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LCMS - 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

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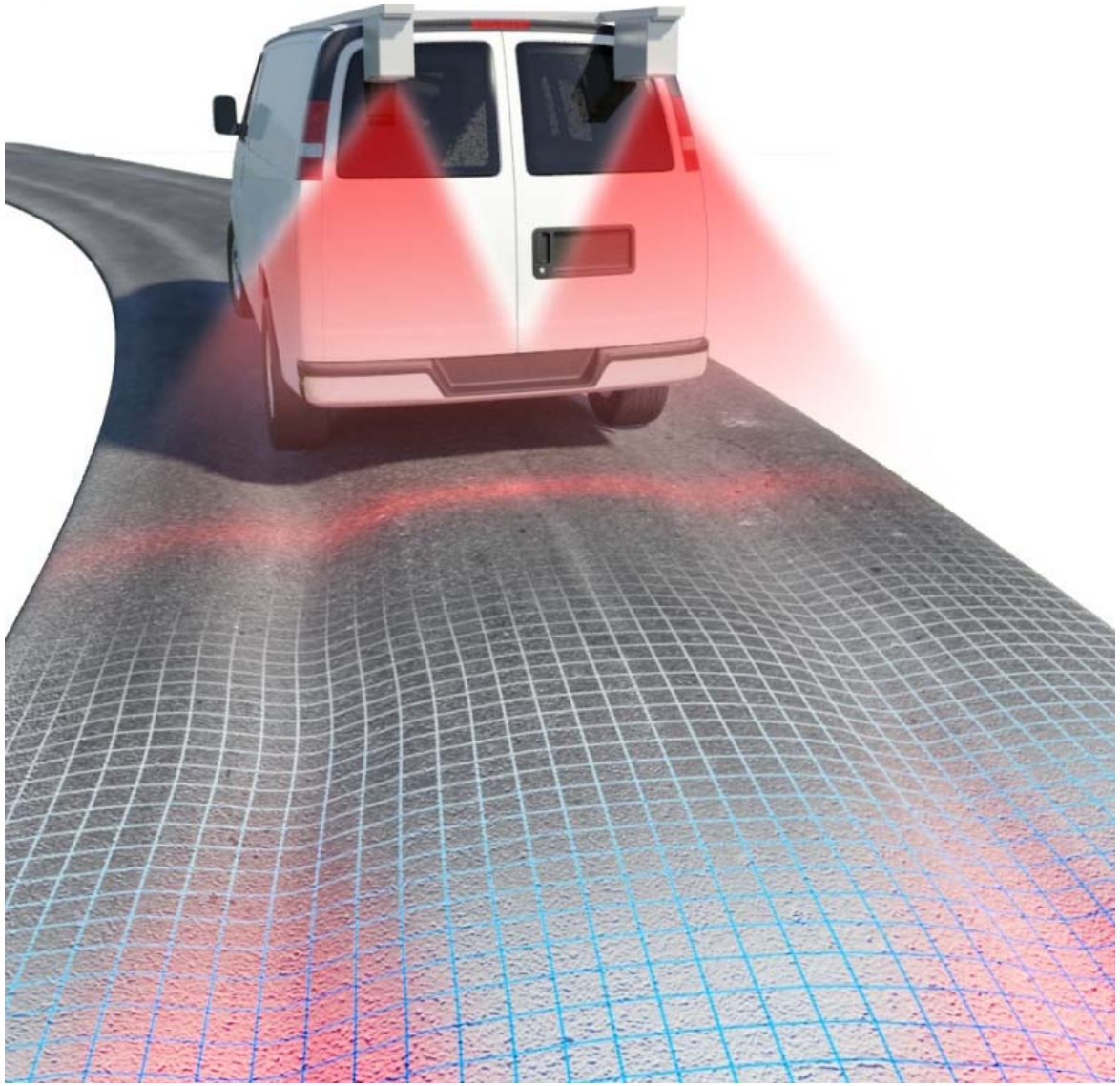
Application: ROADS distress and DTM



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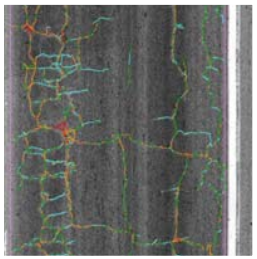
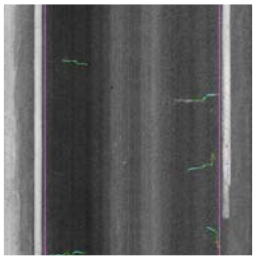
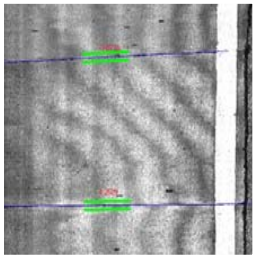
Any Paved Surface



Hotmix

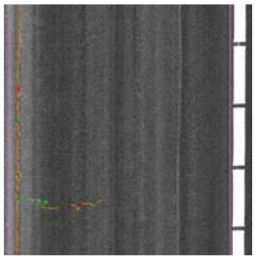
Chipseal





Concrete

Porous



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The Sensor Technology Most Relied-on by DOTs worldwide

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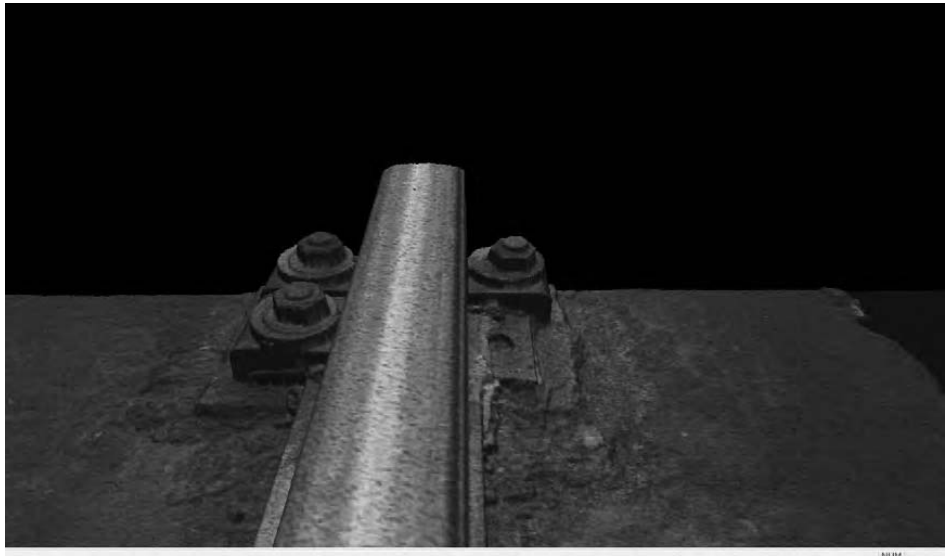
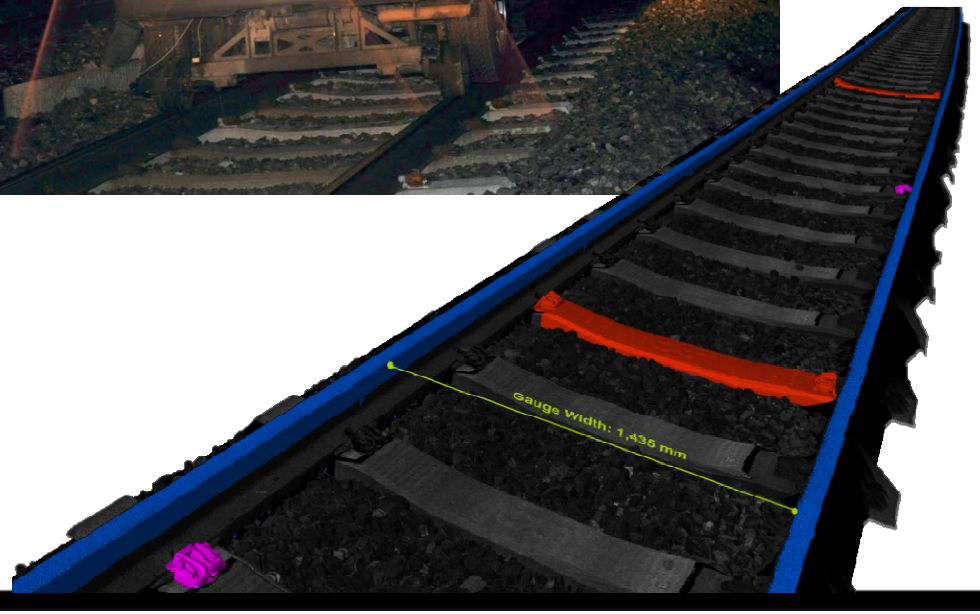
APPLICATION: Rails





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APPLICATION: Tunnels

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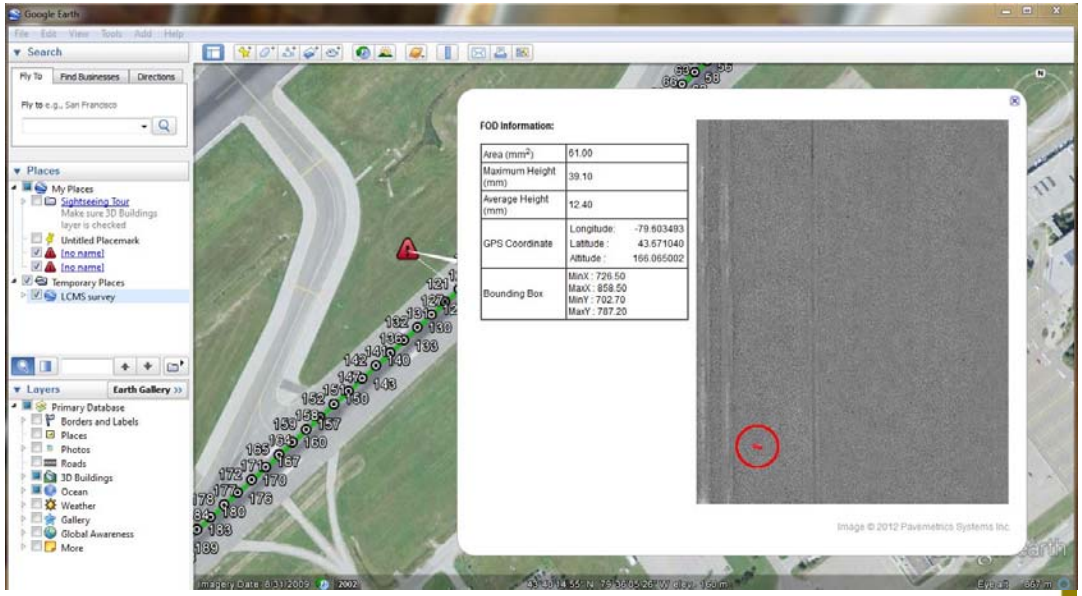
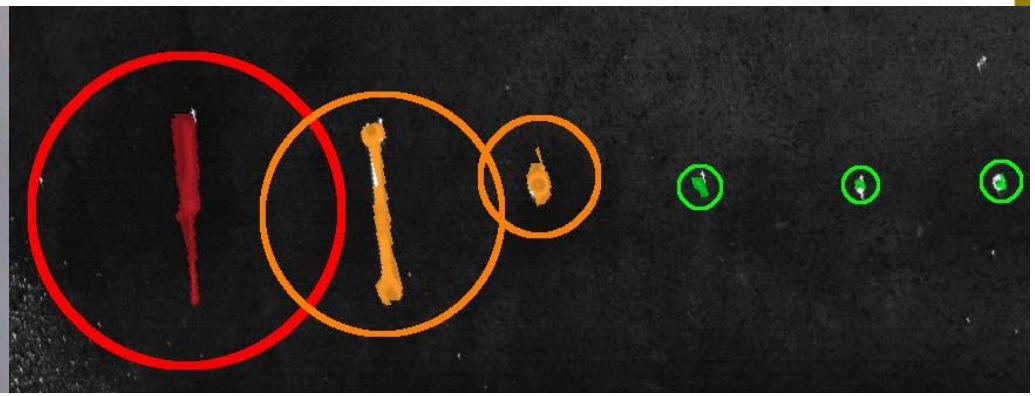
Application: Airports - FOD





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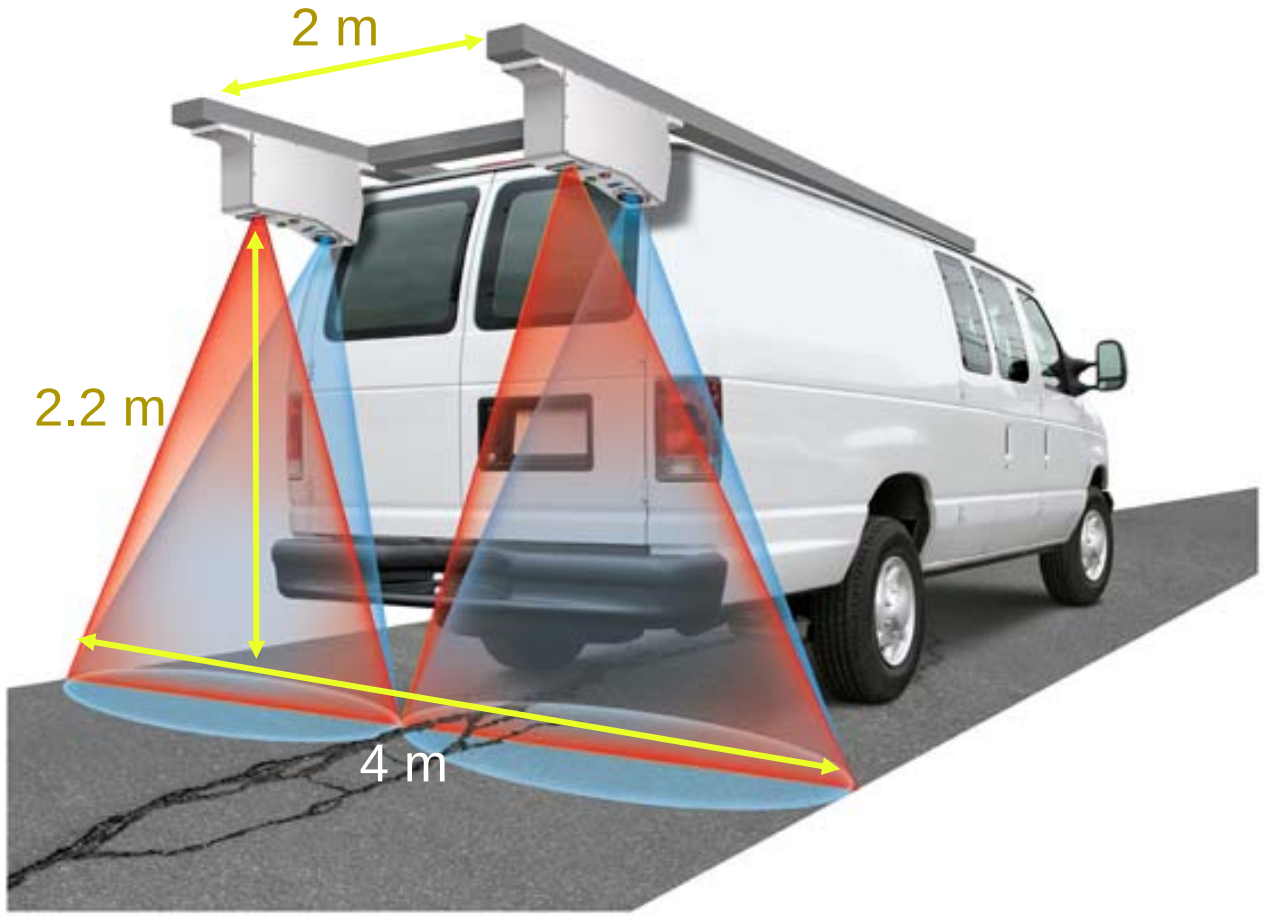
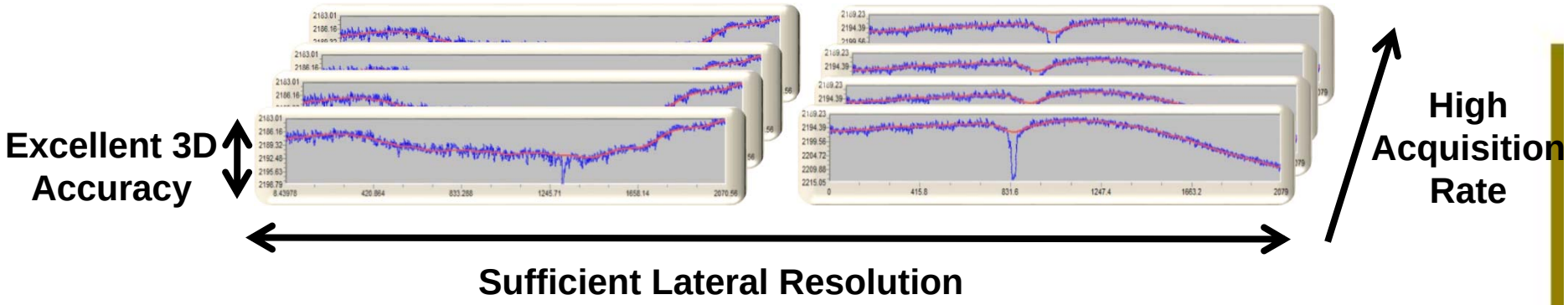
LCMS - System configuration



