

The Pavemetrics logo features a large white circle on a black background. Inside the circle, the word "Pavemetrics" is written in a yellow sans-serif font. Below the text, there is a yellow curved line that ends in a small hook, with three short black dashed lines positioned underneath it.

Pavemetrics

IRI measurements using the LCMS

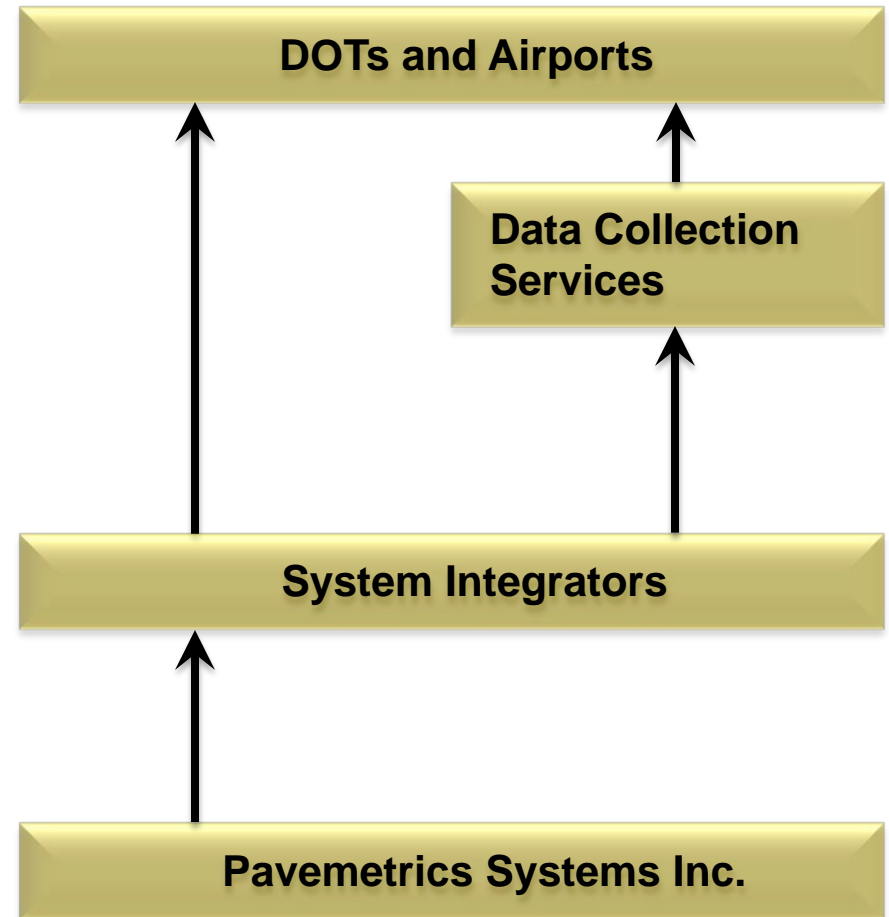
RPUG 2012

Vision Technology for Inspection of Transportation Infrastructures

John Laurent

jlaurent@pavemetrics.com

+1 418 210 3909





LRMS

- Pavement Rutting



LCMS

- 3D Pavement Imaging
- Pavement Rutting
- Macro-Texture
- Pavement Cracking
- Pavement Roughness
- Road/Airport/Tunnel/Rail Inspection



LRIS

- Pavement Imaging



20,000,000 Miles + collected since 1997

- **400 times the entire US Interstate Highway Network**
- **850 times around the world**
- **85 trips to the moon**
- **The entire world road network**

TWICE !

USA

Mandli – (equipment)
ICC – (equipment)
Caltrans (data collection services)
Utah (data collection services)
Kentucky (equipment)
Kansas (equipment)
Tennessee (data collection services)
Nevada (data collection services)
Rhode Island (data collection services)
Illinois (data collection services)
Georgia Tech (equipment)
Virginia Tech (equipment)
US Army Test Tracks (equipment)
University Mass – Lowell (equipment)
PennDOT (equipment)
City of Phoenix, AZ (equipment)

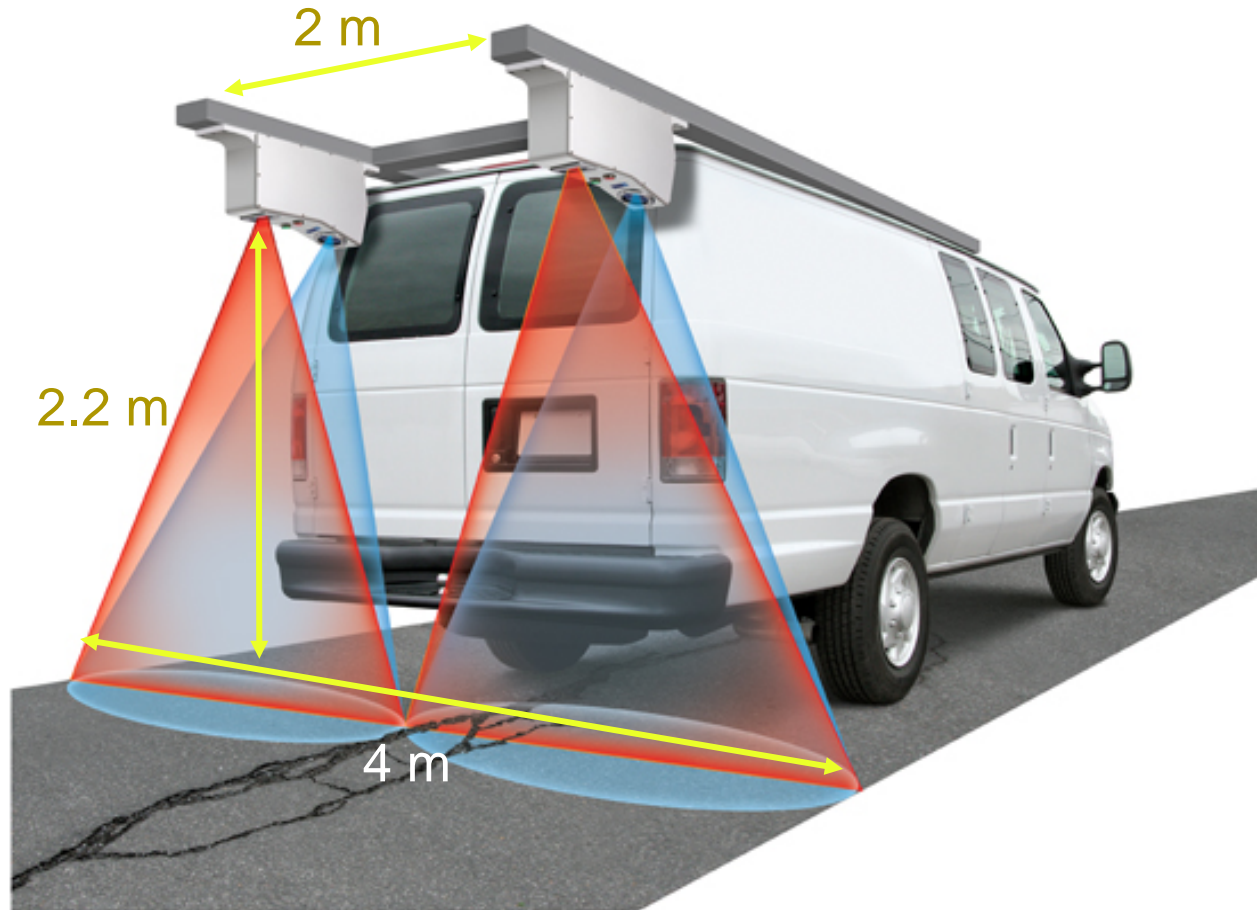
Canada

Fugro-Roadware (equipment)
MTO – Ontario (equipment)
MTQ – Quebec (equipment)
Nova Scotia (equipment)
SNC Lavalin (equipment)
Dessau - LVM (equipment)

