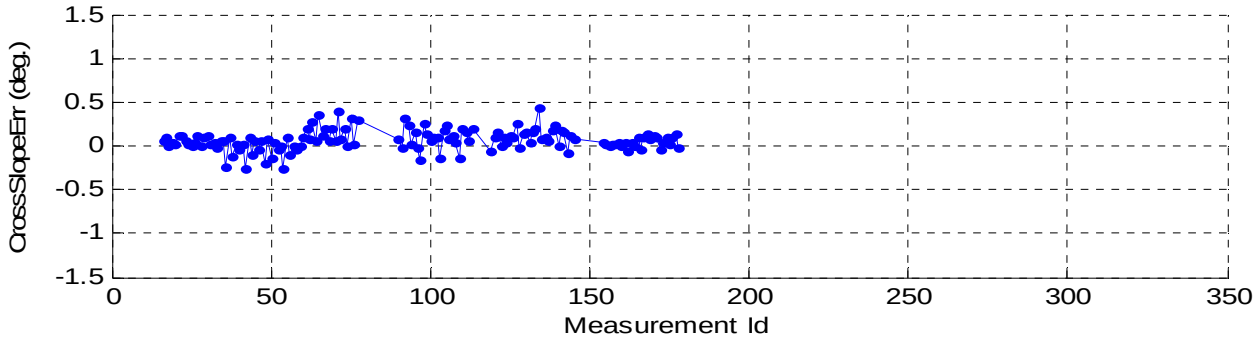


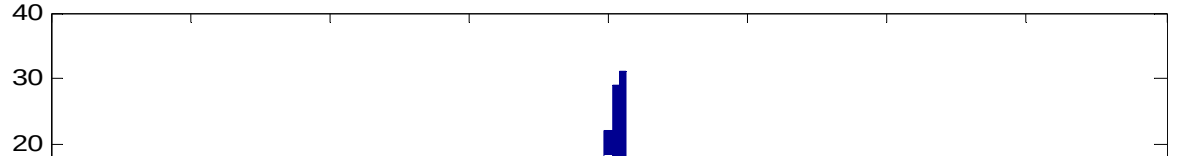
Cross-slope: Dynamic vs GT

lopeErr = 0.07deg
lopeErr = 0.13 %

XSlopeErr = 0.1 deg
XSlopeErr = 0.2%







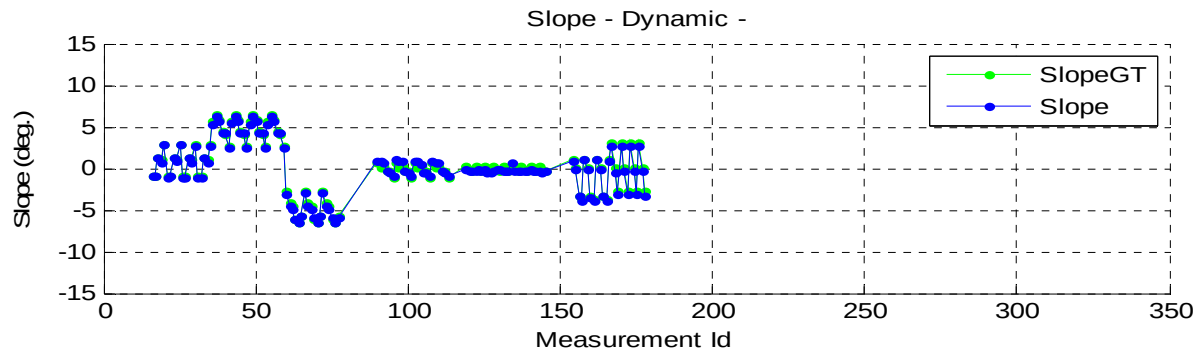
Slope: Dynamic vs GT

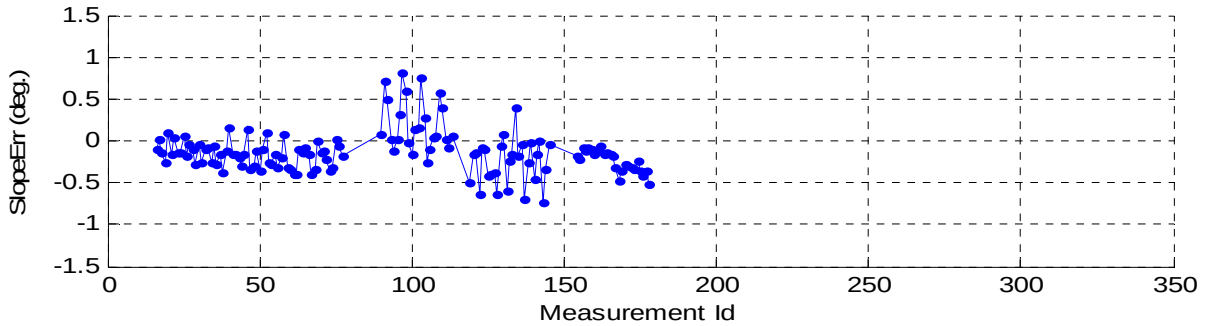
lopeErr = 0.13deg.

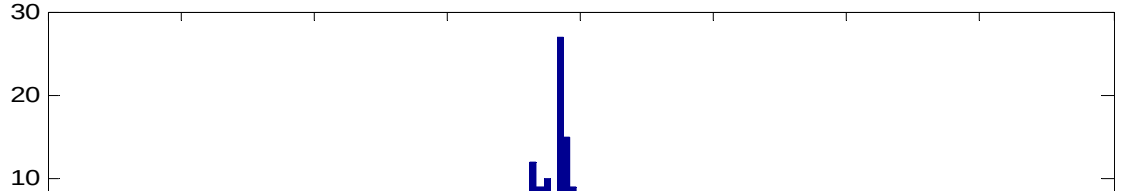
lopeErr = 0.25%

. SlopeErr = 0.26deg.