LCMS - Specifications



LCMS Specifications	LCMS-1 / LCMS-2
Acquisition Rate	5,600 - 28,000 profiles/s
Elevation (z) Resolution	*0.25mm / 0.1mm*
Lateral Resolution	1mm (FOV = 4m)

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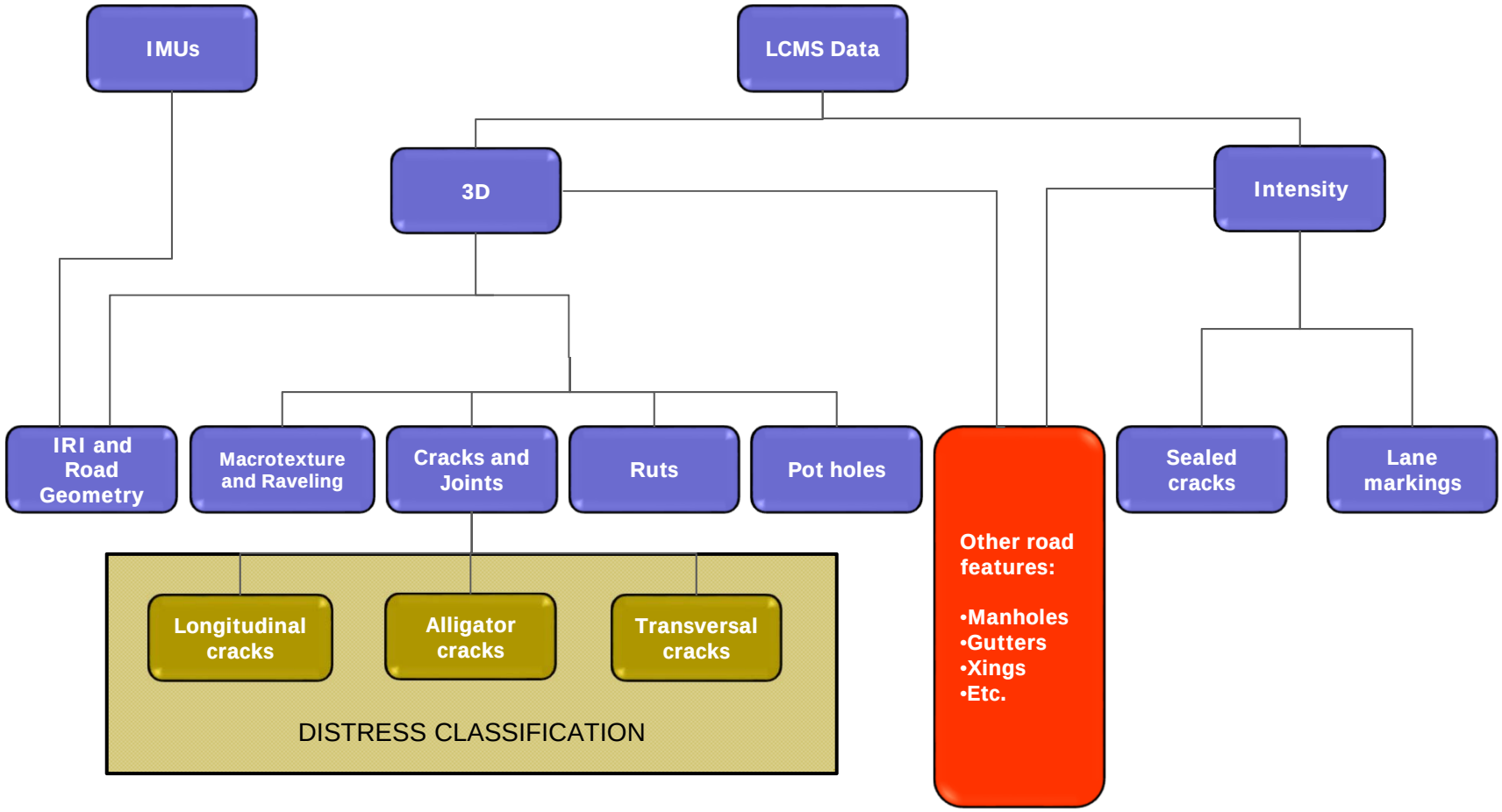
LCMS Data Processing Tree



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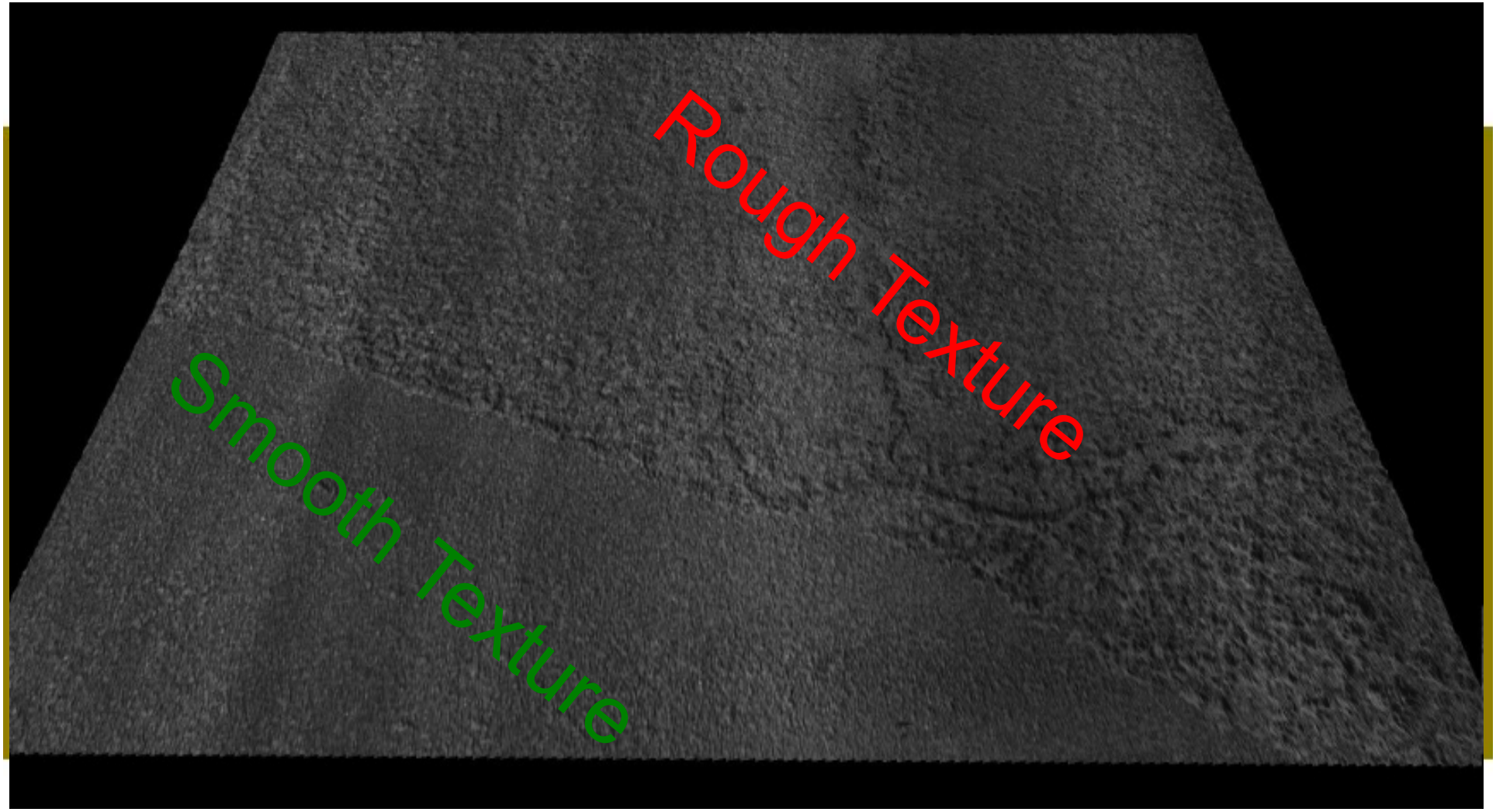
Macrotexture – Example LCMS raw data



Mean Profile Depth (MPD) (ASTM E1845) – Texture laser

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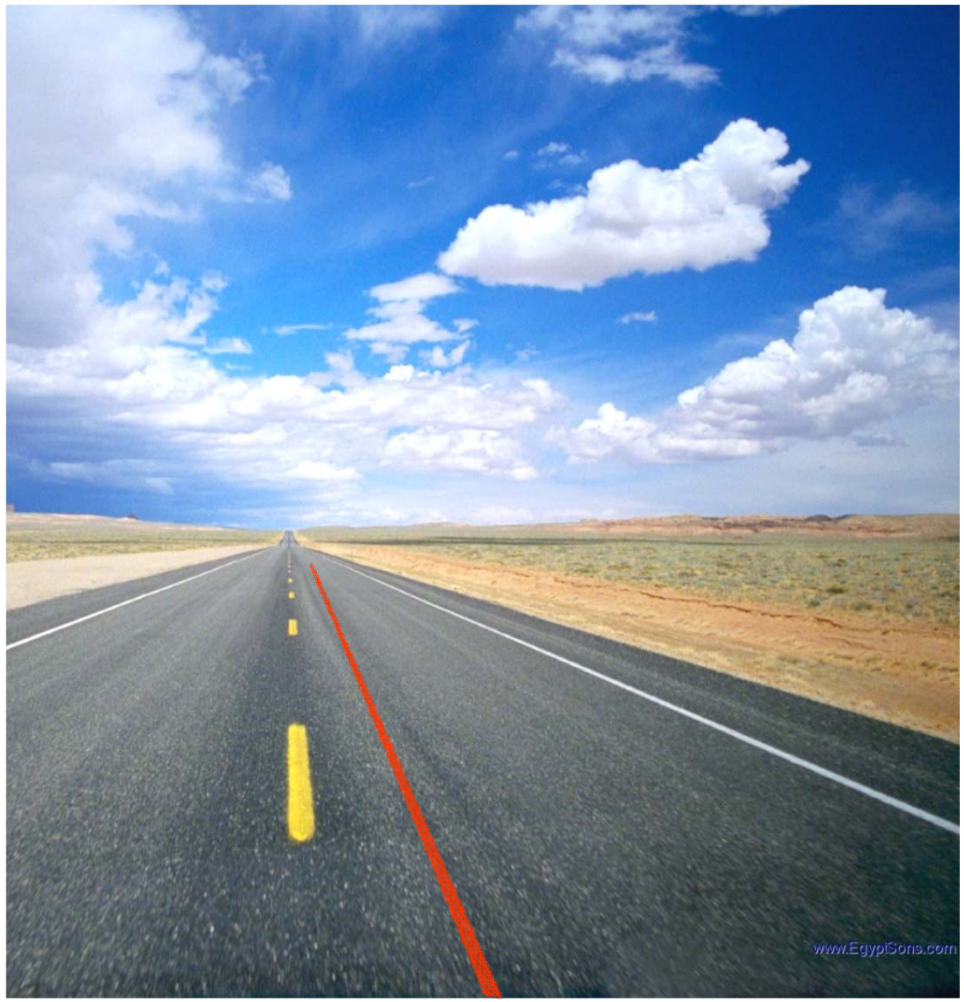
Specifications:

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



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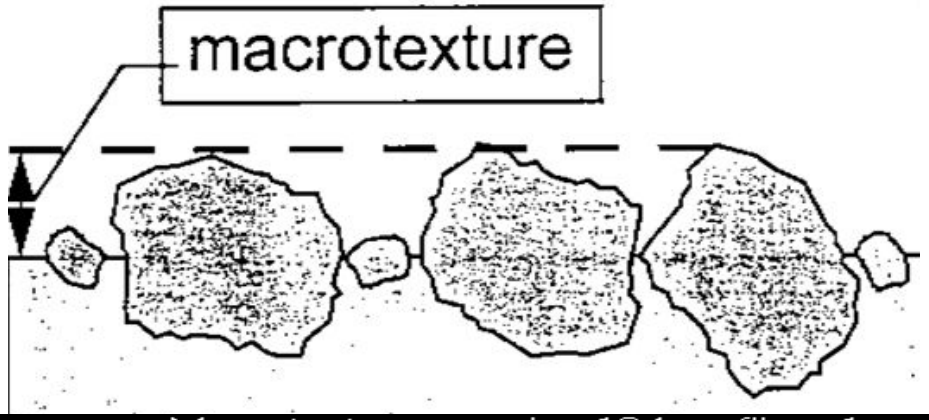
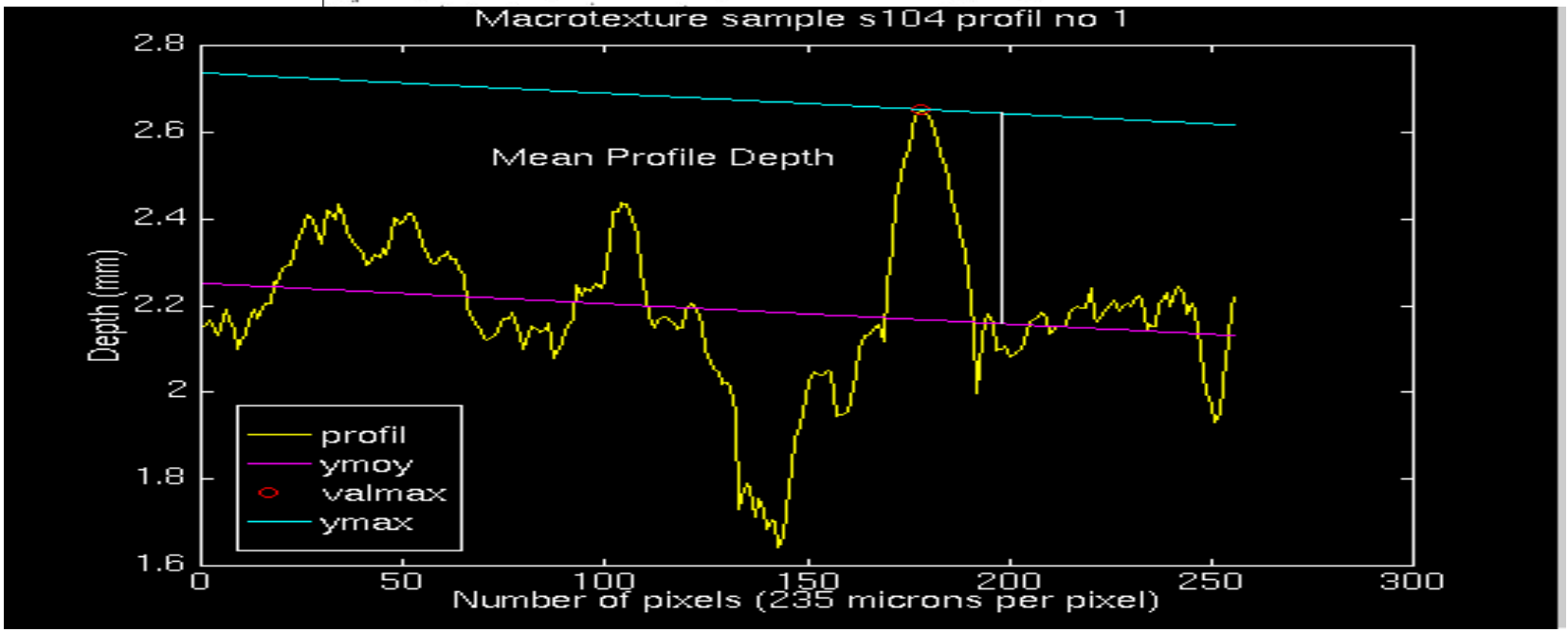
Mean Profile Depth (MPD) (ASTM E1845-01)