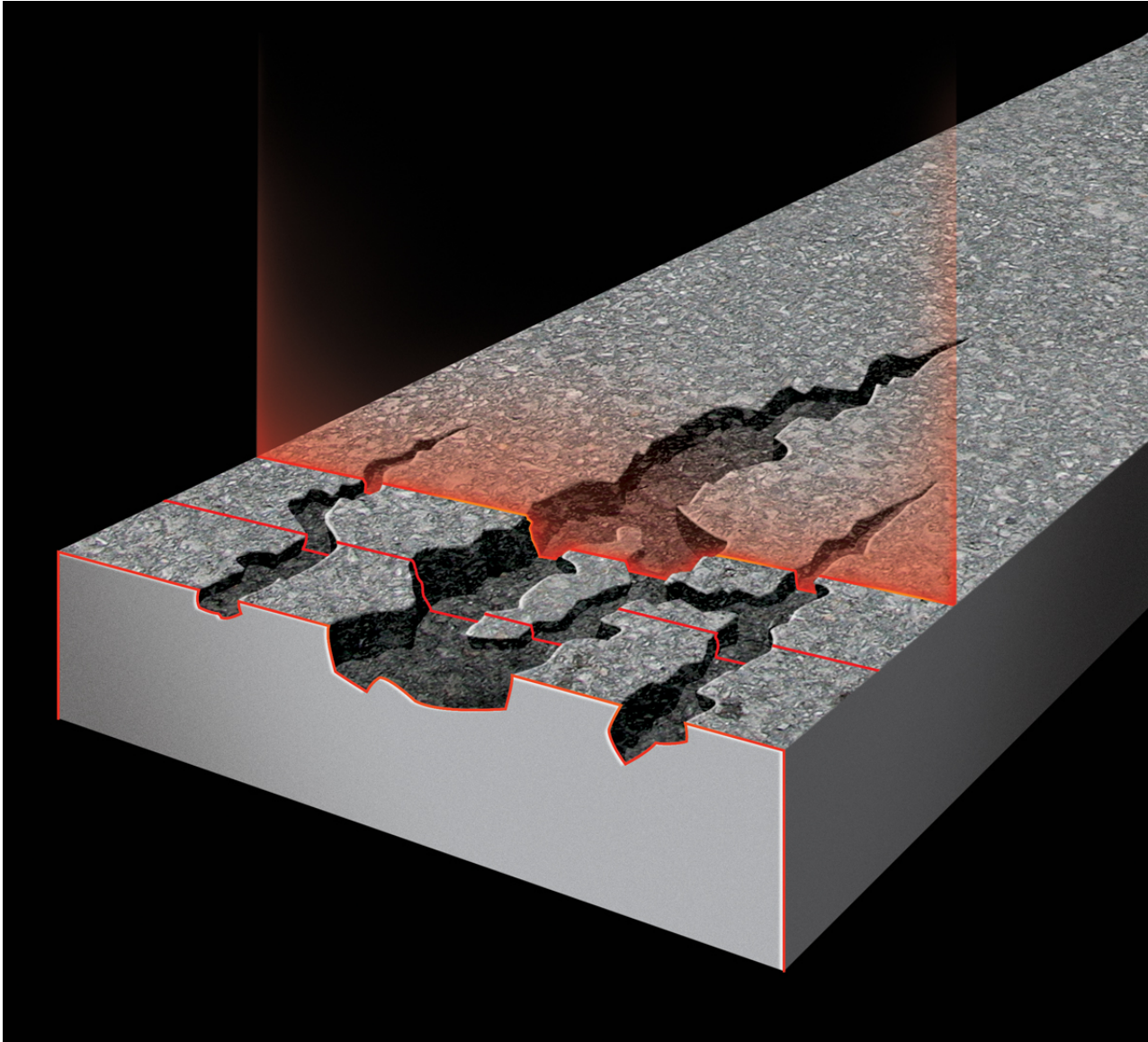
Is NOT a prototype

It is a well used and certified system.

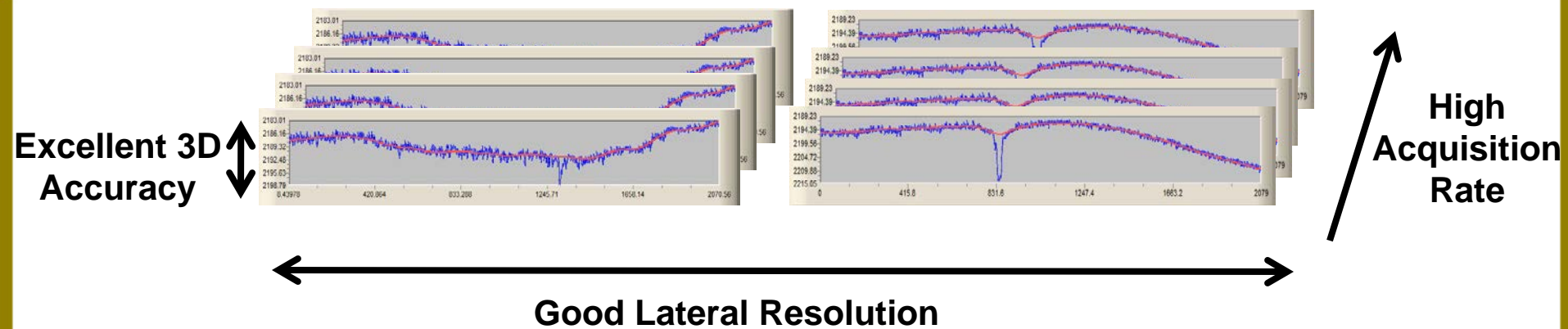




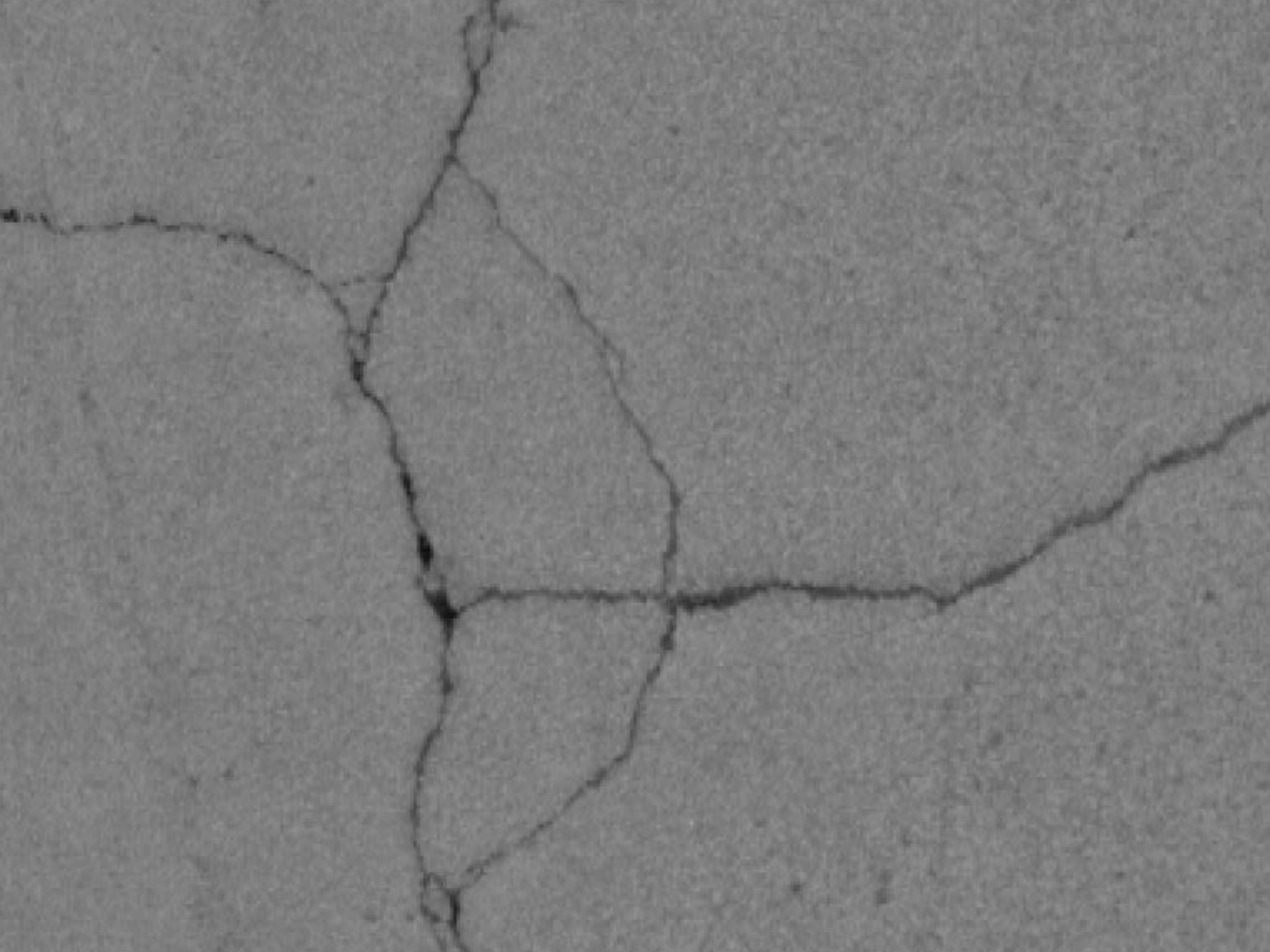
Laser profiling (principle)



What makes a 3D sensor very good for crack measurement?