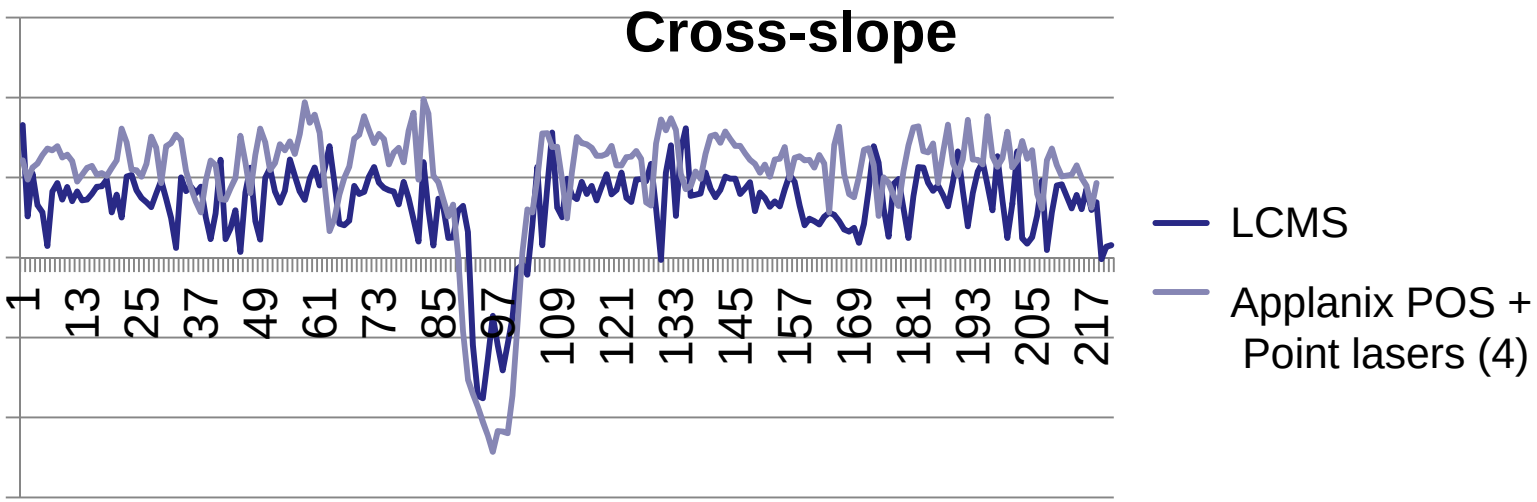
. SlopeErr = 0.46%

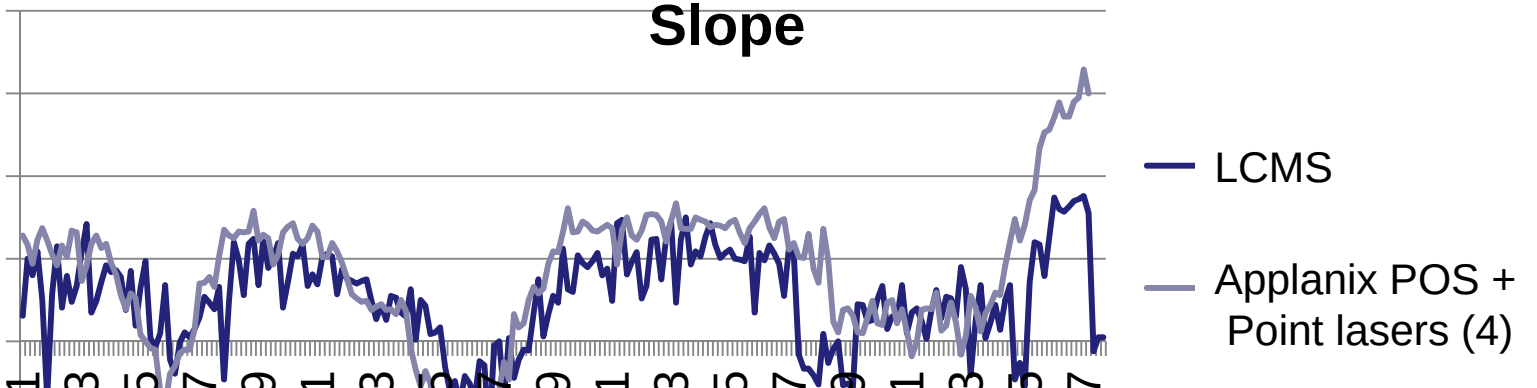




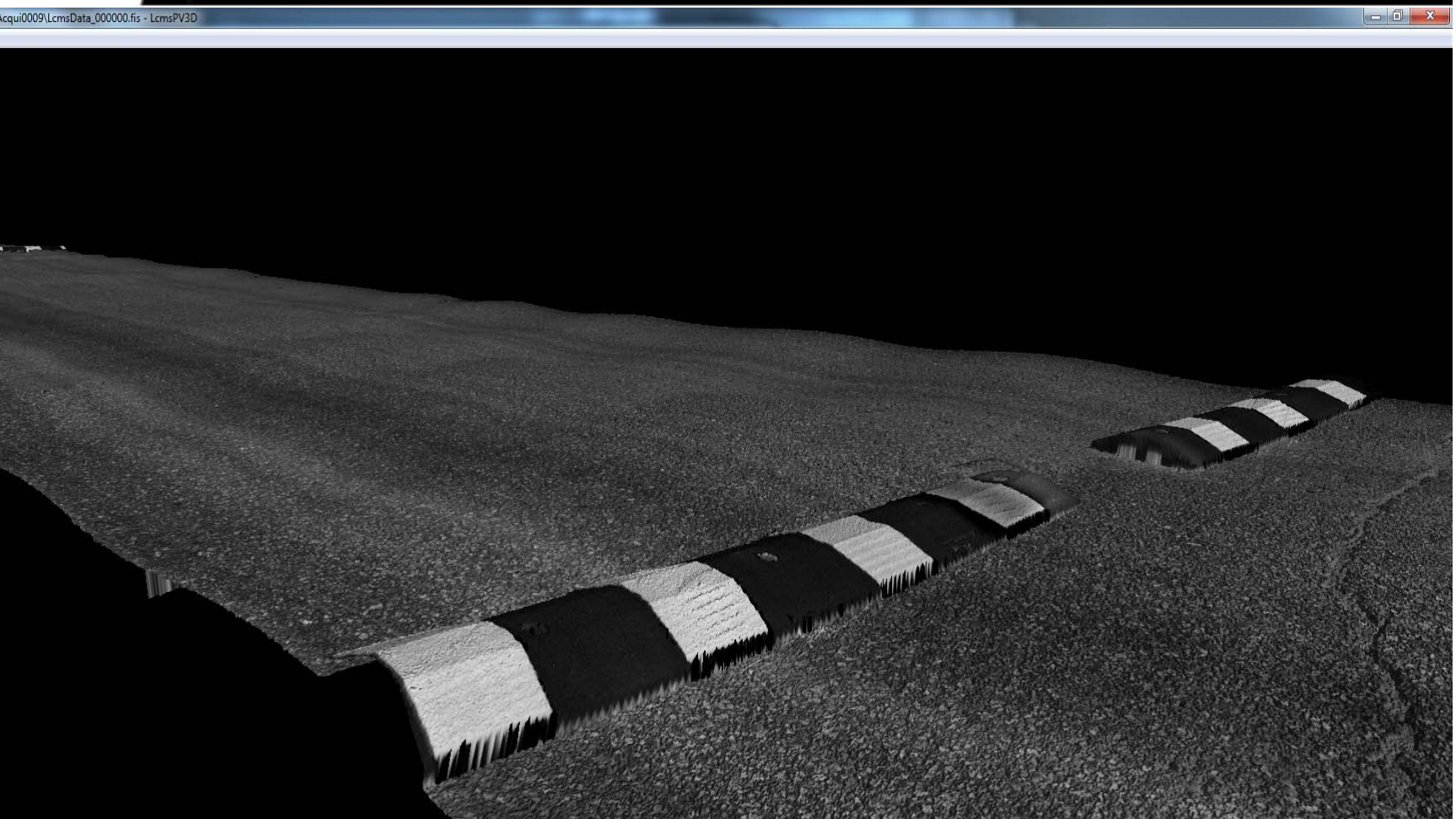


Road tests - Geometry