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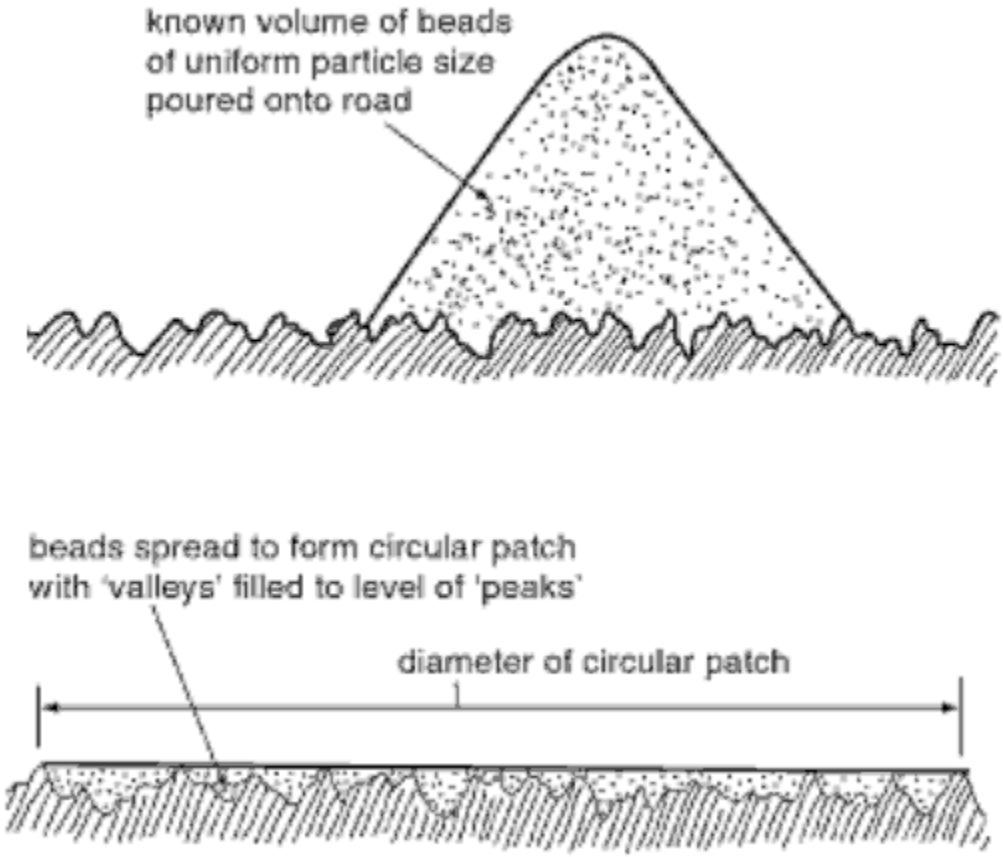
Sand patch method (MTD) (ASTM E965)

Sand patch method (MTD) = Volume of sand (fixed) divided by diameter measured (surface area)



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Macrotexture : MPD or MTD?

It doesn't really matter because:

$$MTD = 0.8 * MPD + 0.2$$

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Macrotexture – LCMS

- Full lane network level texture survey is possible at 100kmh
- Digital Sand Patch method (MTD)
- Macro-texture is reported:
  - 5 AASHTO bands
  - 25x25cm texture maps

Sand patch method (MTD) (Automated)

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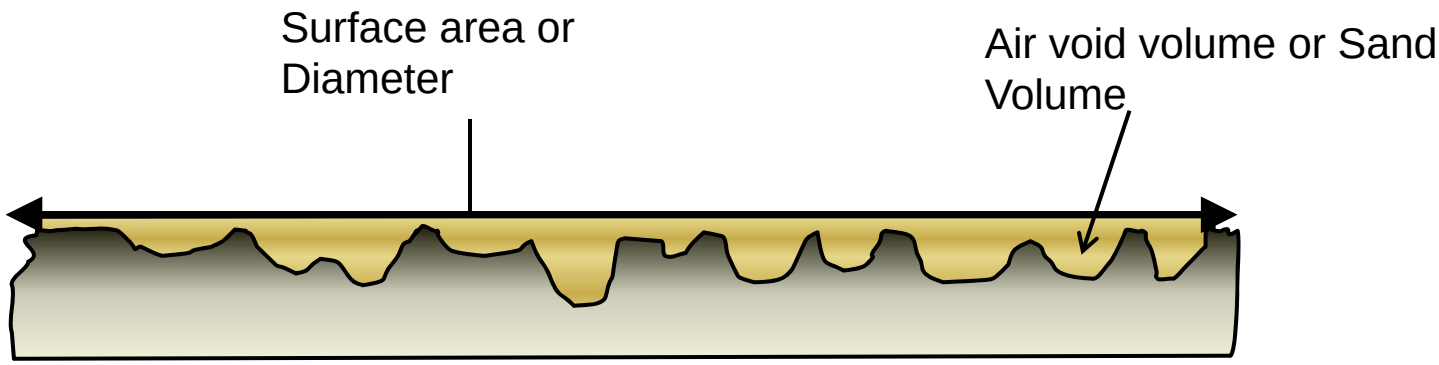
Automatic method MTD = Air void volume measured divided by a fixed surface area (approx square foot, 25x25 cm)



$$MTD = \frac{(Volume_{air\ void})}{Surface\ Area}$$

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NZTA – Macro-texture validation with SLP

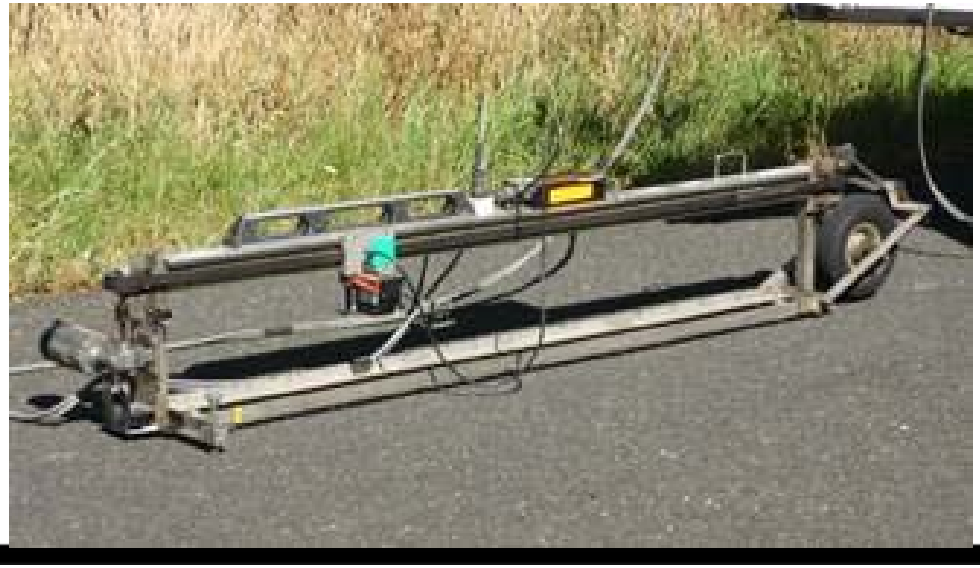
- Reference device is a SLP (Stationary Laser Profiler) used by New Zealand Transit Authority

- The SLP uses a 32kHz Selcom® laser with a spot size of 0.5 mm to take a profile measurement every 0.3 mm.

- The laser traverses along a 1.67m track by a drive from a toothed belt.

- It was laid end to end throughout the texture validation sites to provide the reference texture measurements (MPD).

- To compare with LCMS texture the SLP results were converted using MTD = 0.8*MPD +0.2



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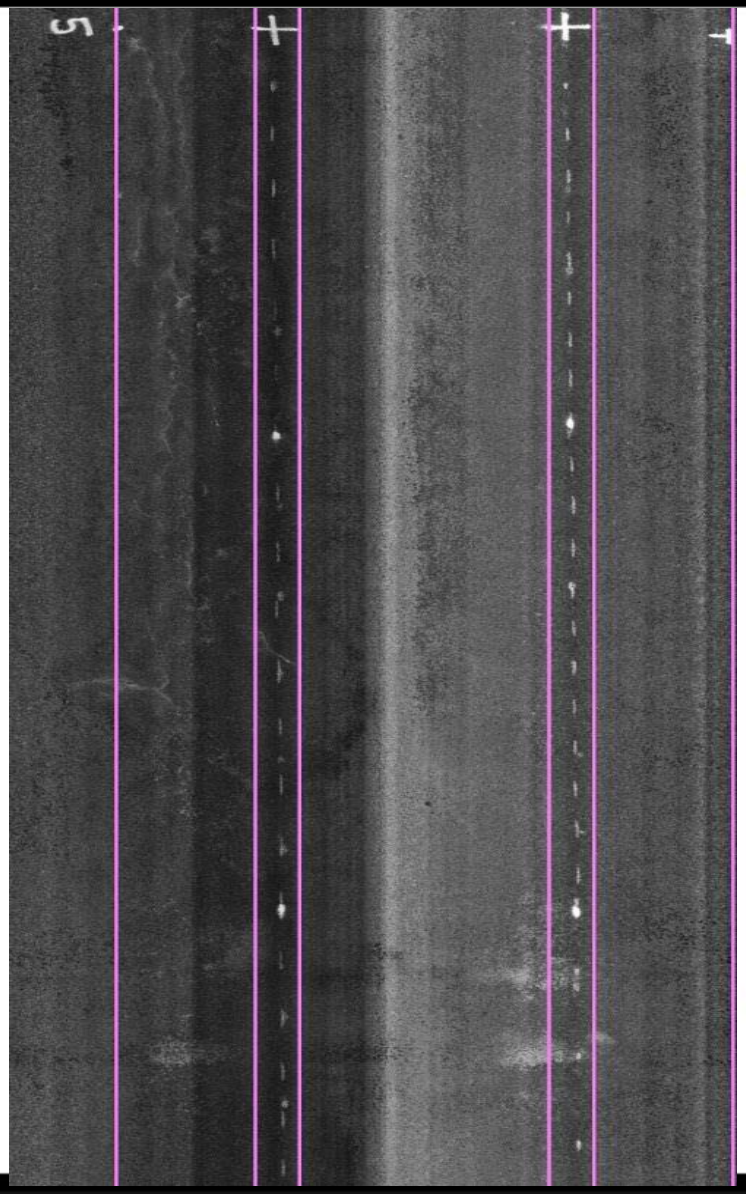
NZTA – Macro-texture validation with SLP

- 7 different survey sites in New Zealand.
- The length is each survey site is 200m (except site V07 which is 300m).
- Texture range from 0.4mm (MPD) to 3.5mm (MPD)
- Multiple runs of LCMS data were collected on each survey site, at different speed (30km/h, 50km/h and 80km/h).
- The SLP measurement paths are marked with paint. This is the transversal position where the SLP device measures the texture.
- The SLP device outputs one MPD value every 10cm, for each wheel path



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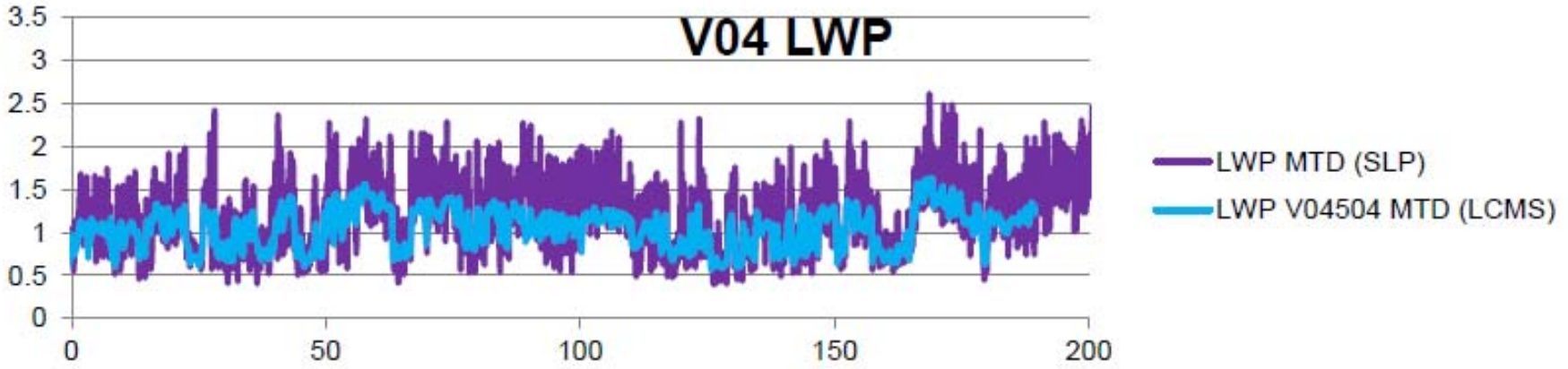
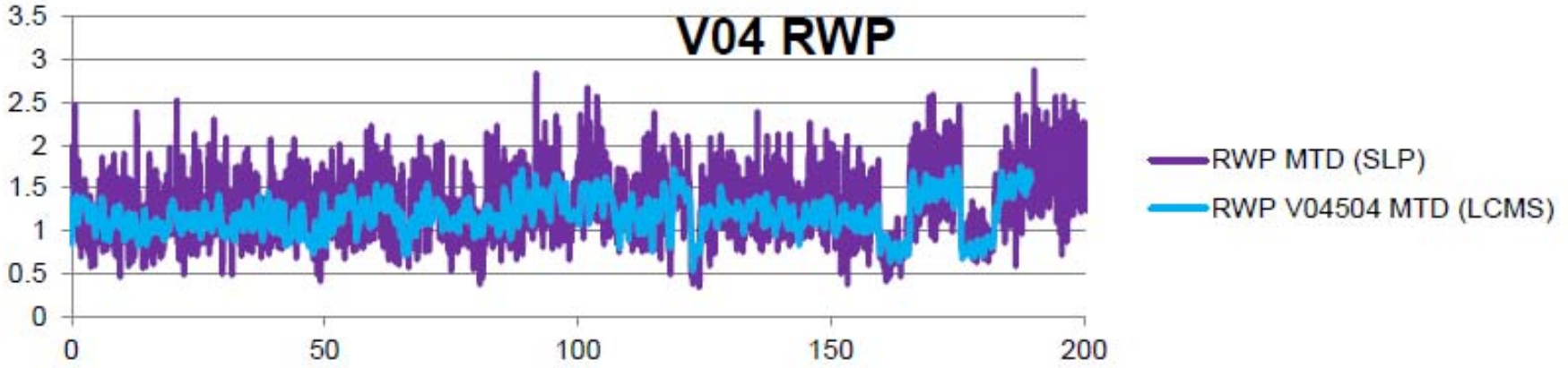
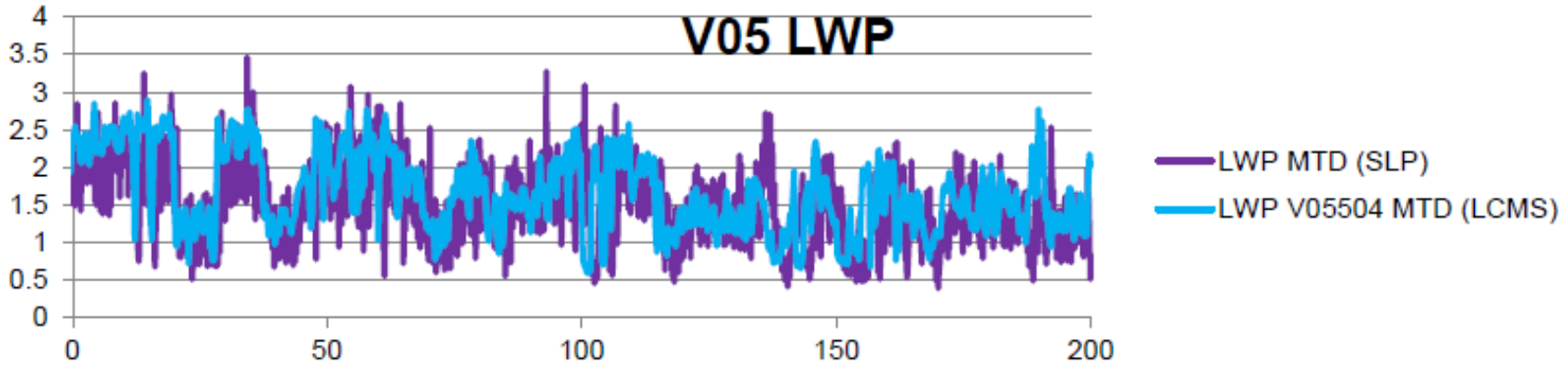
SLP vs LCMS(MTD unfiltered)