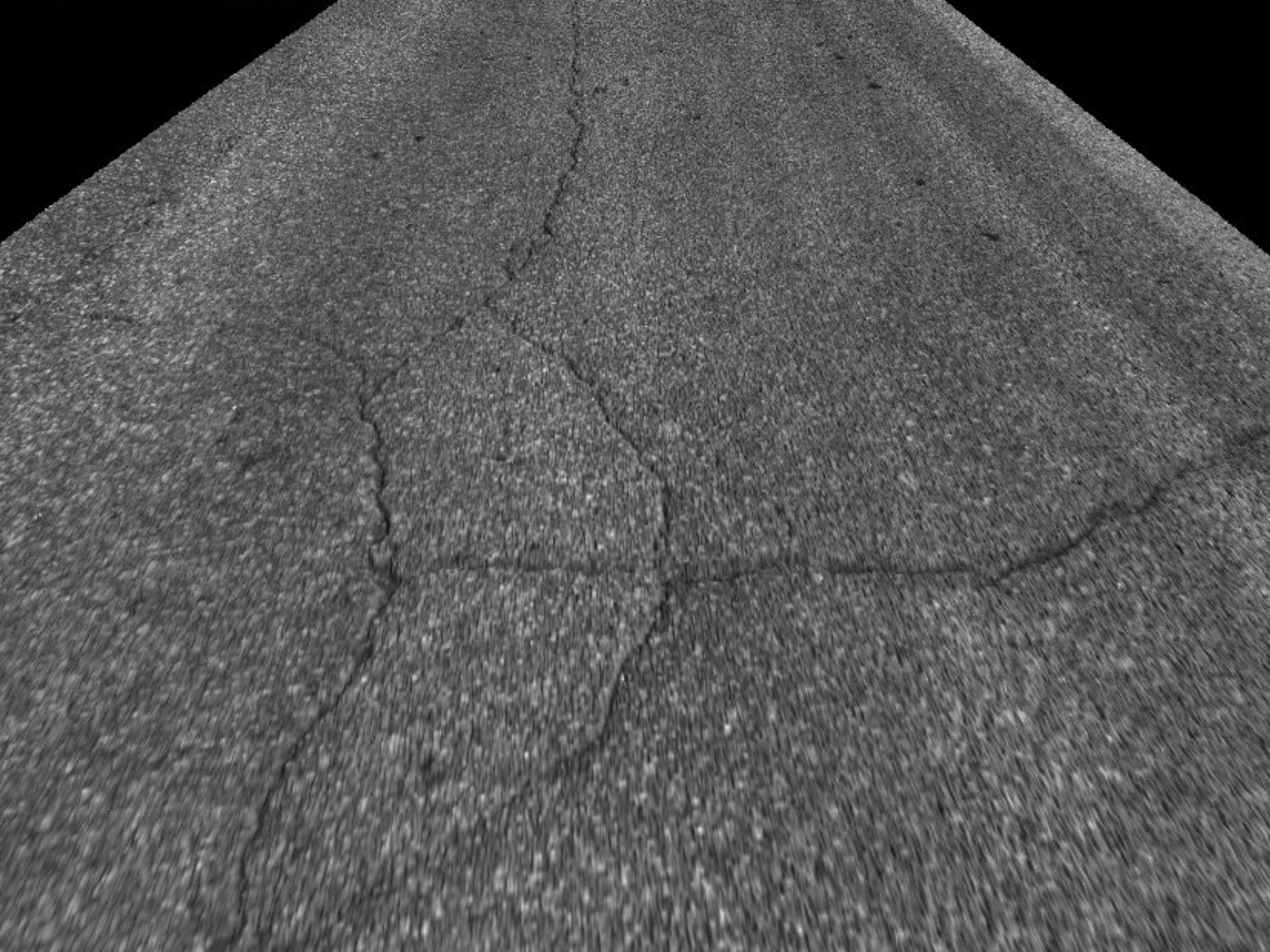


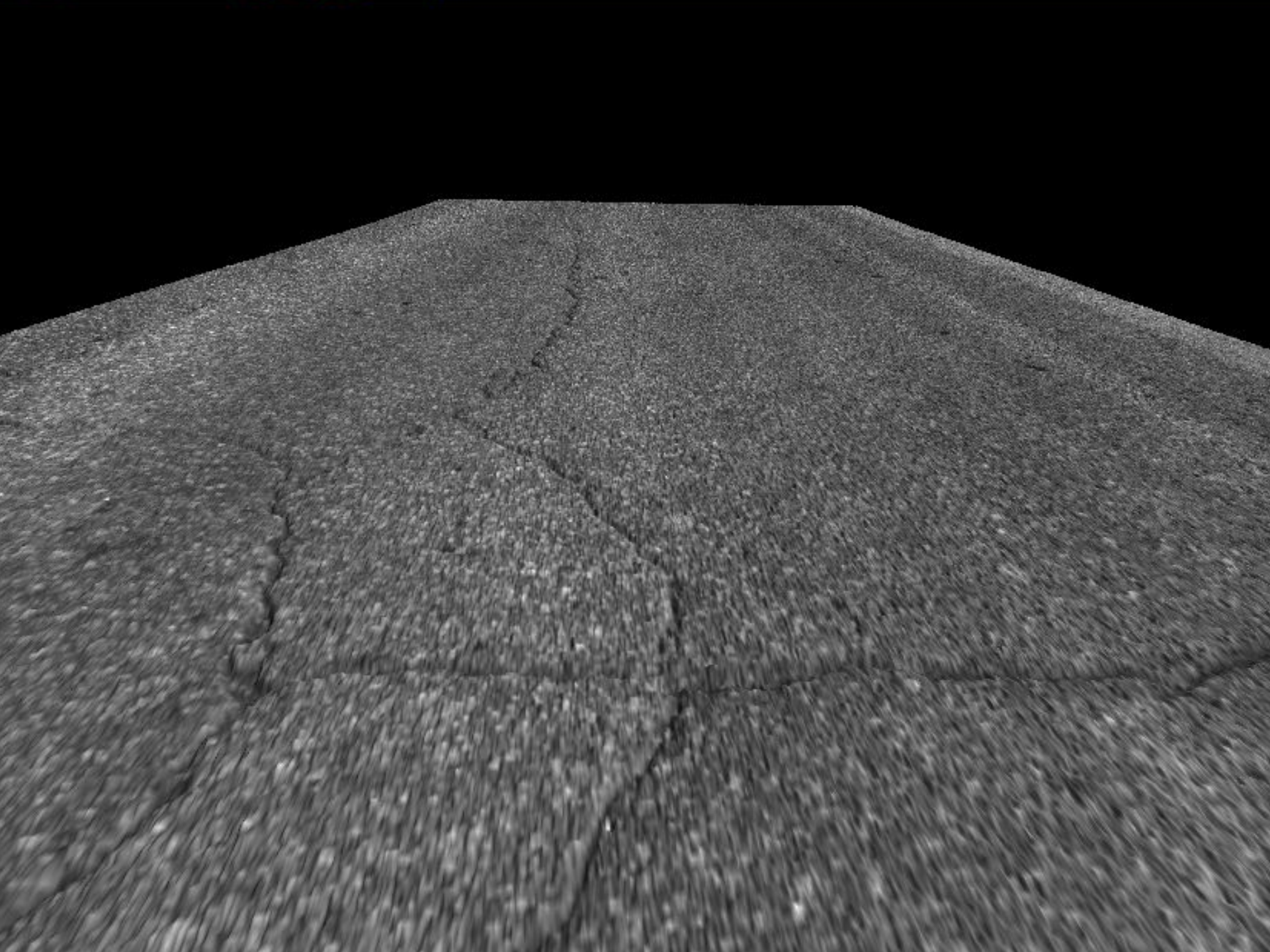
LCMS Specifications	
Acquisition Rate	11,200 profiles/s
Range Accuracy	0.5mm
Lateral Resolution	1mm (FOV = 4m)
Nbr of points/sec	45 million 3D and 2D points/s












The background of the image is a dark, textured surface that resembles a rocky or metallic terrain. The texture is composed of many small, irregular grains and larger, more prominent ridges and cracks, giving it a rugged appearance. The lighting is somewhat uneven, with brighter areas highlighting the texture and darker areas in the shadows. Overlaid on this background is the text "SOFTWARE IS KEY!" in a bright red, sans-serif font. The text is centered and arranged in three lines: "SOFTWARE" on the top line, "IS" on the middle line, and "KEY!" on the bottom line. The red color of the text contrasts sharply with the dark, textured background, making it the focal point of the image.

SOFTWARE
IS
KEY!