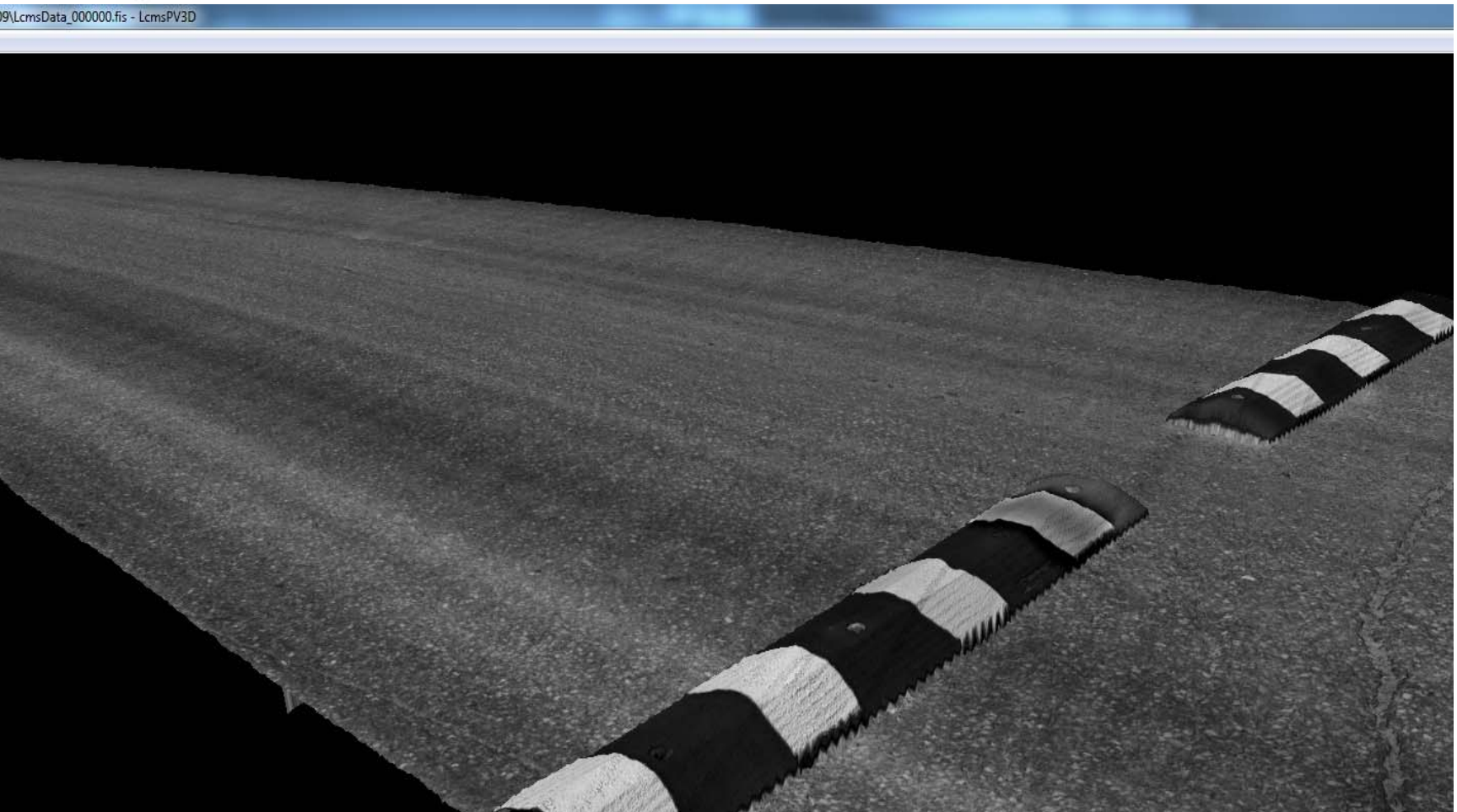




3D Road Profile Before Dynamic Corrections

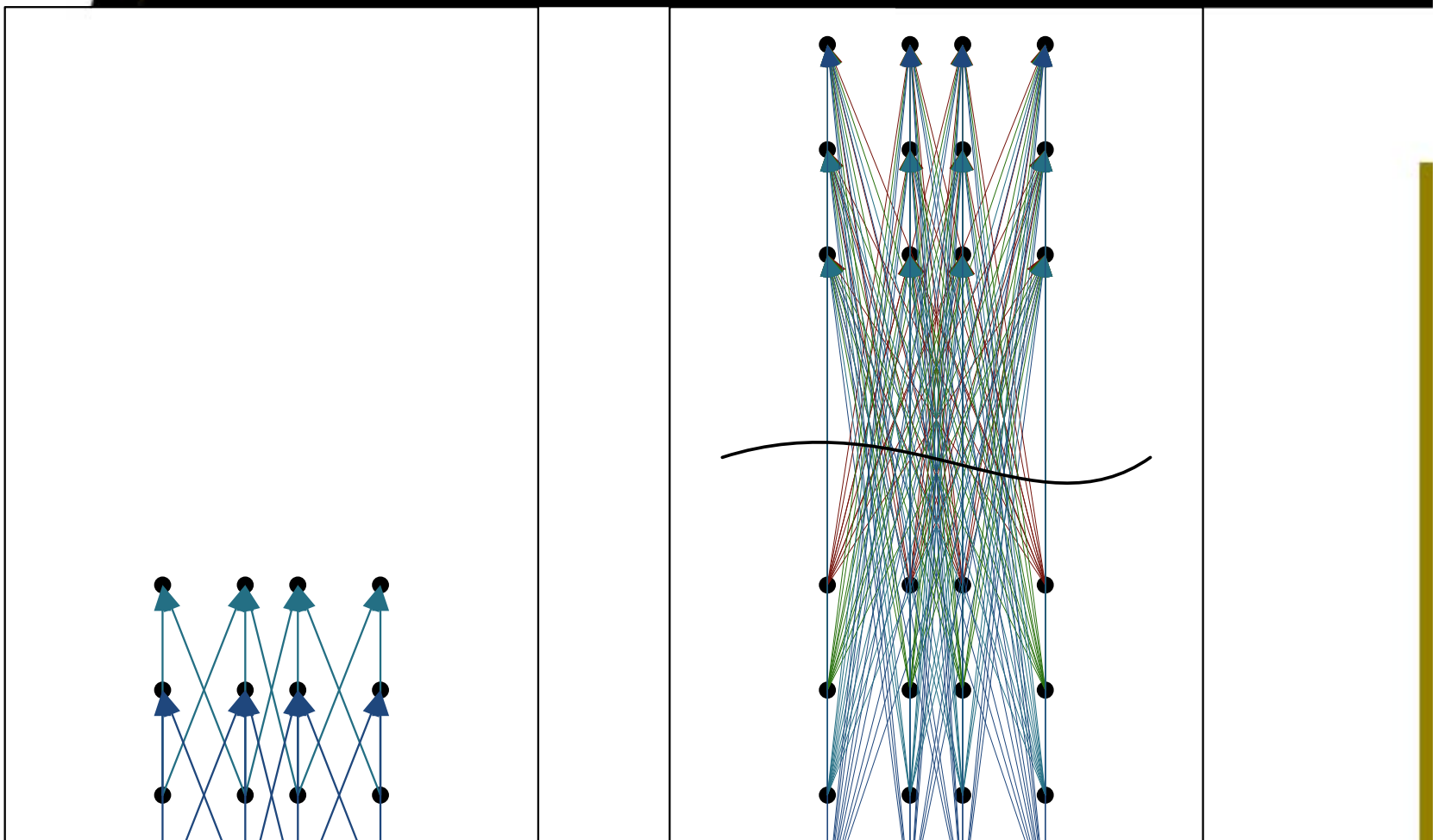


3D Road Profile After Dynamic Corrections



Field validation

Field validation