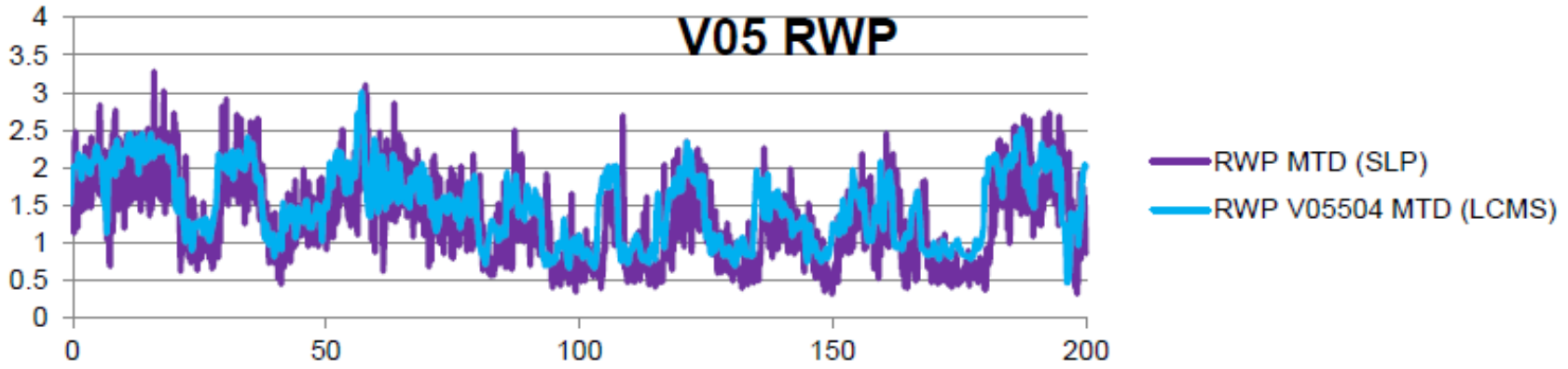




Pavemetrics

SLP vs LCMS(MTD unfiltered)





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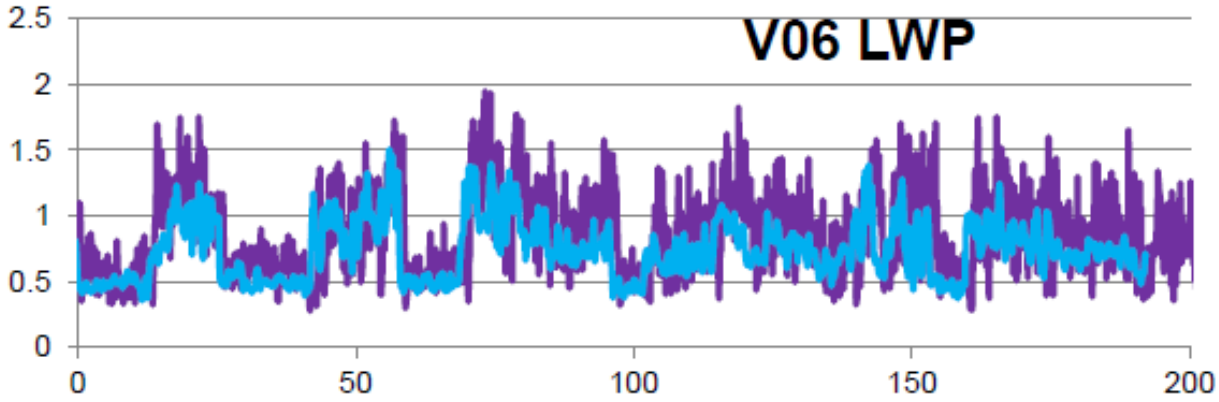
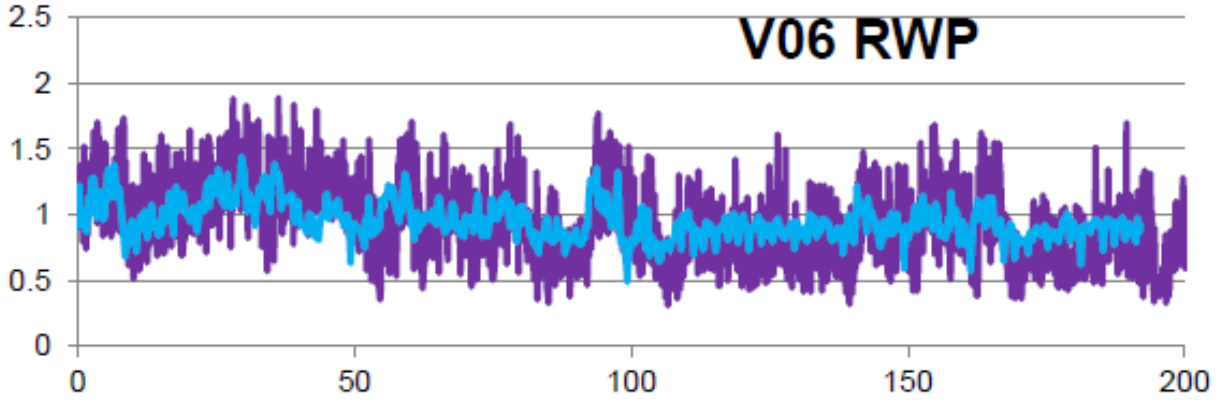
SLP vs LCMS(MTD unfiltered)





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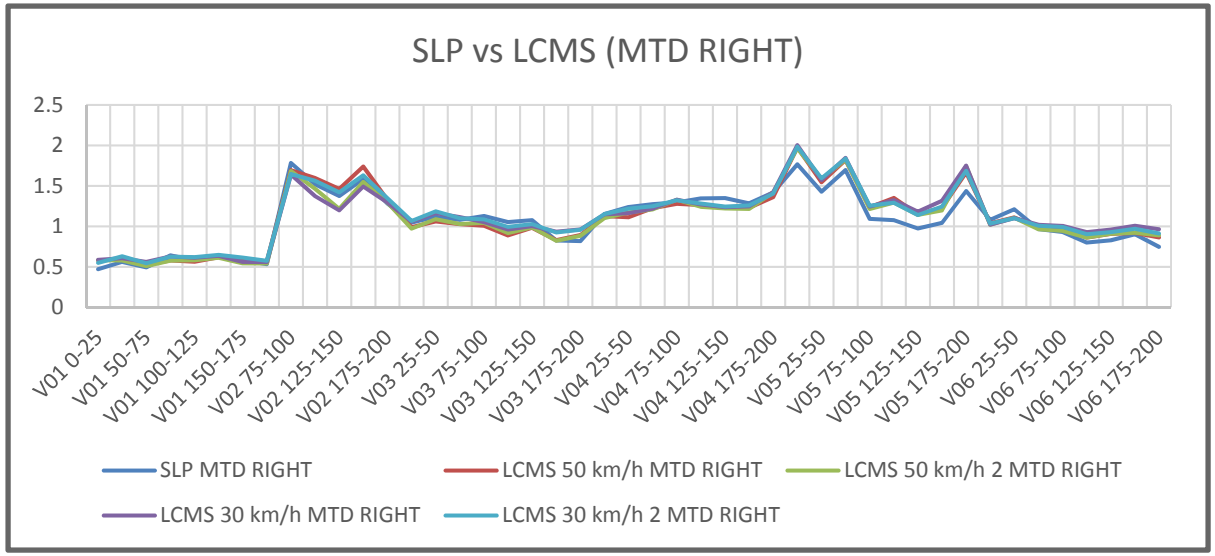
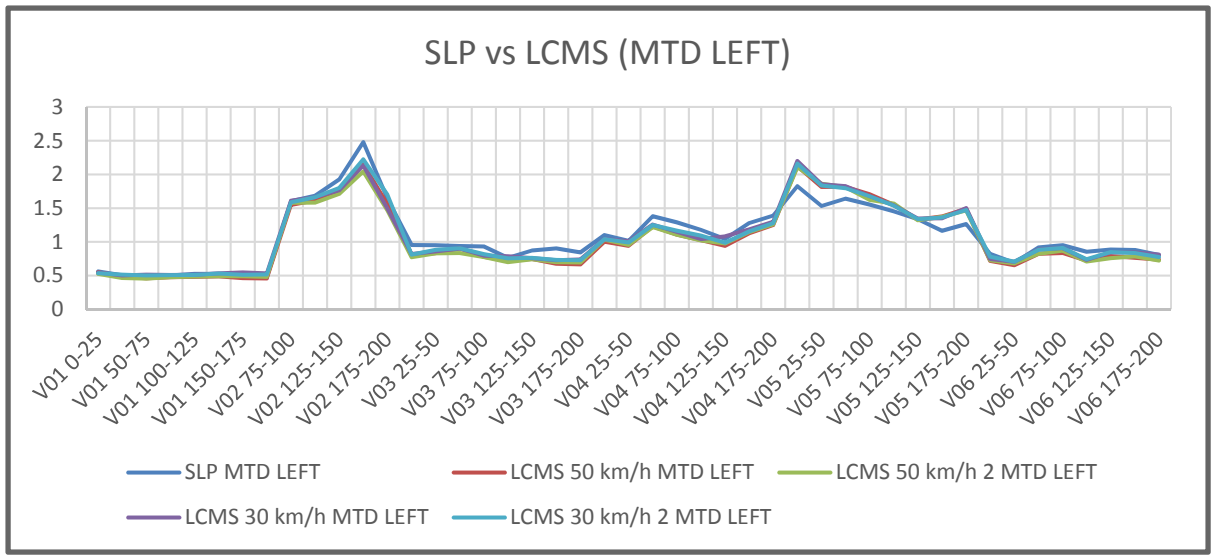
SLP vs LCMS (MTD average 25m)





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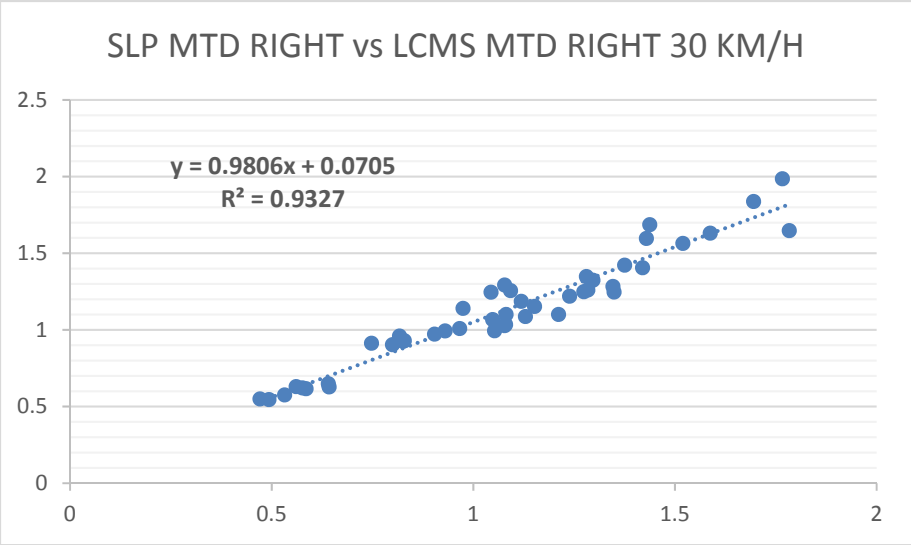
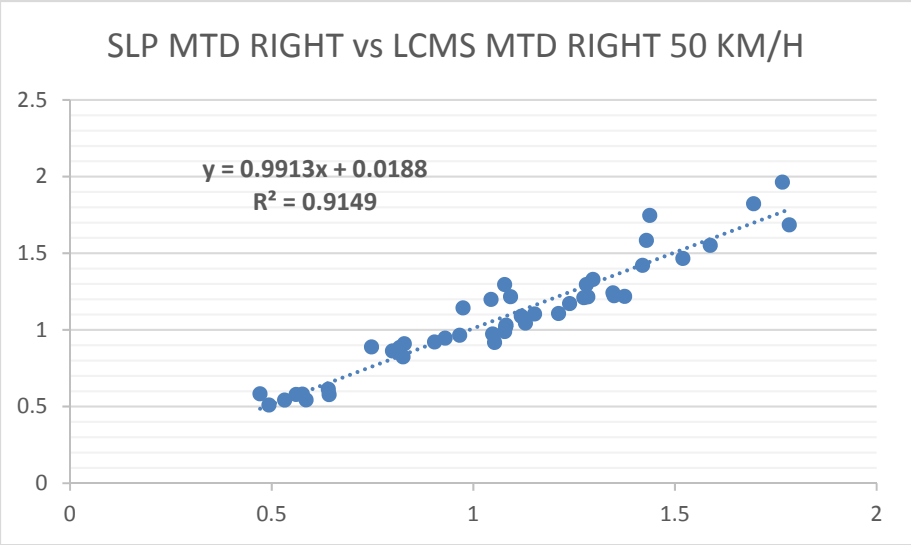
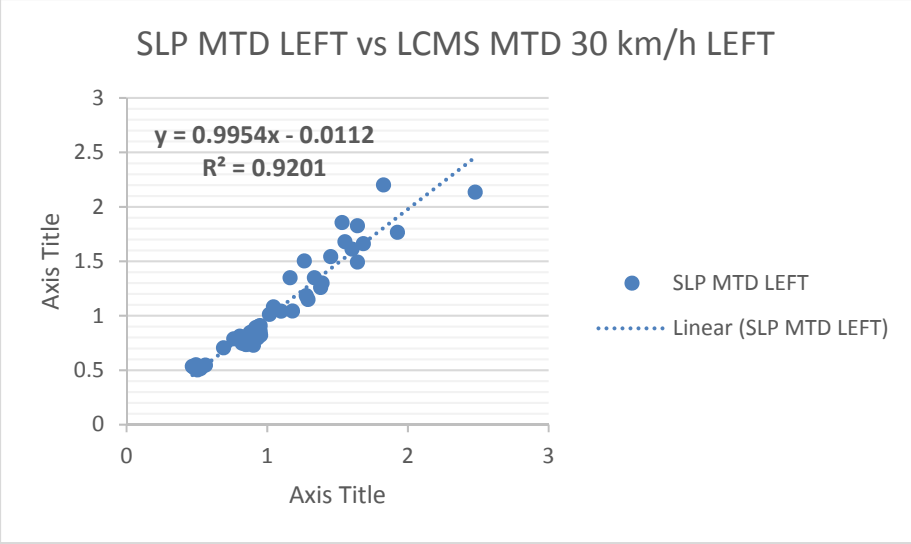
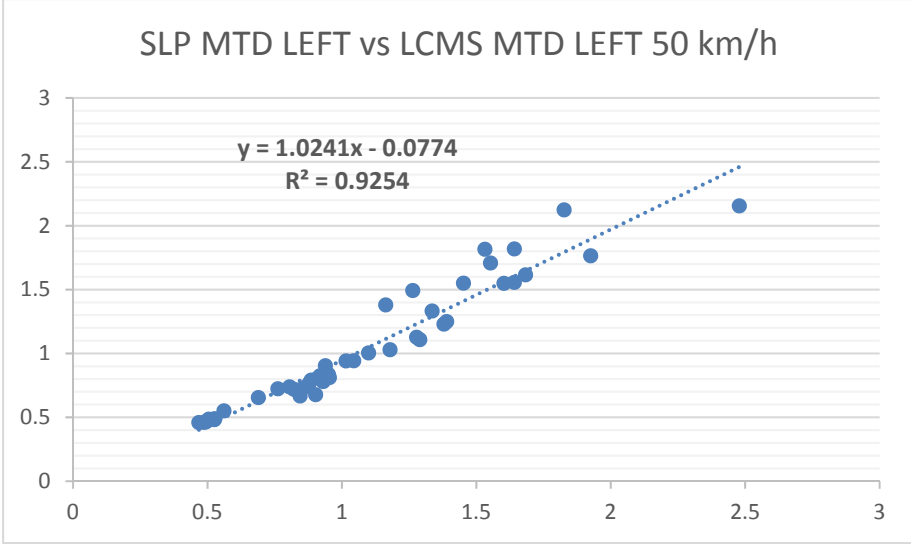
NZTA – Macro-texture validation with SLP