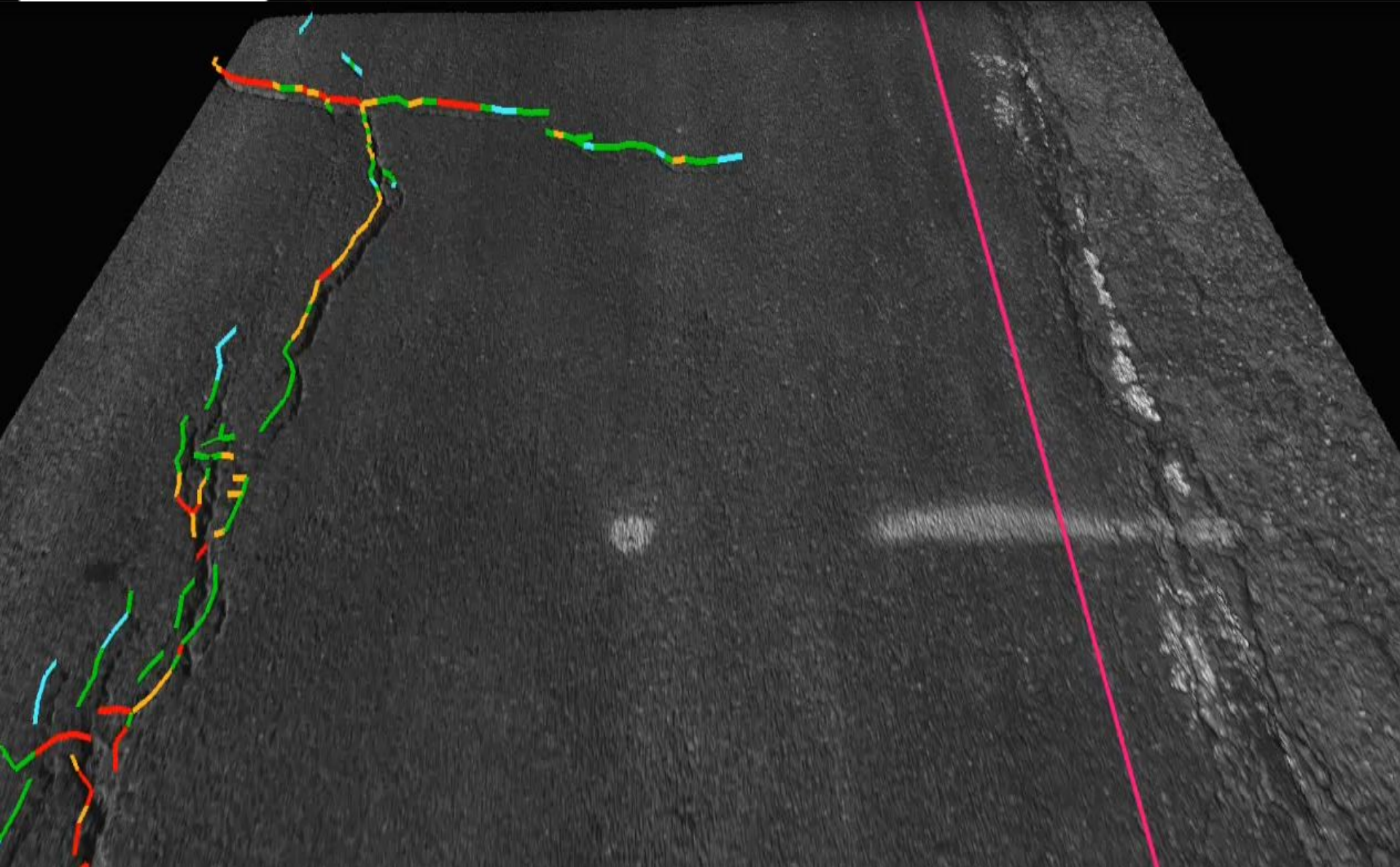
Pavemetrics

Crack Detection

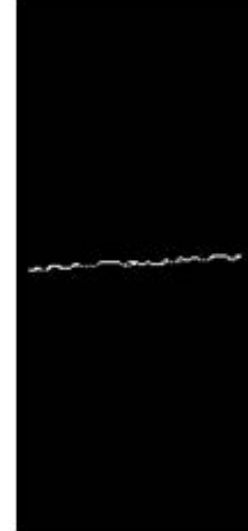
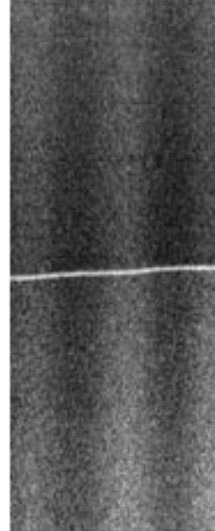
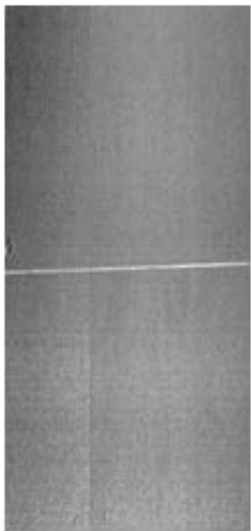
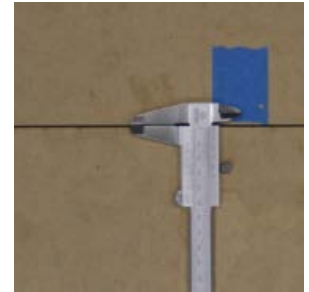


Pavemetrics

Edge Dropoff Detection



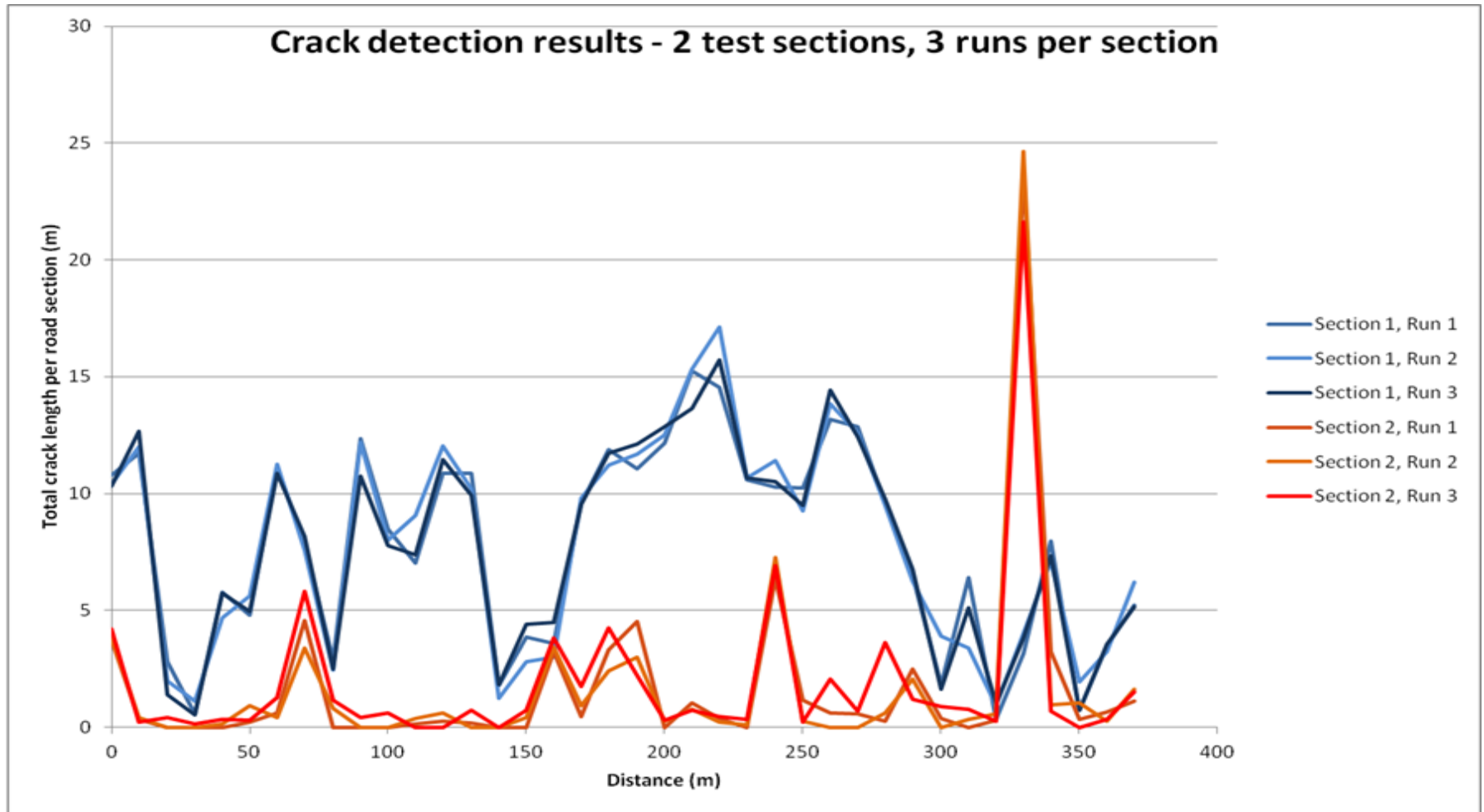
LCMS crack detection tests



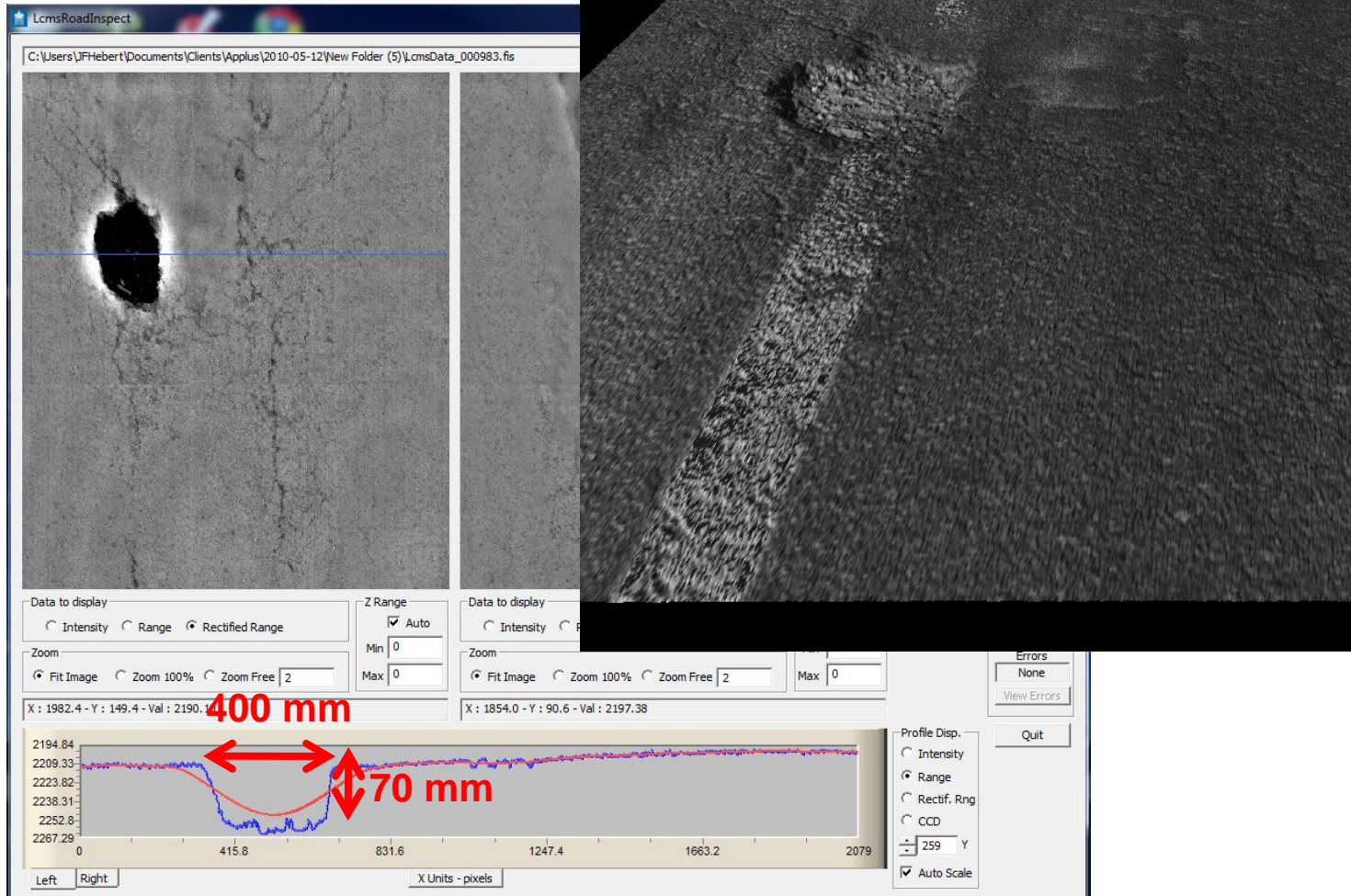
(c) 2mm (daytime)