Accuracy tests - RMS error

nertial - 4m

	RMS	RMS Geometry preservation error (mm)			
	Registrati	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
an	**3.66**	**2.59**	**4.08**	**4.21**	**6.54**

100% Inertial - 4m 2 known points

Scan	RMS	RMS Geometry preservation error (mm)			
	Registrati	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**

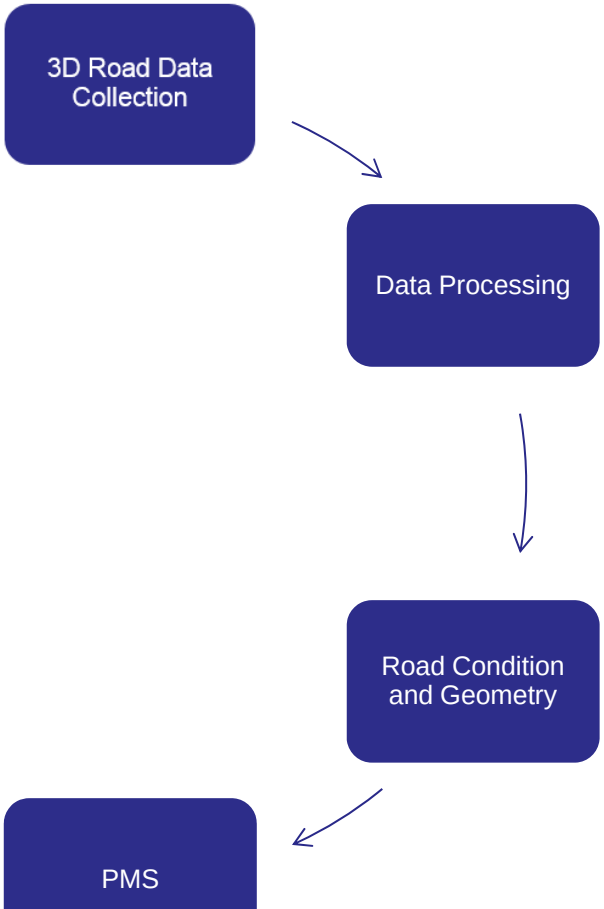
nertial - 84m

	RMS	RMS Geometry preservation error (mm)			
	Registrati	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
an	**12.07**	**2.94**	**24.46**	**3.65**	**24.98**