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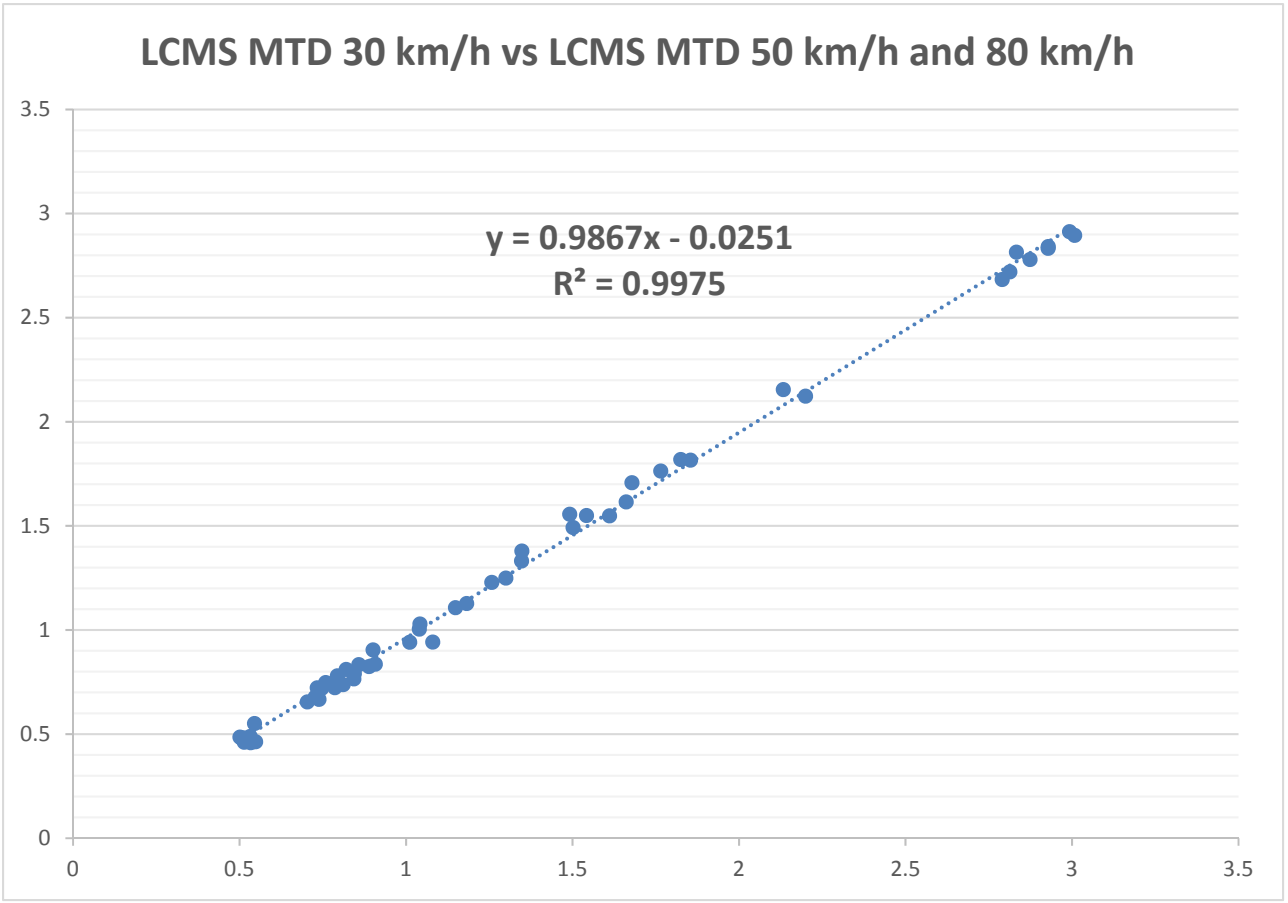
LCMS – Macro-texture (30km/h, 50km/h, 80km/h)



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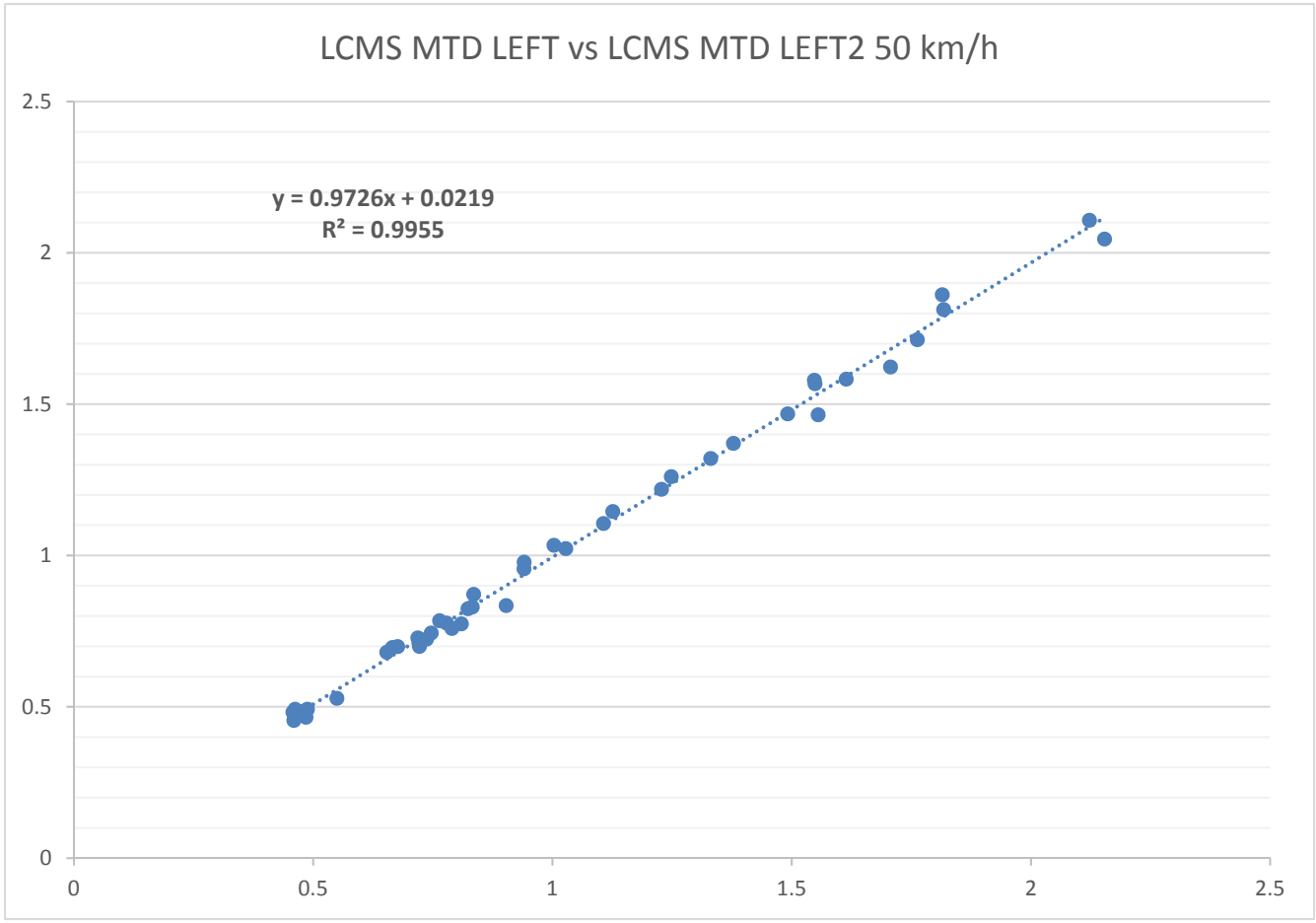
LCMS – MTD repeatability



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LCMS vs SLP - Results

- 7 different survey sites in New Zealand measured with SLP.
- Texture range from 0.4mm (MPD) to 3.5mm (MPD)
- Multiple runs of LCMS data were collected at different speed (30km/h, 50km/h and 80km/h).
- The LCMS high speed texture measurements correlate very well (92%) with high accuracy ground truth from SLP.
- The repeatability of LCMS texture measurements when averaged over 25m correlate very well (99+%) between different runs even at different speeds (30km/h, 50km/h, 80km/h).

Macrotexture – LCMS

- Full lane network level texture survey is possible at 100kmh
- Digital Sand Patch method (MTD)
- Macro-texture is reported:
  - 5 AASHTO bands
  - 25x25cm texture maps
- Texture maps can be used to detect:
  - Bleeding
  - Sealed cracks
  - Raveling

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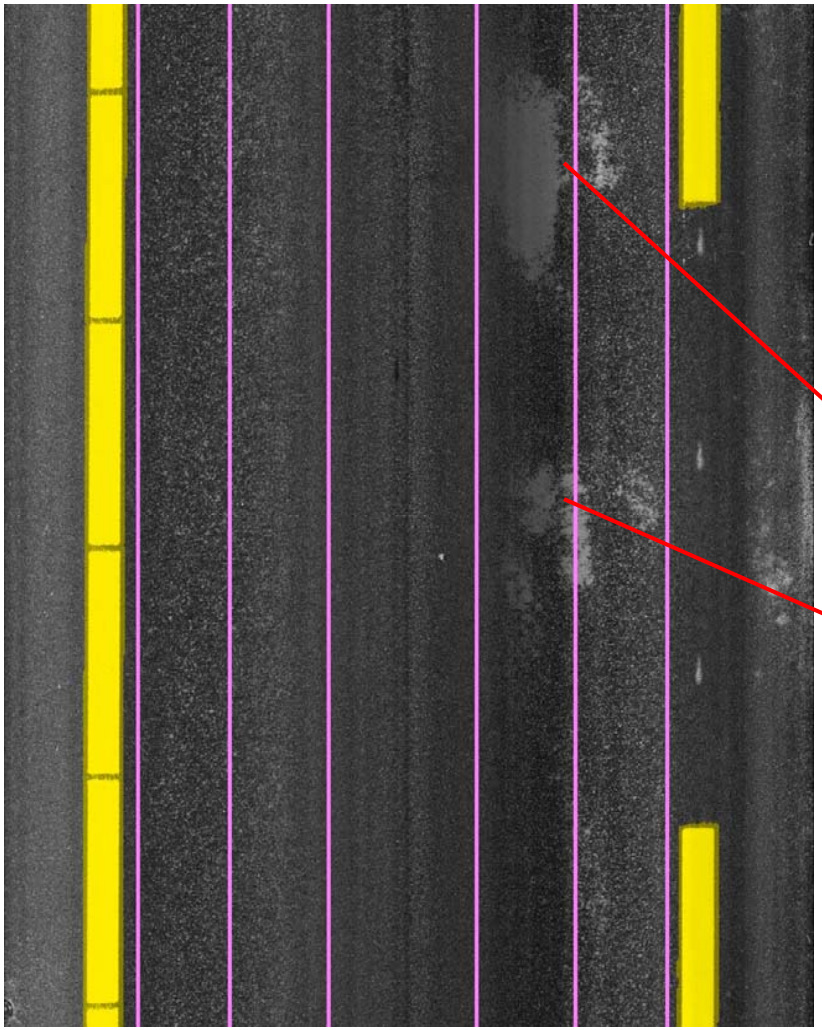
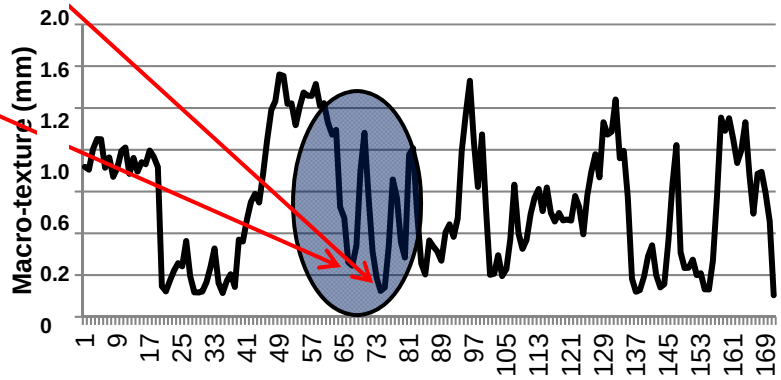
Bleeding





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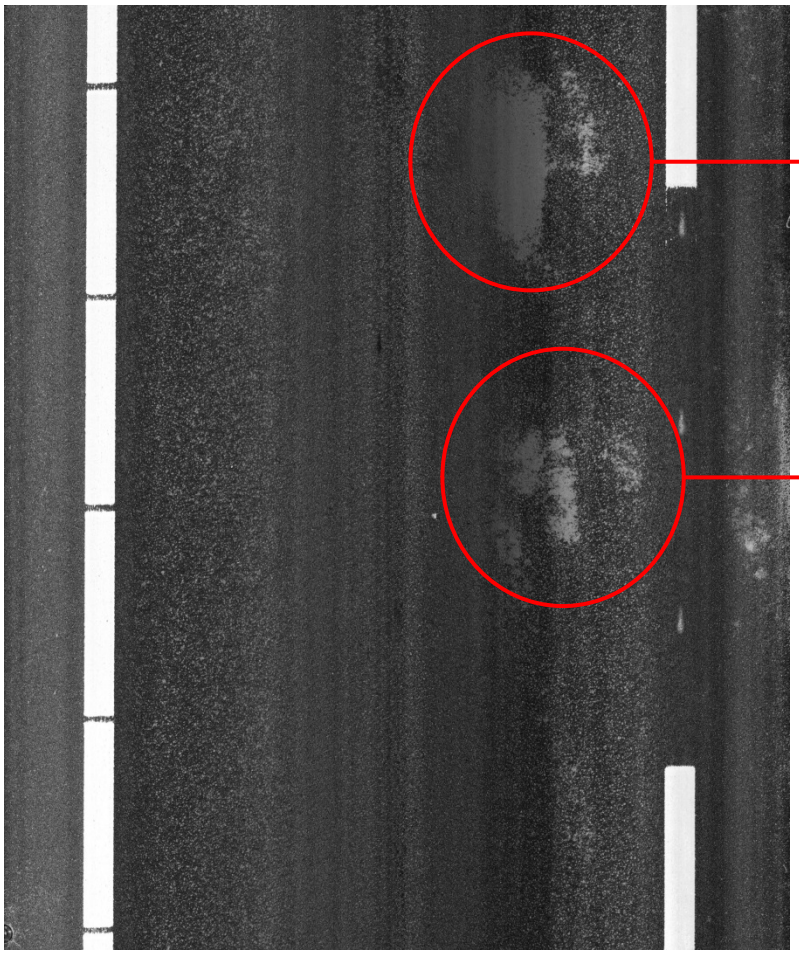
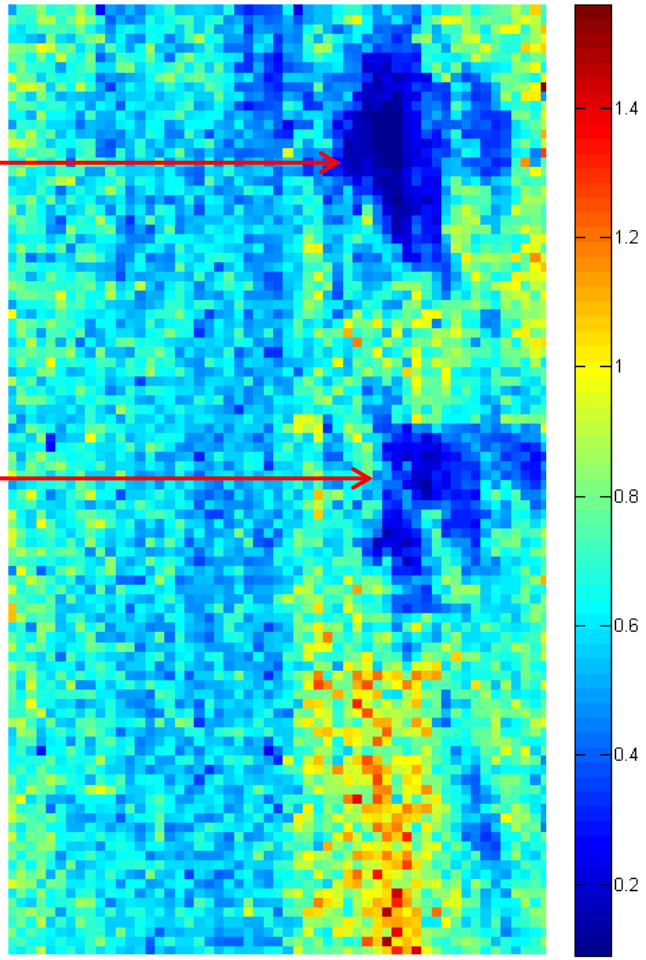
Macrotexture: bleeding