(d) 2mm (night)

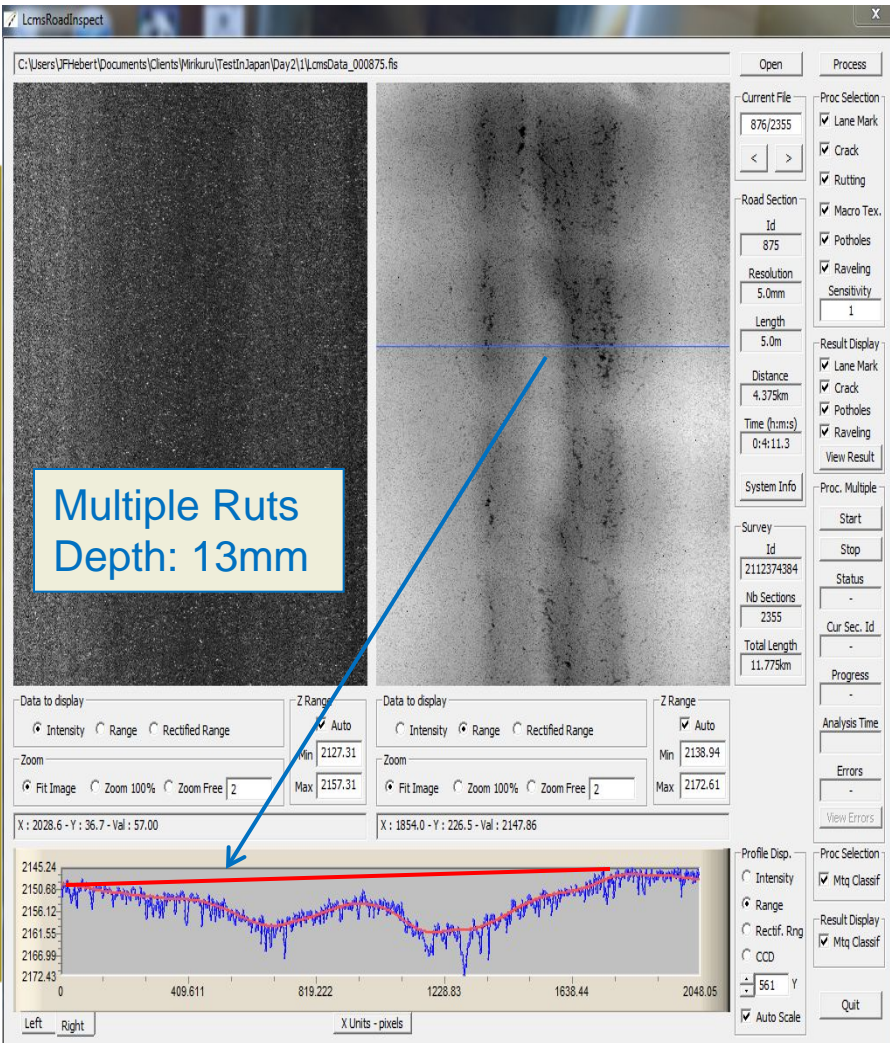
LCMS crack detection repeatability tests



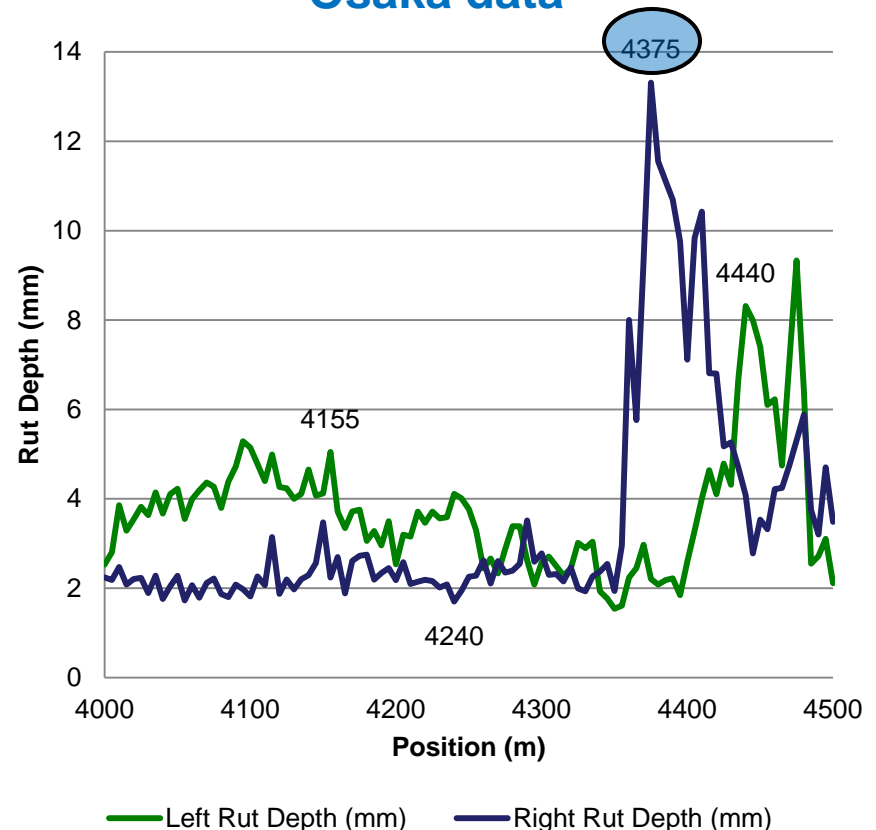
Pothole Detection

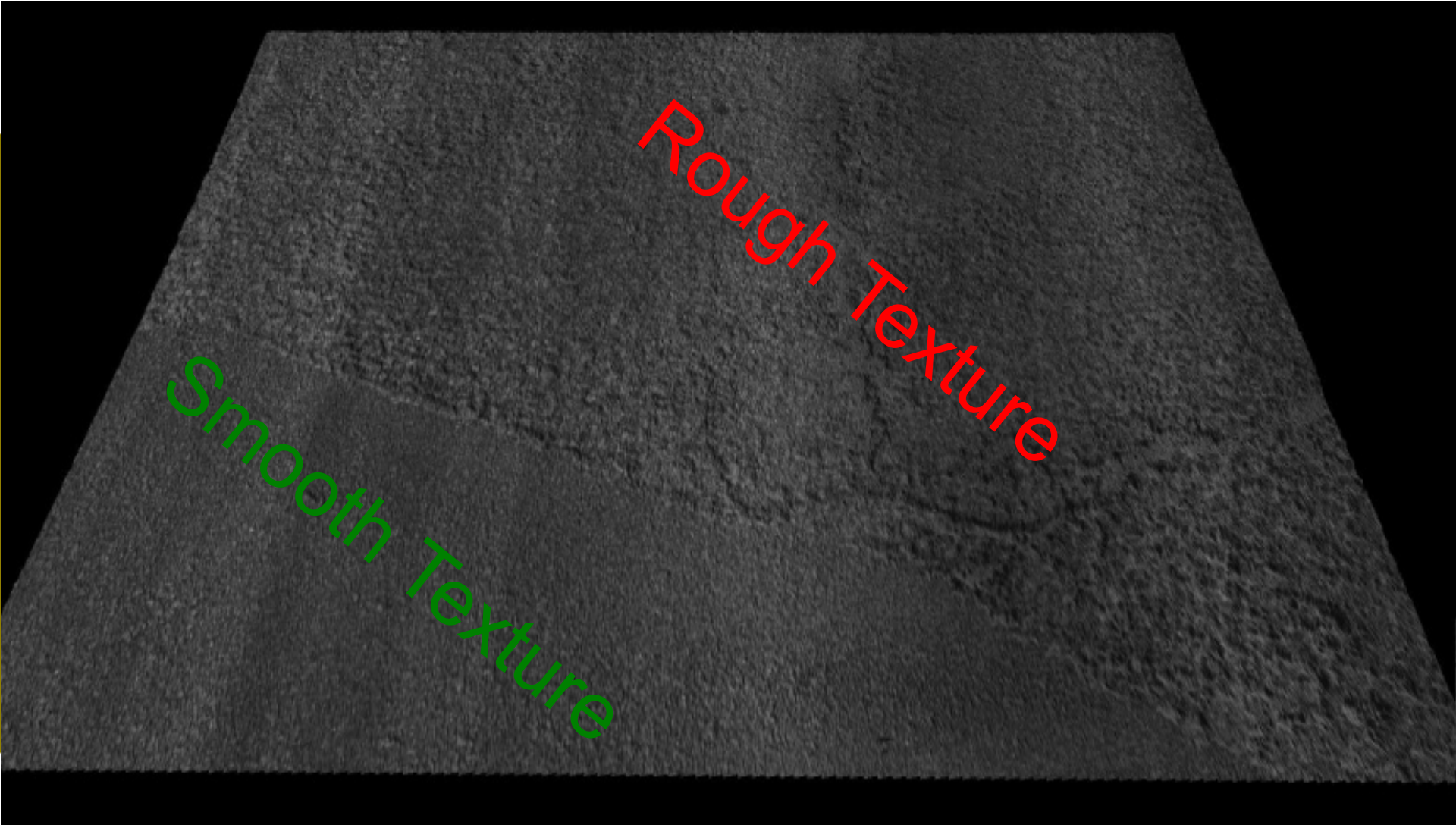


Rutting (depth, width, type)