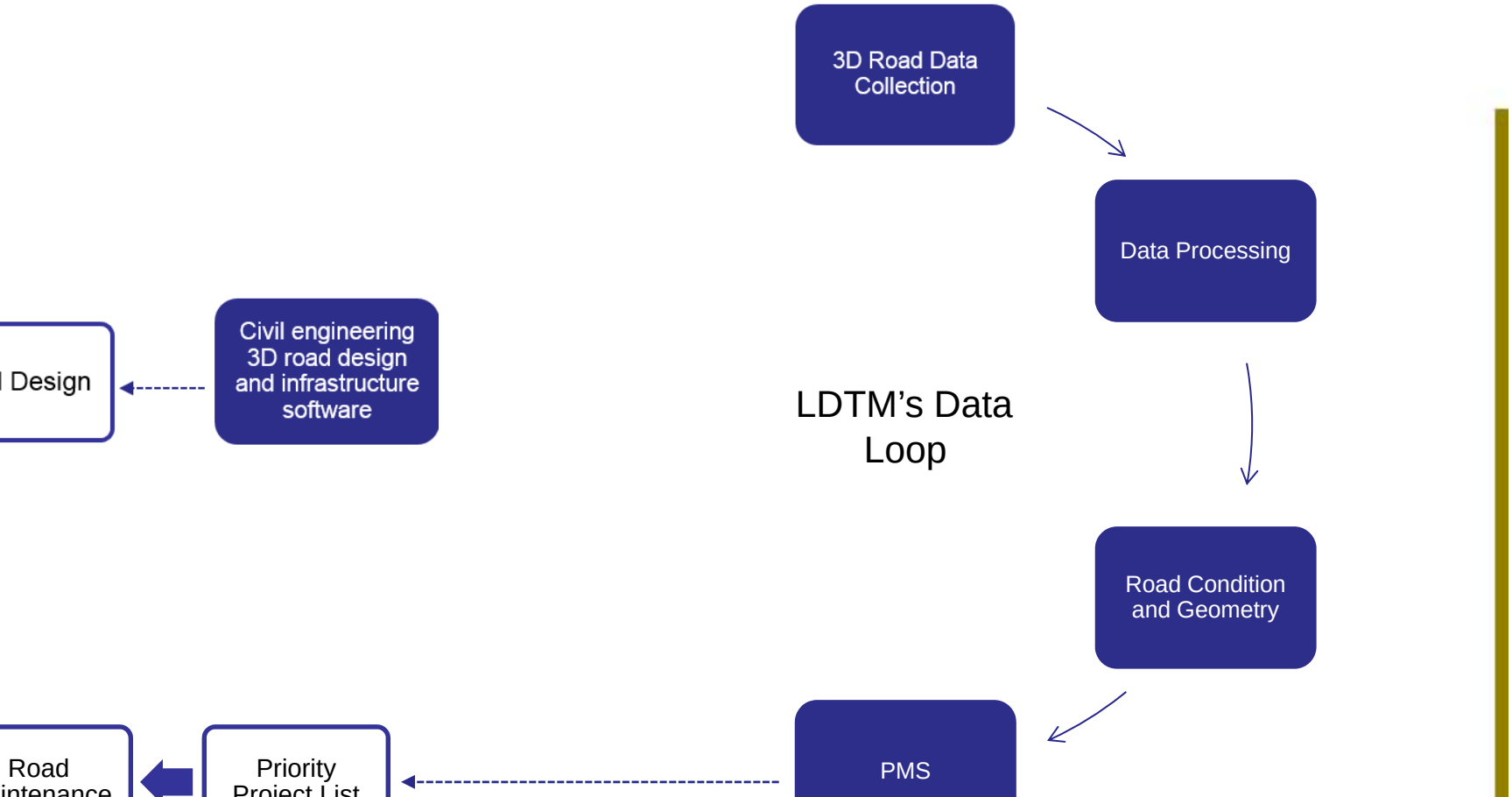
100% Inertiel - 84m 2 known points

Scan	RMS	RMS Geometry preservation error (mm)			
	Registrati	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**