Intensity image



Texture image (MTD, mm)



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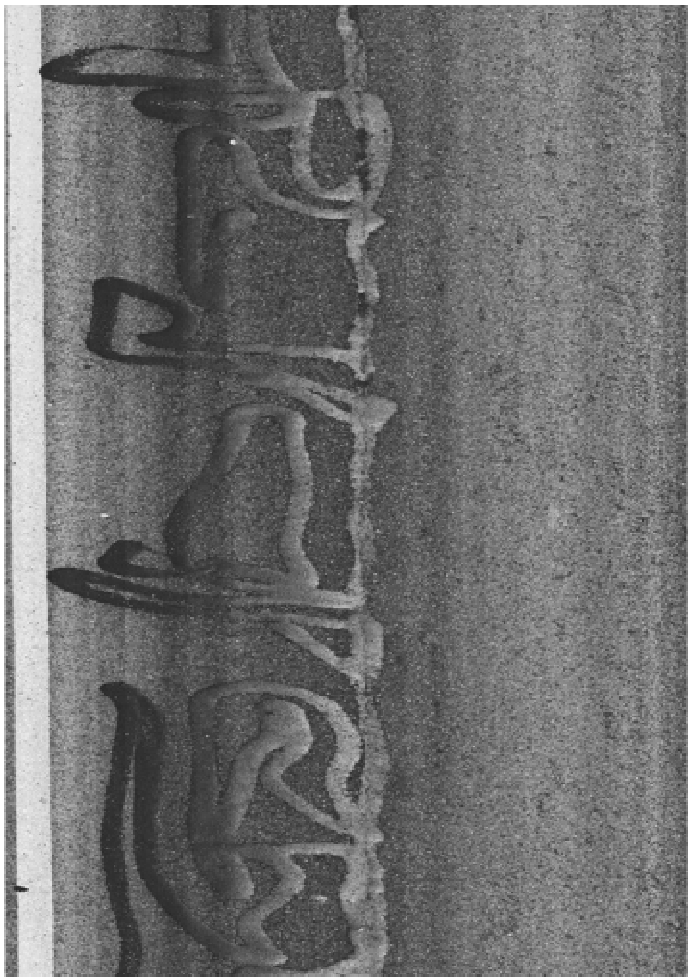
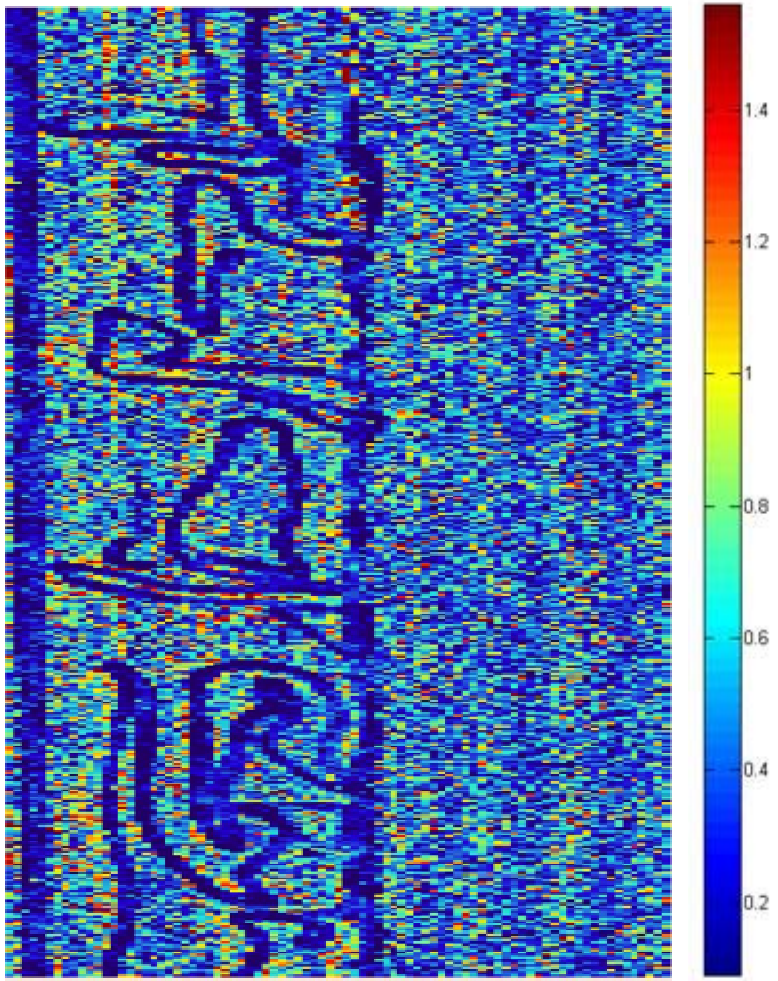
Using Texture to detect Sealed Cracks



Intensity image (sealed cracks)



Texture image (sealed cracks)

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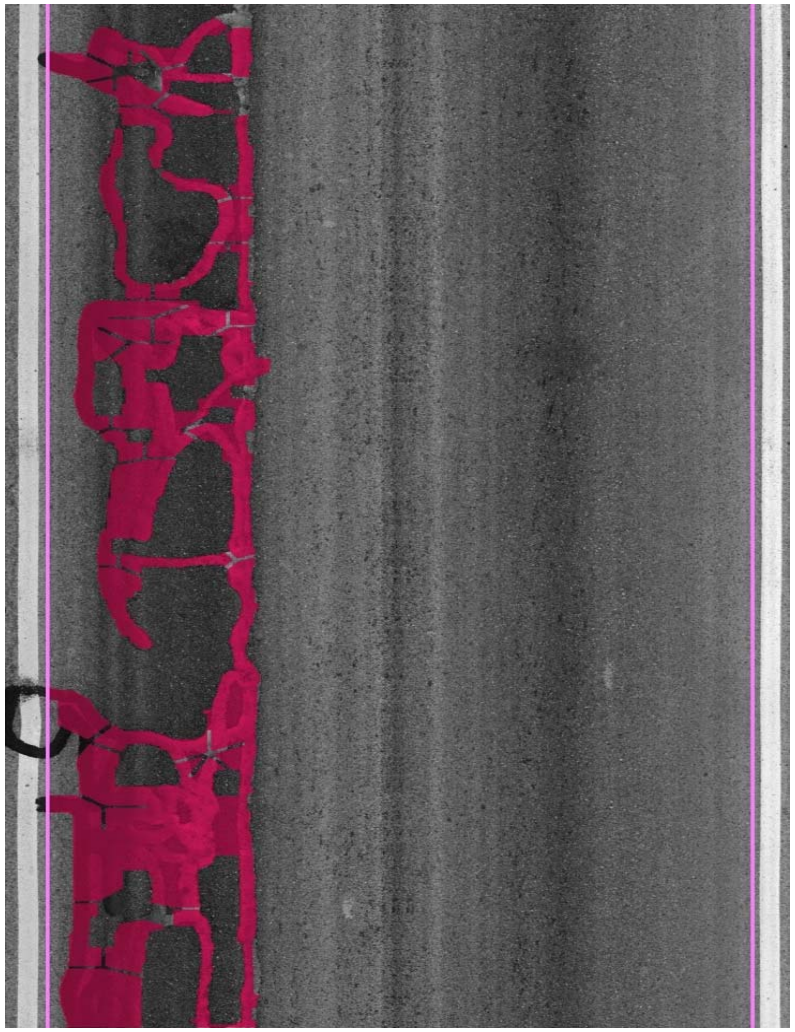
Example (white and dark sealed cracks)

Intensity image (sealed cracks)



Detection image (sealed cracks)

Ravelling – Loss of aggregate

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

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

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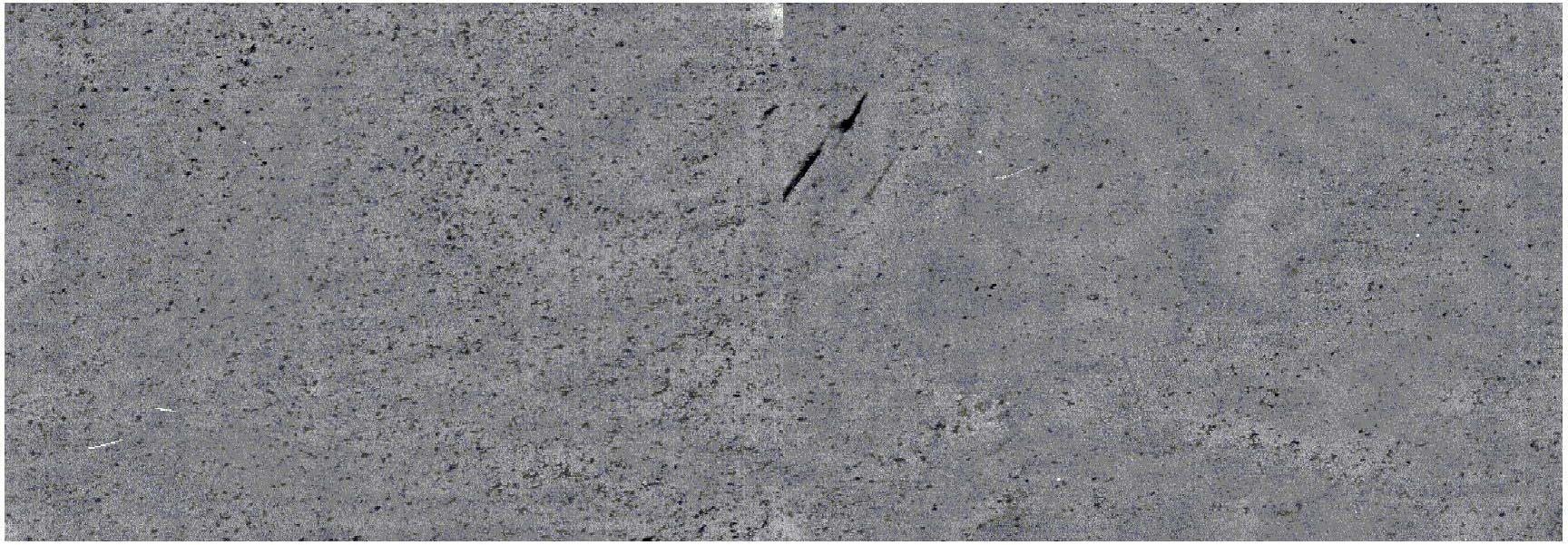
Aggregate loss detection



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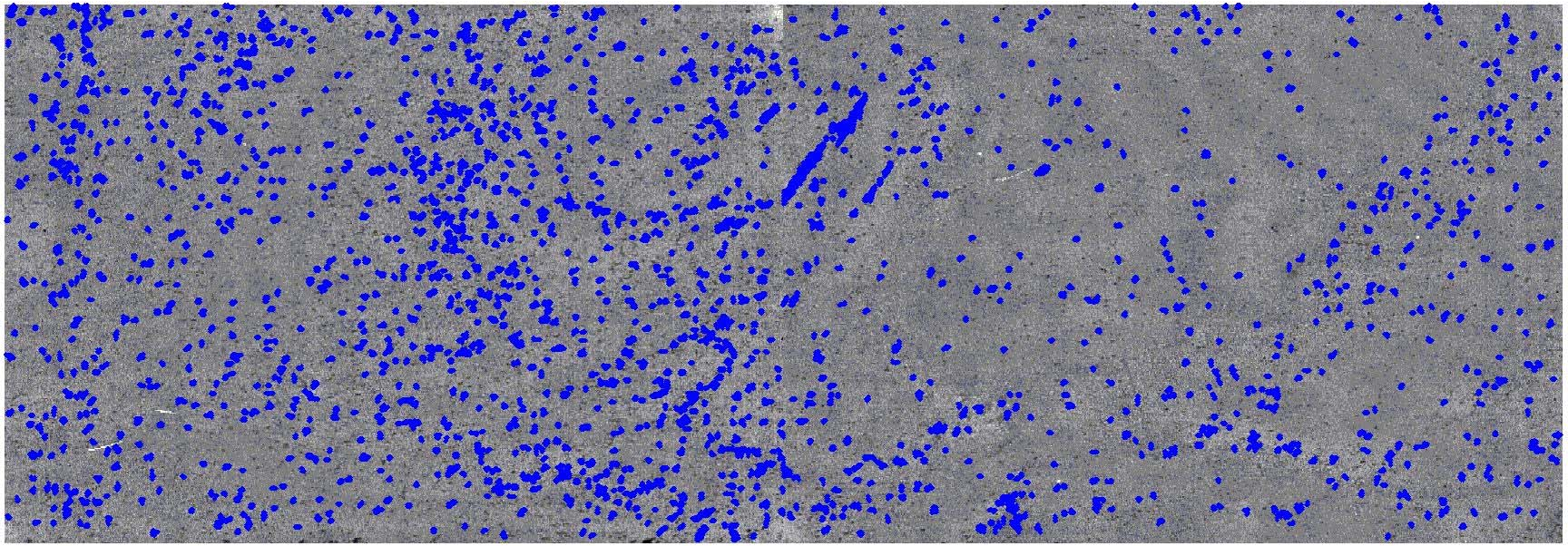
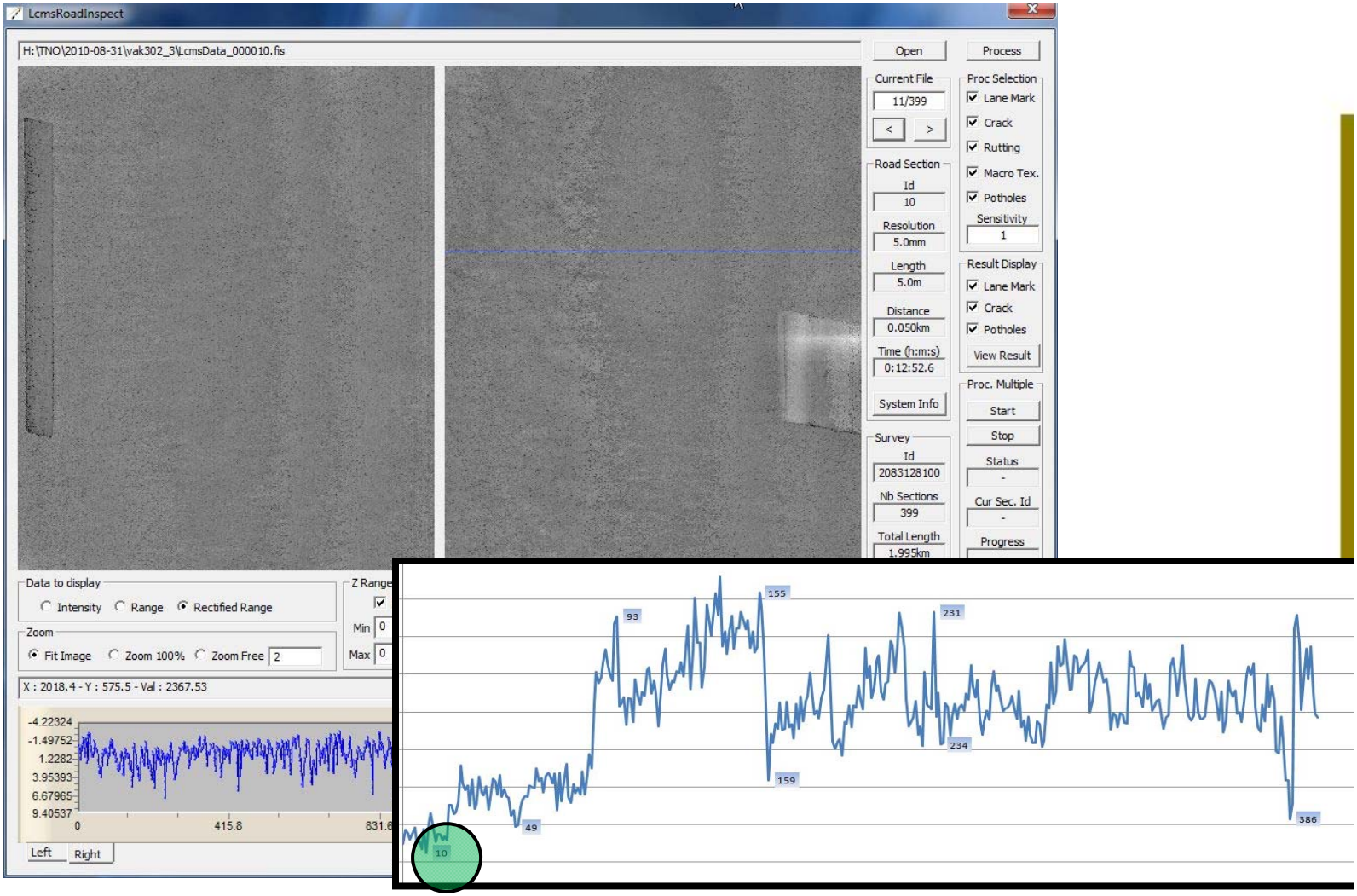
Aggregate loss detection