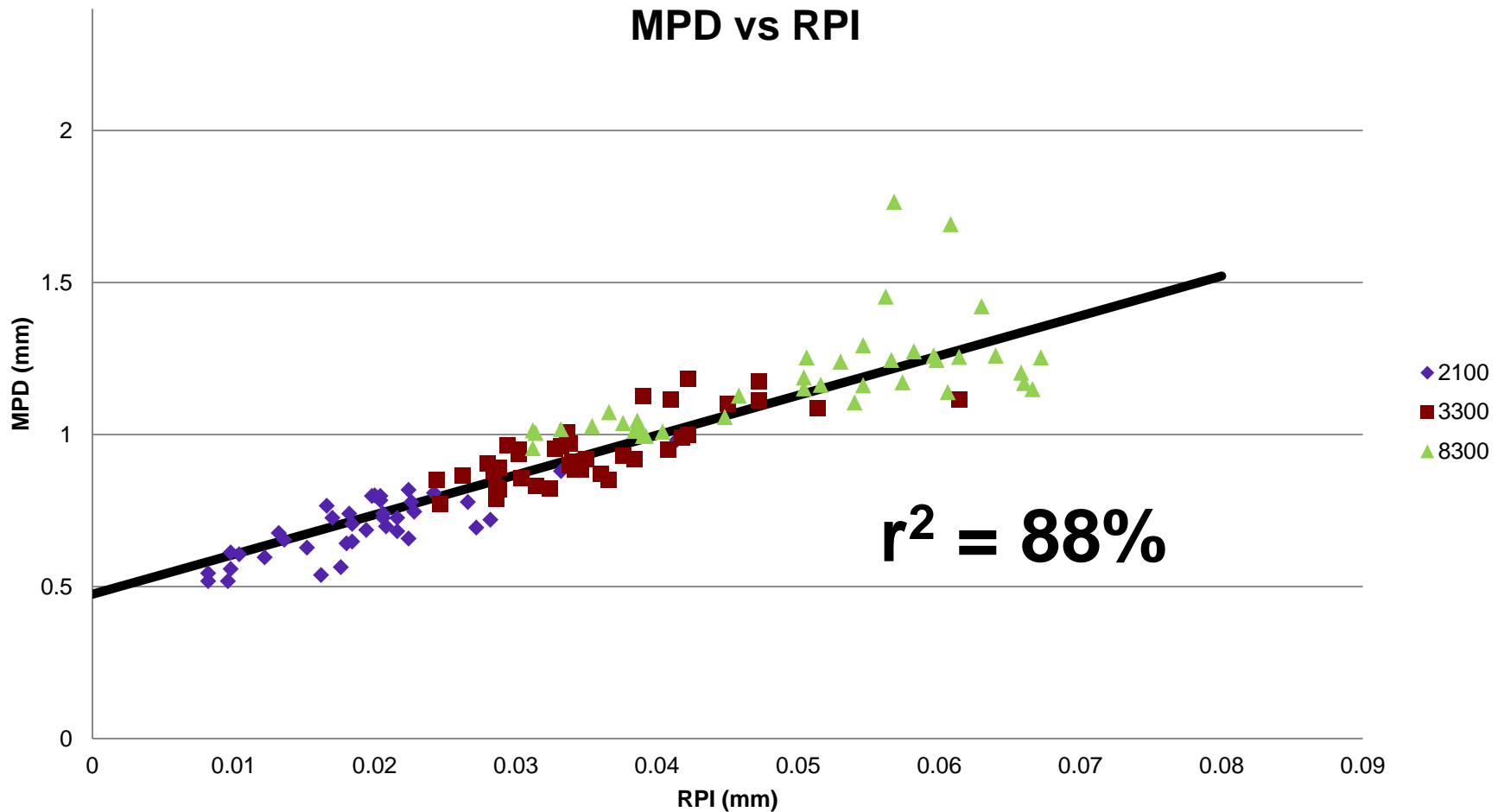


Rut Depth (per road section) between 4.0km and 4.5km for Osaka data

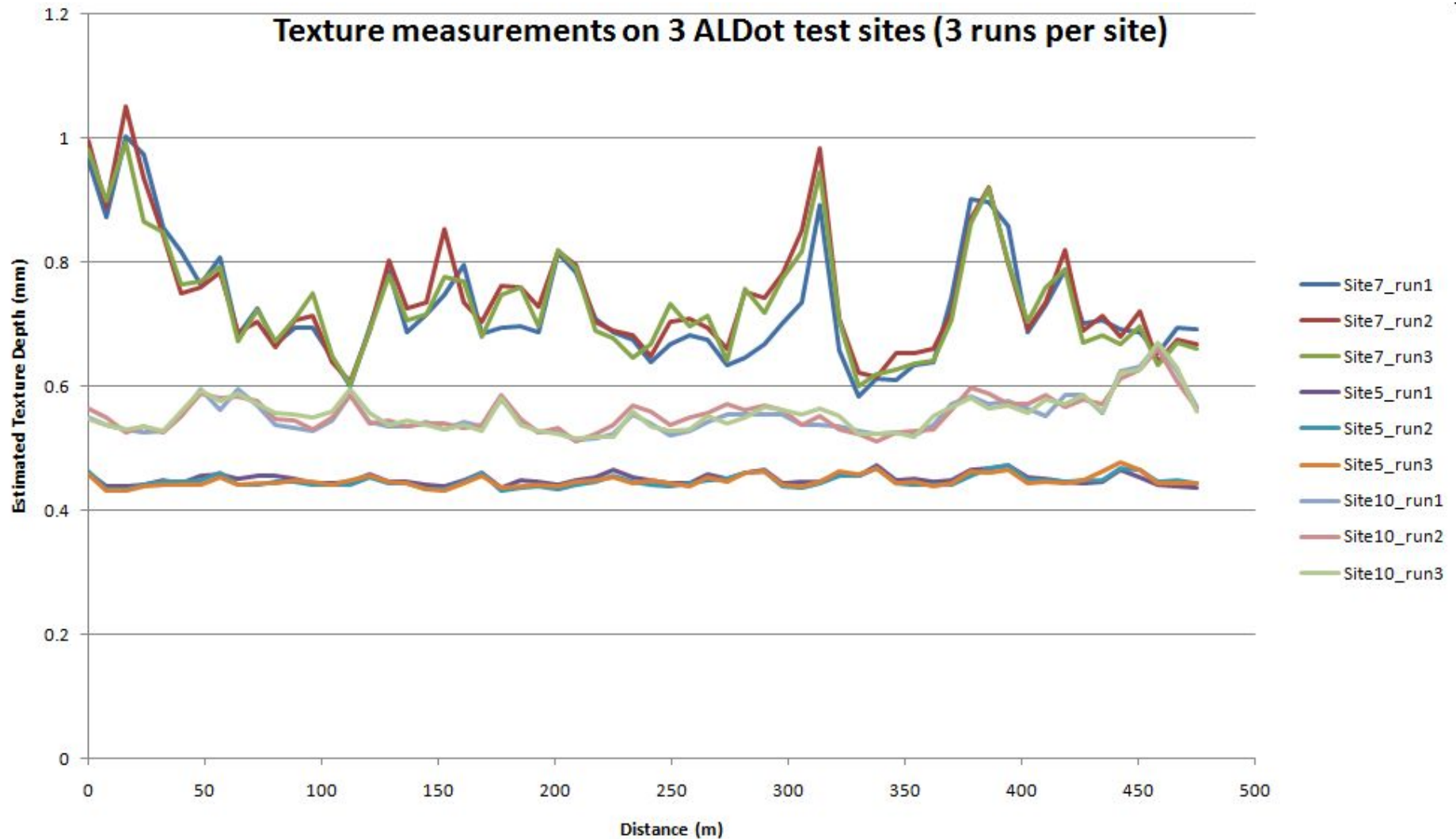


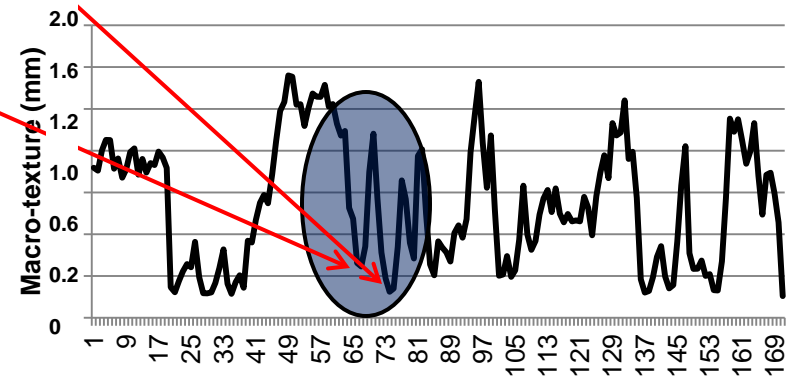
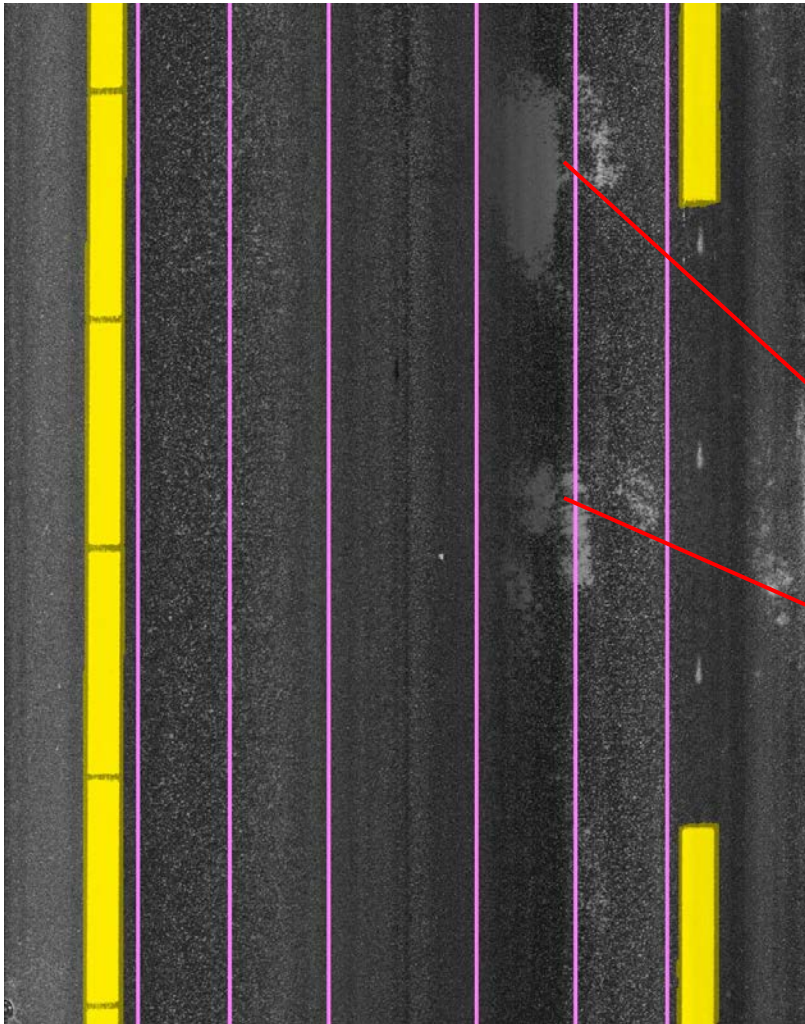


Texture laser MPD Correlation vs LCMS (RPI)