LDTM – Closing the Loop



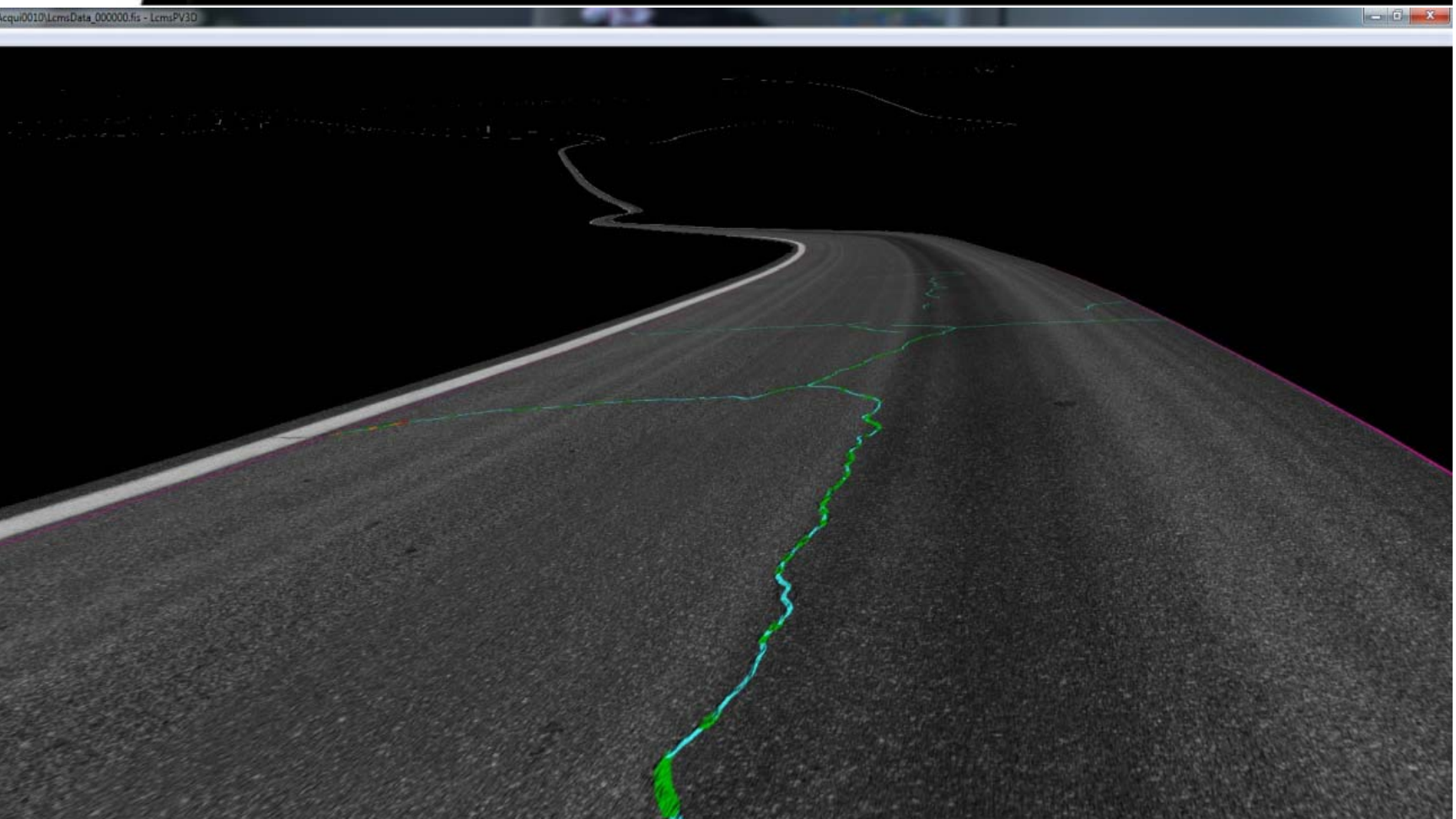
LDTM – Closing the Loop



Road Profile Before Corrections

Road Profile After Geometric and Dynamic Corrections

One Sensor; Many Outputs

- Pavement Management
  - Pavement Image
  - IRI
  - Macro Texture
  - Potholes
  - Raveling
  - Rutting
  - Longitudinal Cracking
  - Transverse Cracking
  - Alligator Cracking
  - Sealed cracks
  - Joint Faulting
  - Transverse Profile
- Inventory
  - Pavement Width
  - Pavement Lengths
  - Pavement Type
  - GPS Tagging
  - Linear Referencing
- Safety
  - Foreign Object Debris
  - Pavement Markings
  - Horizontal Curvature
  - Cross Fall
  - Longitudinal Grade
  - Automatic Breaklining
- Design

Any Questions?