RI – Road test – Porous Asphalt in the Netherlands



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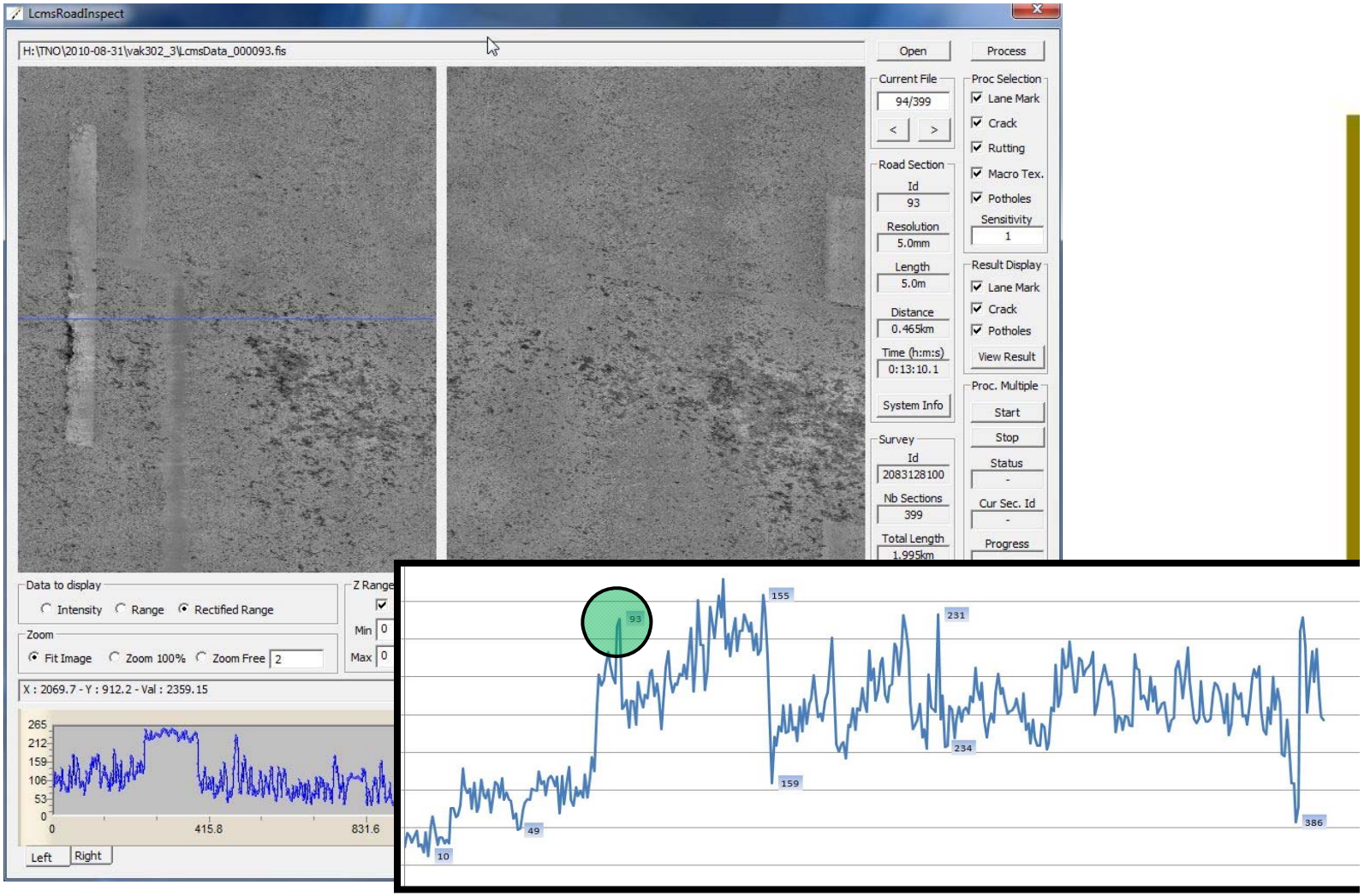
Road Section #93 : Transition between Ravelling and new pavement (Range)



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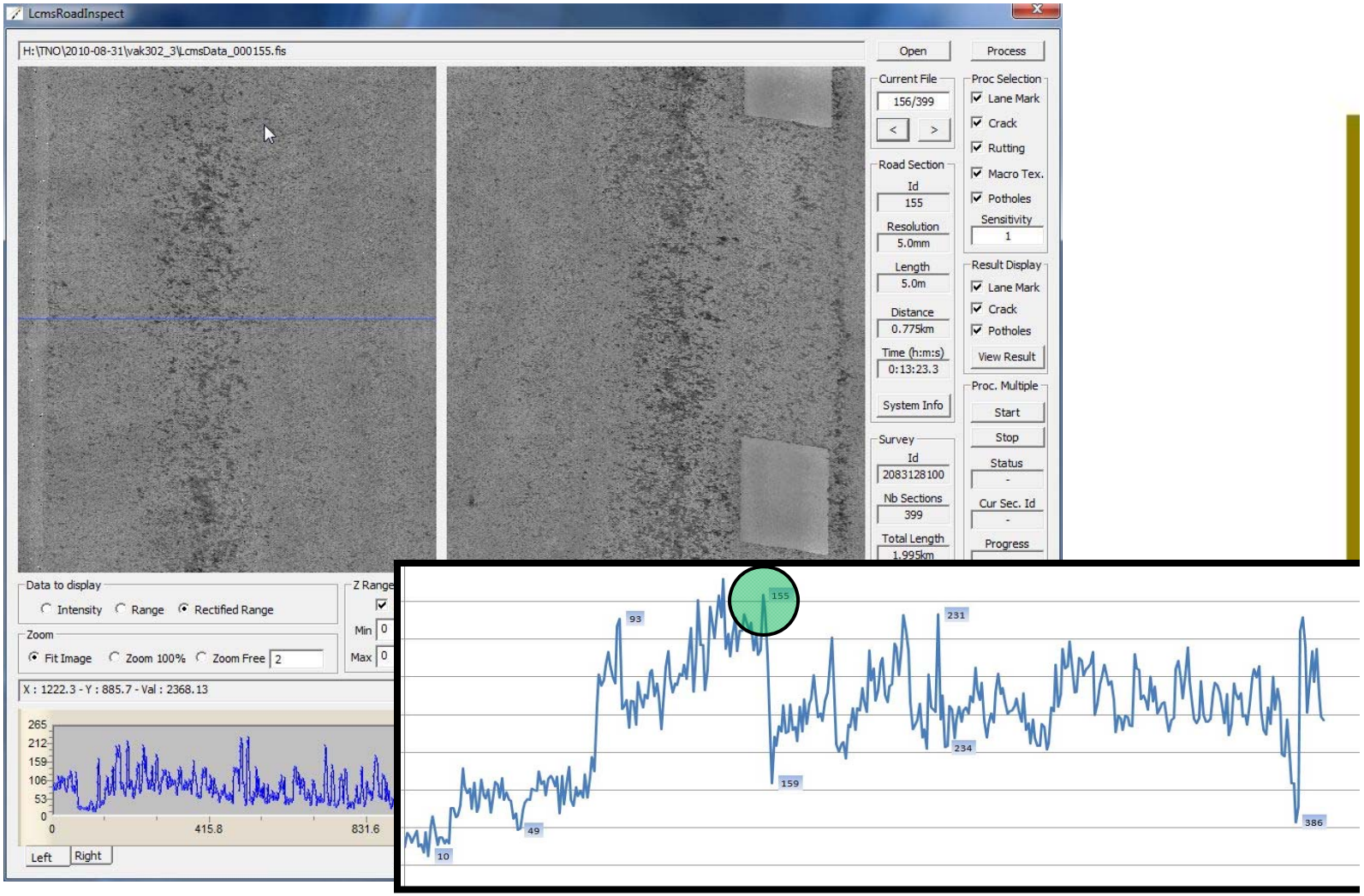
Road Section #155 : Raveling patch



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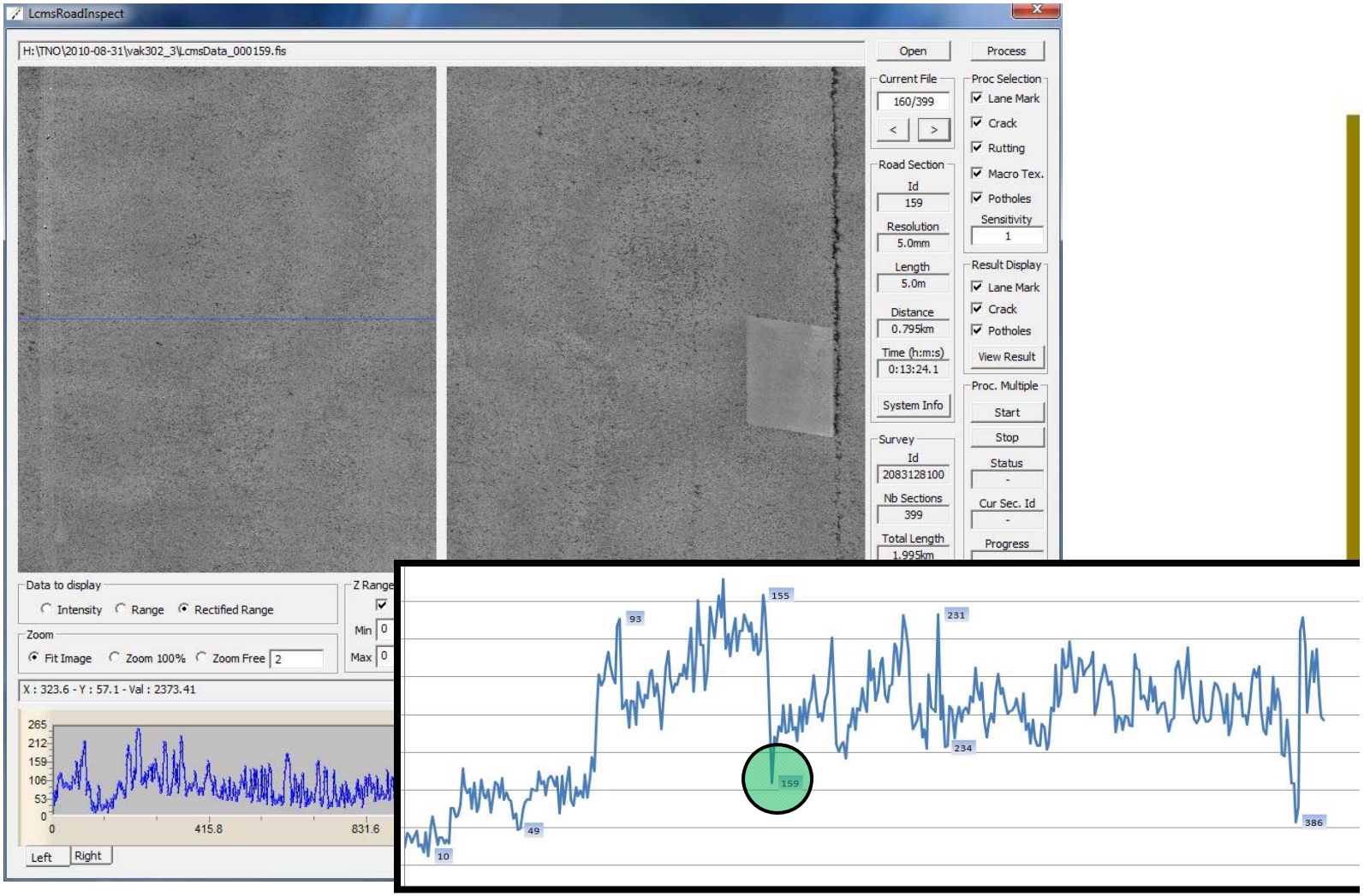
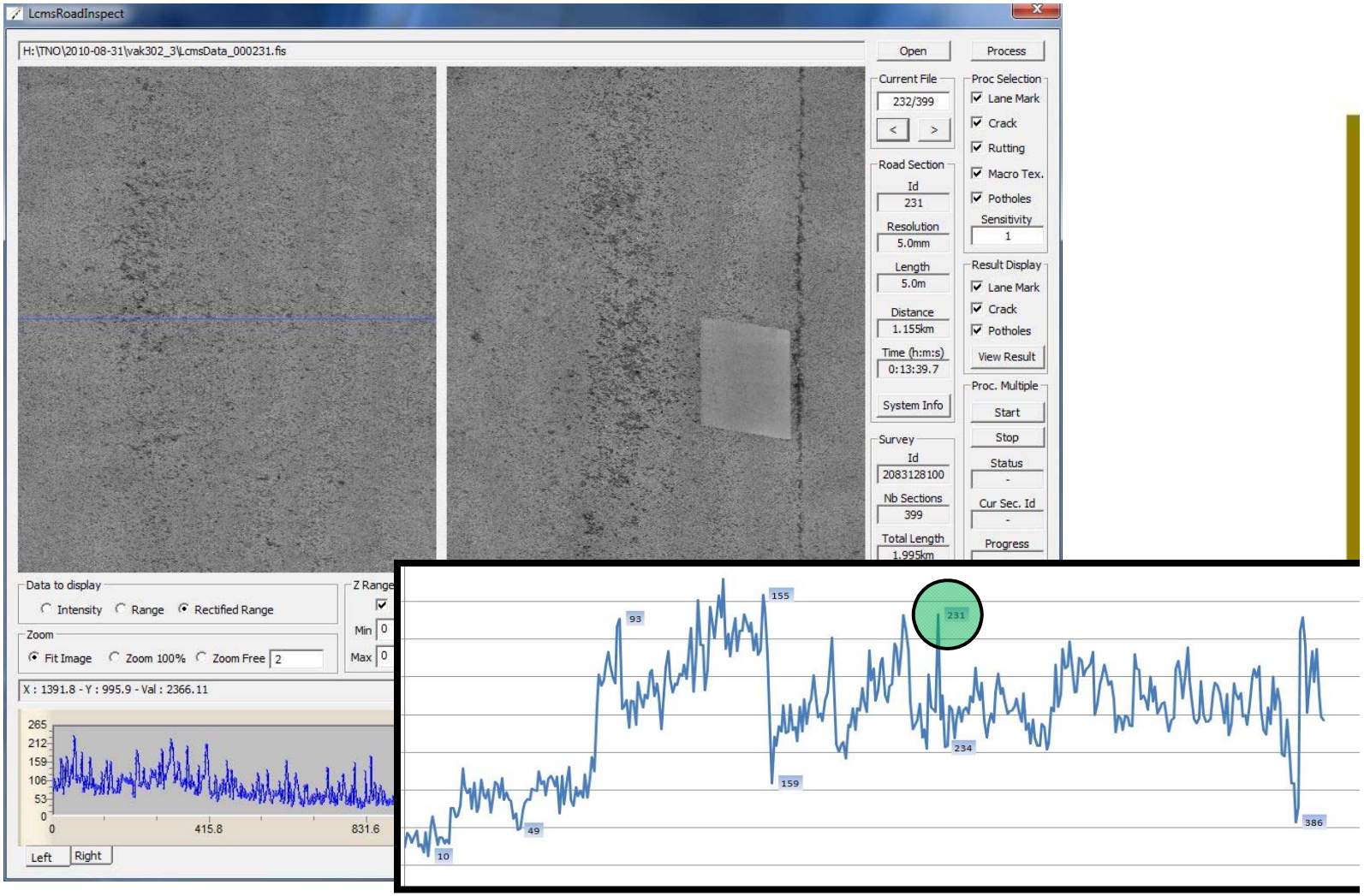
Road Section #159 : Smooth texture