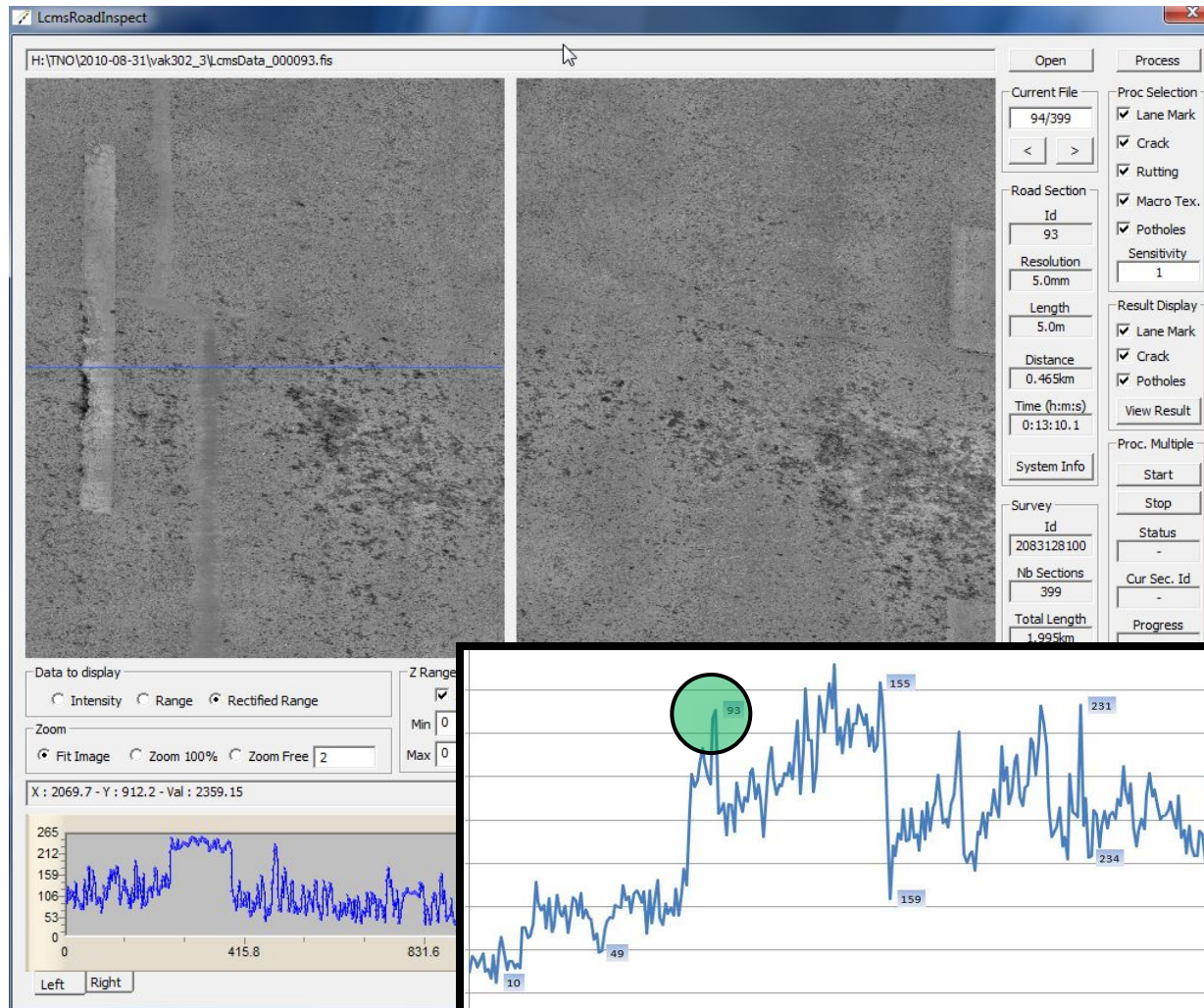
Texture measurements on 3 ALDot test sites (3 runs per site)



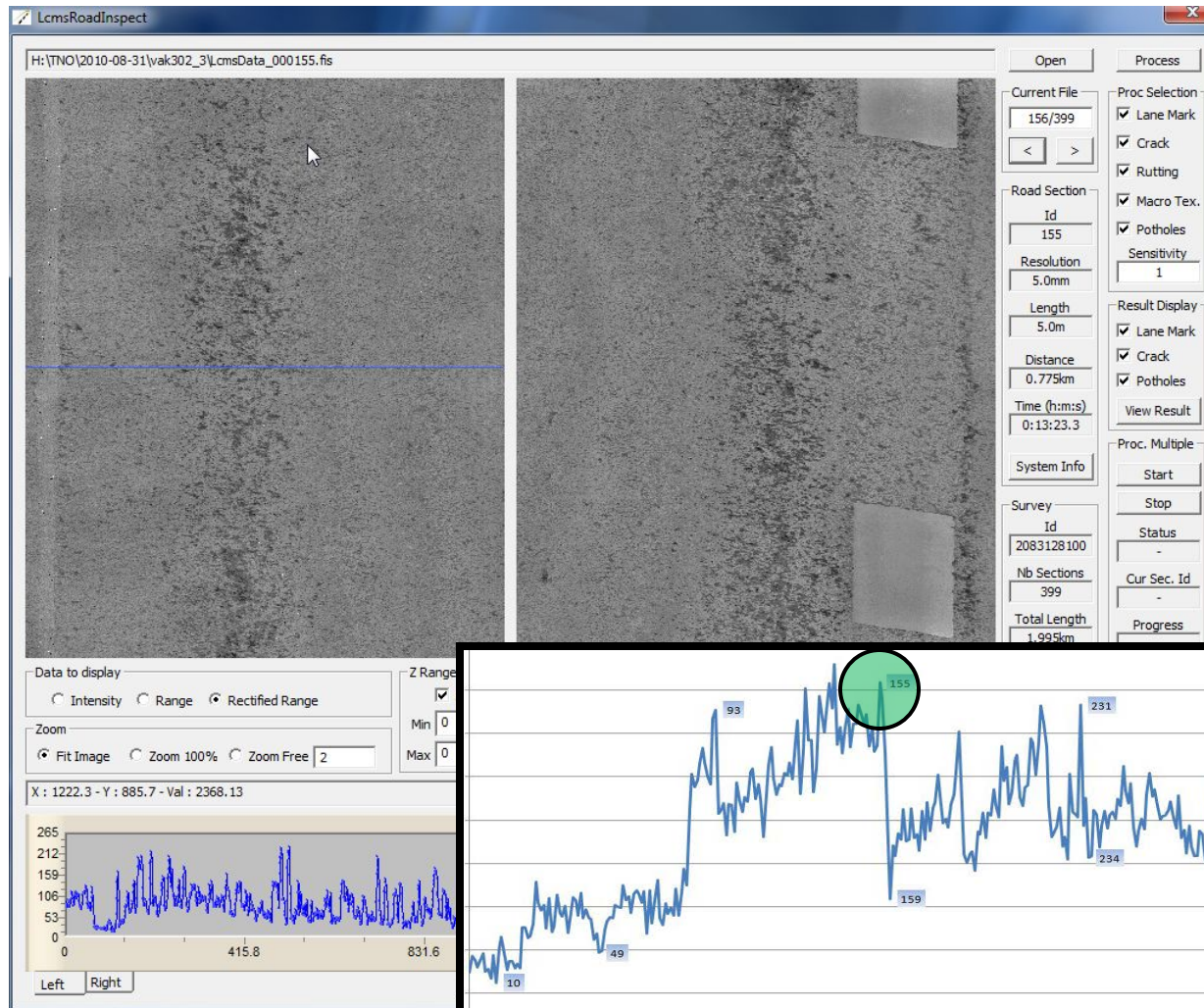


Index (each road section has 19 macro-texture values (1-19 = Section 1, 20-38=section 2, etc...))