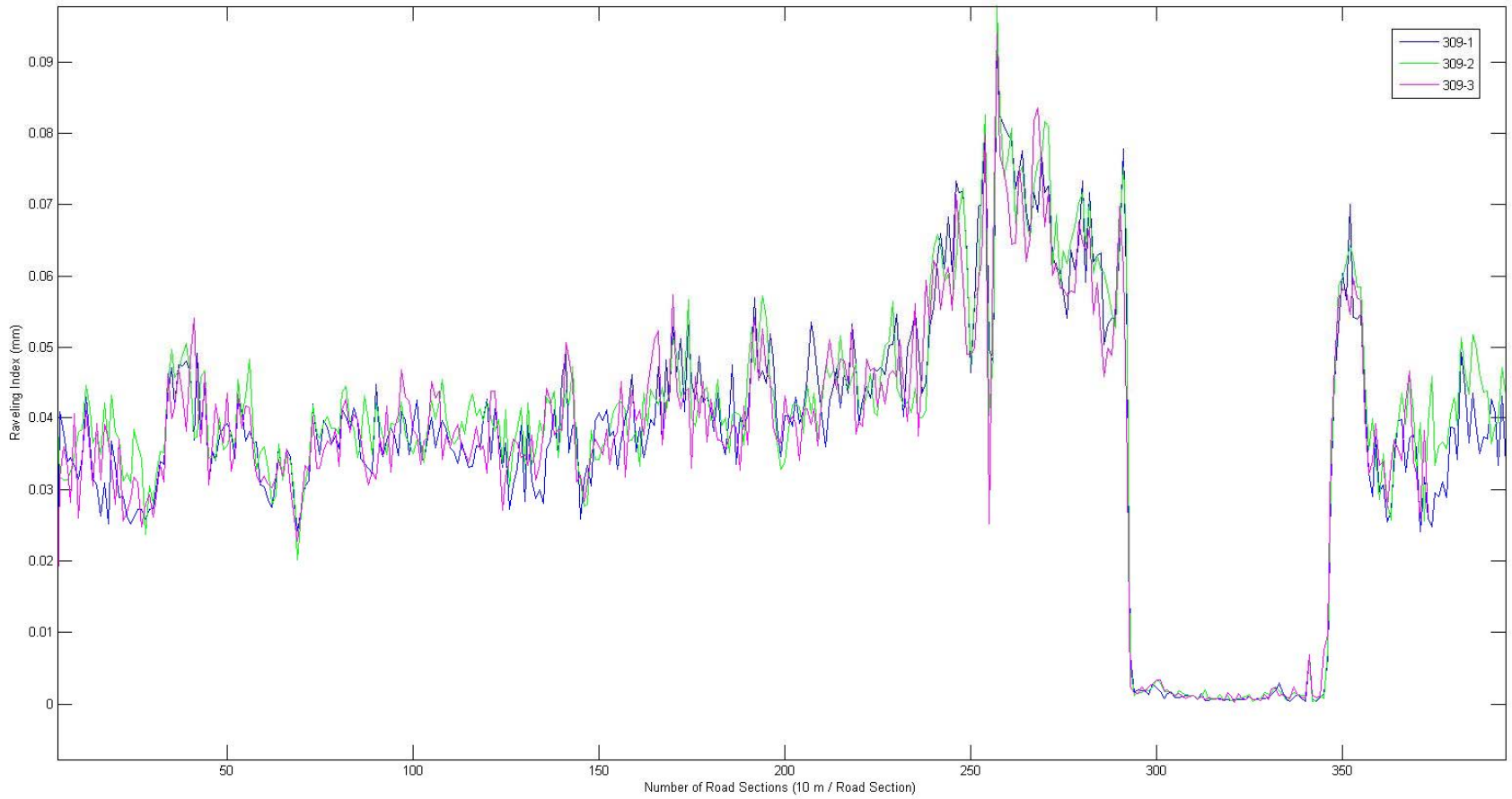
Pavemetrics

Road Section #231 : Raveling patch



Pavemetrics

Ravelling Index - Repeatability (Porous asphalt Netherlands)



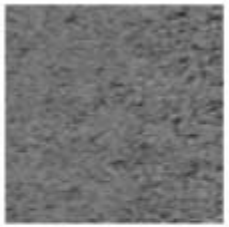
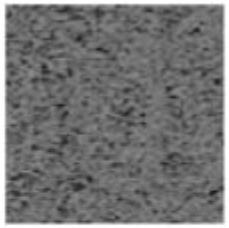
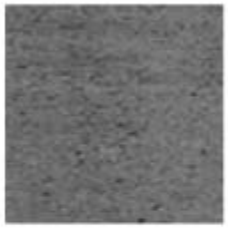
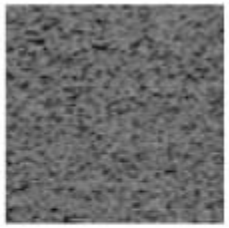
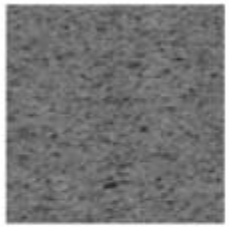
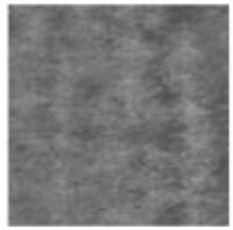
Raveling tests Netherlands

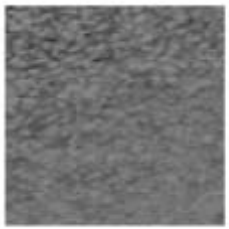
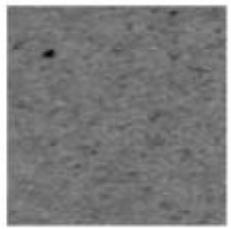
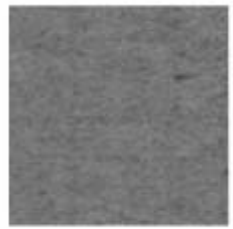
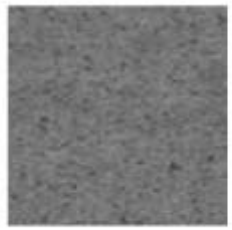
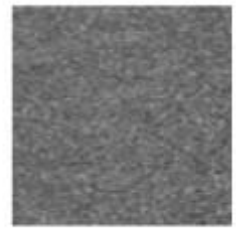
- **Highways; 5,010 km (~20,000 lane km)**
  - 10% DAC and SMA
  - 90% Porous Asphalt
- **Raveling detection using LCMS**
  - Texture analysis is used to evaluate porous pavement type and measure aggregate loss.
  - Calibration is done by matching of severity levels with manual evaluators.

Rijkswaterstaat vehicle

Pavemetrics

Texture analysis to detect pavement type

					
NOVACP	OAB	SMA	ZOAB	ZOABTW	ZOEAB

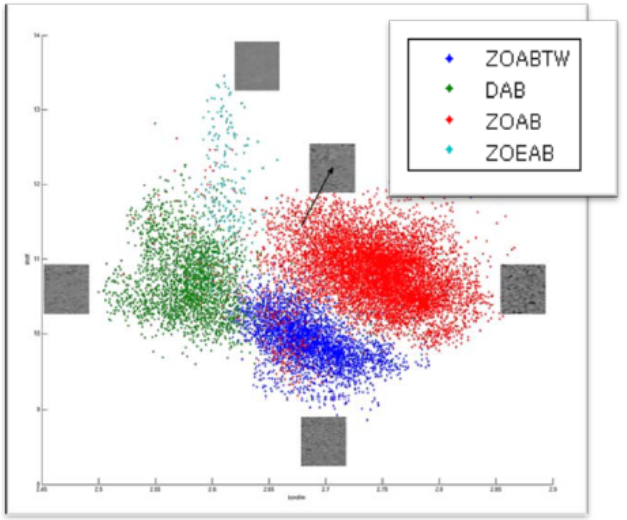
				
COMBID	DAB	DAD	EAB	EOB

Texture analysis to detect pavement type

Pavemetrics

	Berekend / Administratief	COMBID	DAB	DAD	EAB	EOB	NOVACP	OAB	SMA	ZOAB	ZOABTW	ZOEAB	Totaal	% correct	
		Dicht								Open					
Dicht	COMBID	27											27	100,0%	
	DAB		2326	2	31	2			100	5	7	10	2483	93,7%	
	DAD			163	2								165	98,8%	
	EAB		10		70						2	1	83	84,3%	92,5%
	EOB					8							8	100,0%	
	NOVACP						53						53	100,0%	
	OAB							17					17	100,0%	
	SMA		64			1			598	22	6		691	86,5%	
Open	ZOAB	1								19155			19156	100,0%	
	ZOABTW		3		8				5	24	4195	1	4236	99,0%	99,7%
	ZOEAB		7		13				3		1	185	209	88,5%	
	Totaal	28	2410	165	124	11	53	17	706	19206	4211	197	27128	98,8%	
		96,4%	96,5%	98,8%	56,5%	72,7%	100,0%	100,0%	84,7%	99,7%	99,6%	93,9%			
		92,8%								99,7%					

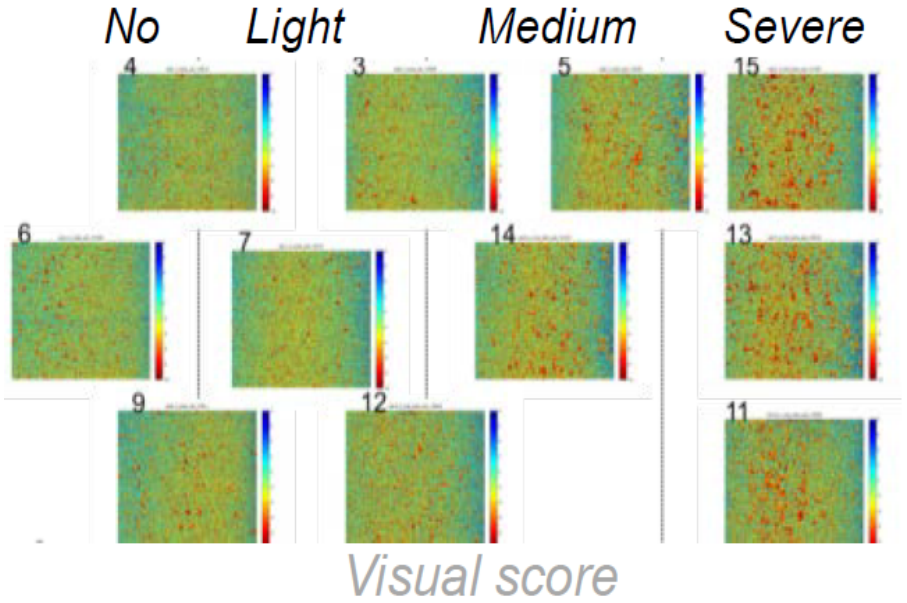
Texture analysis

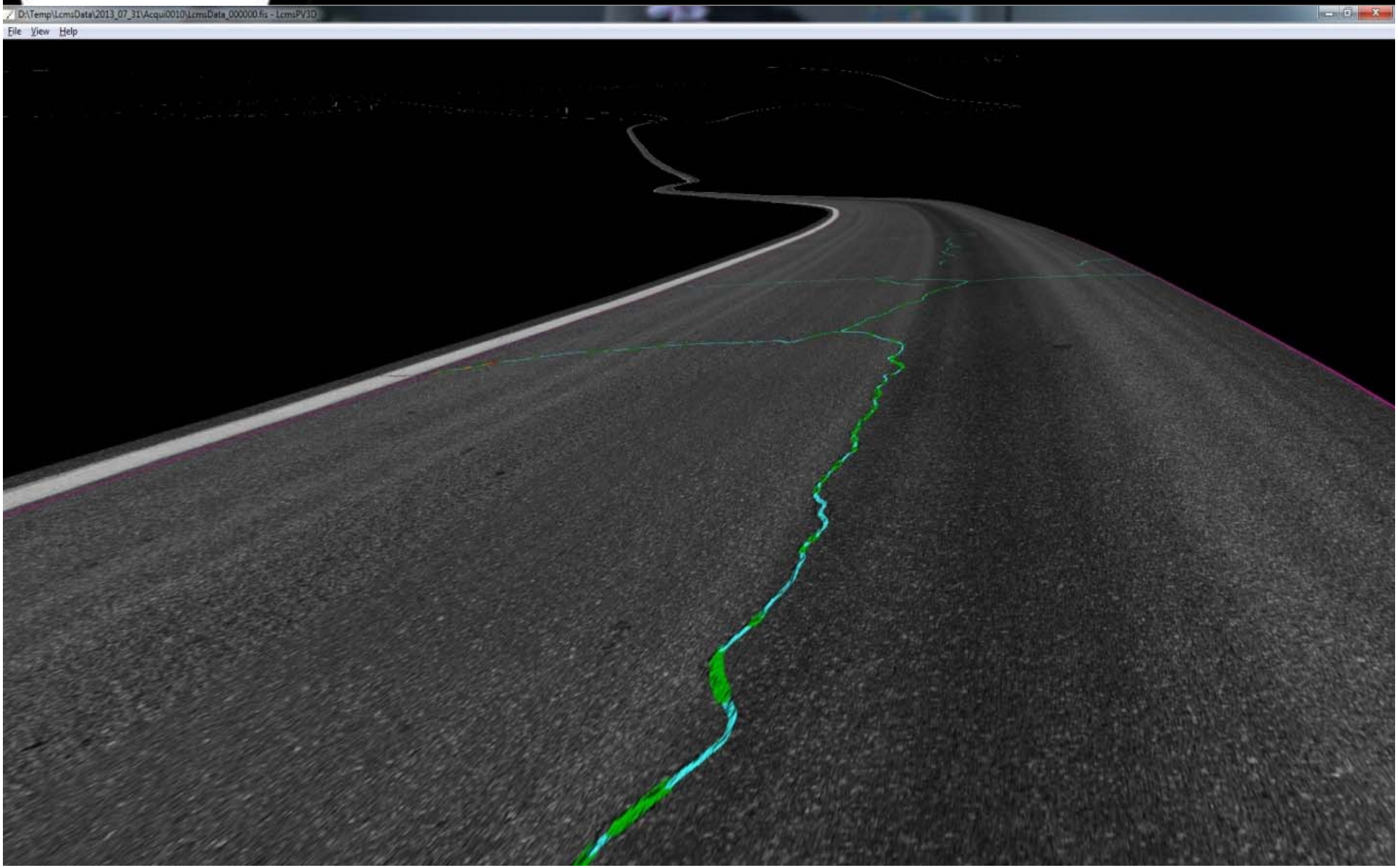


Calibration with Visual

- **Raveling detection using LCMS ZOAB pavements in the Netherlands**

- Calibration is done by matching of severity levels with manual evaluators.
- 93% good correlation with visual inspections!
- System operational since 2012 replacing manual surveys.



Pavemetrics

Any Questions?