Road Section #93 : Raveling patch



Road Section #155 : Raveling patch



Pavemetrics



Concrete Roads

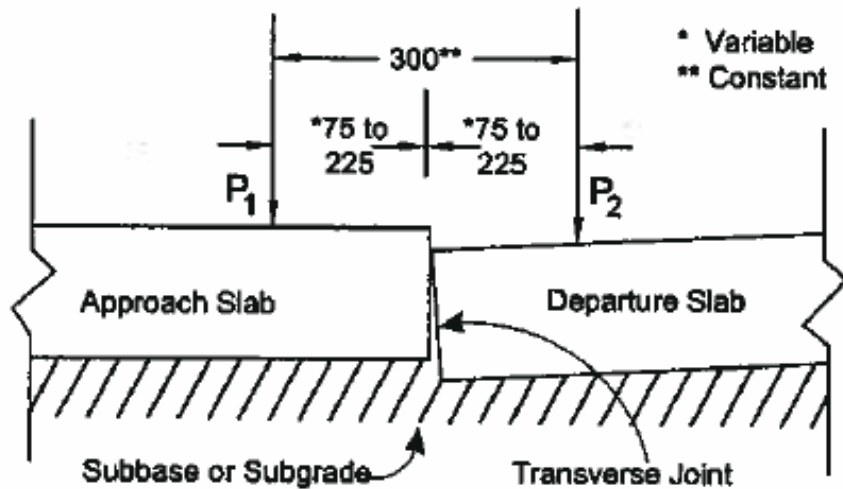


Pavemetrics

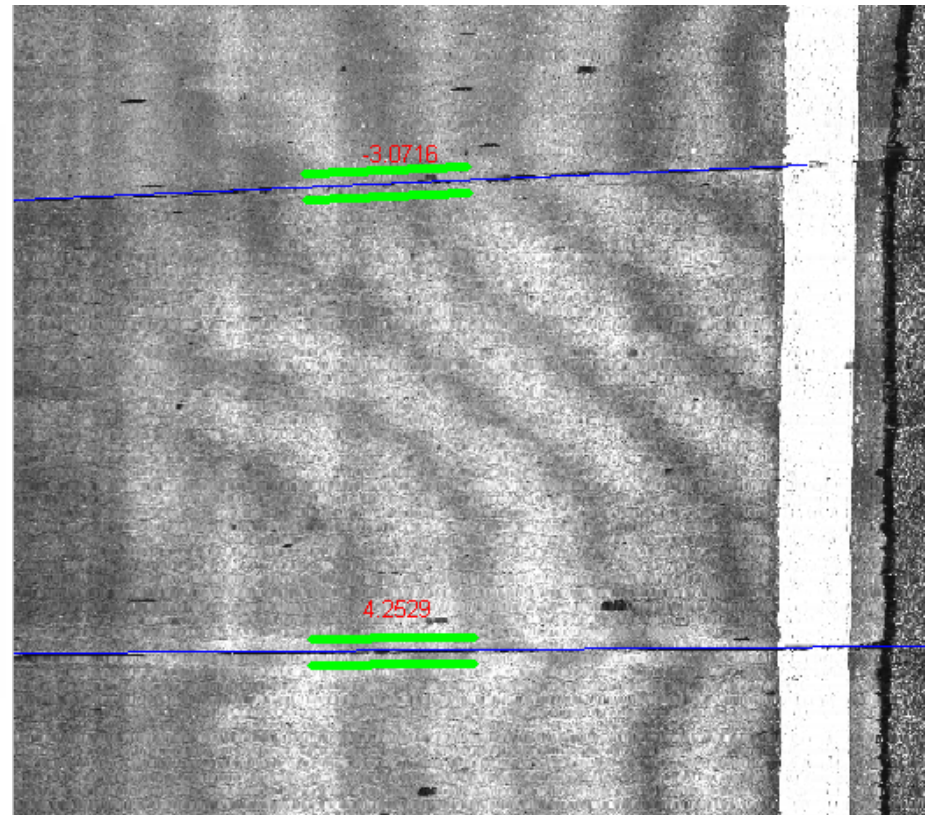
Concrete Roads



Joint detection and faulting

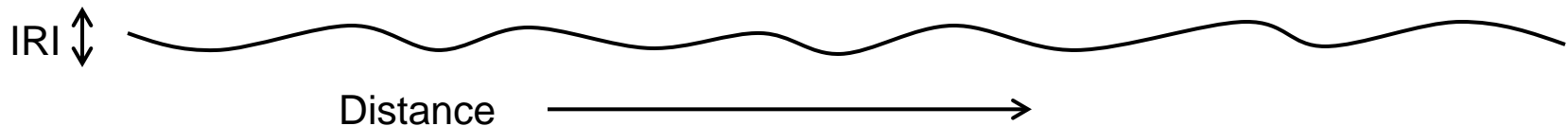
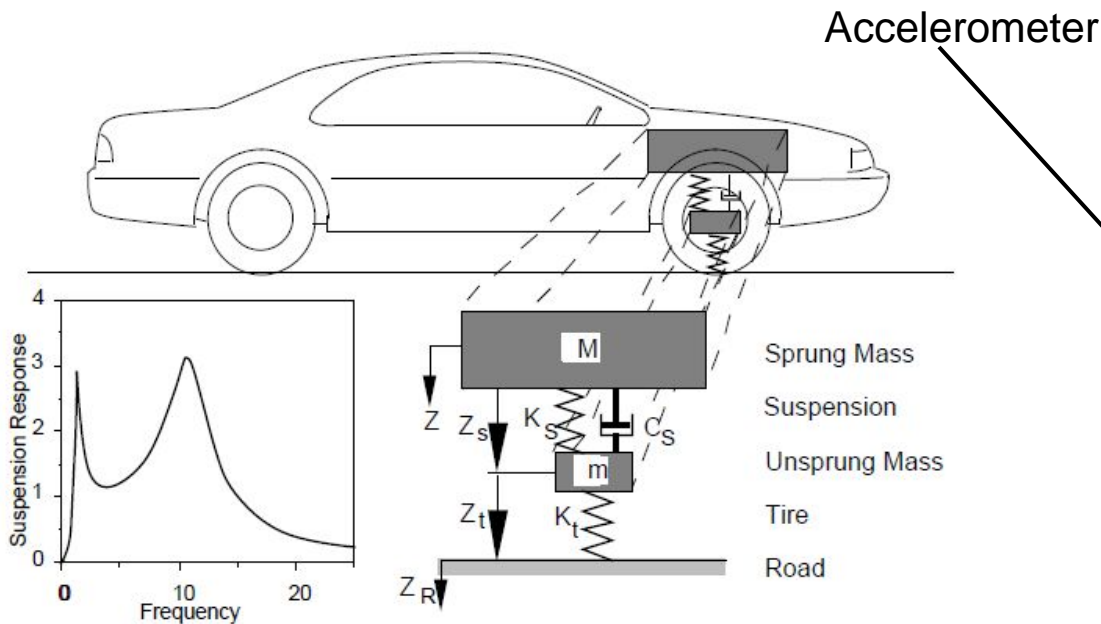


Note: All dimensions shown in millimeters unless otherwise noted.



IRI – Longitudinal profile

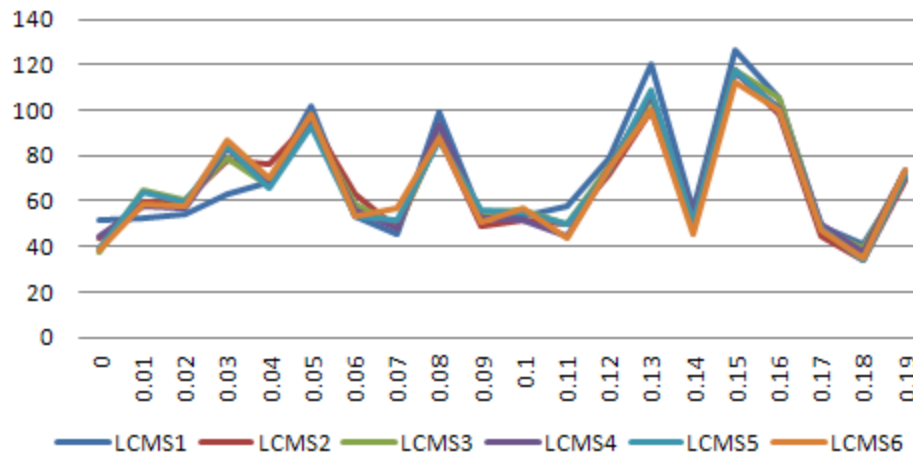
Longitudinal profile and
International Roughness Index (IRI)



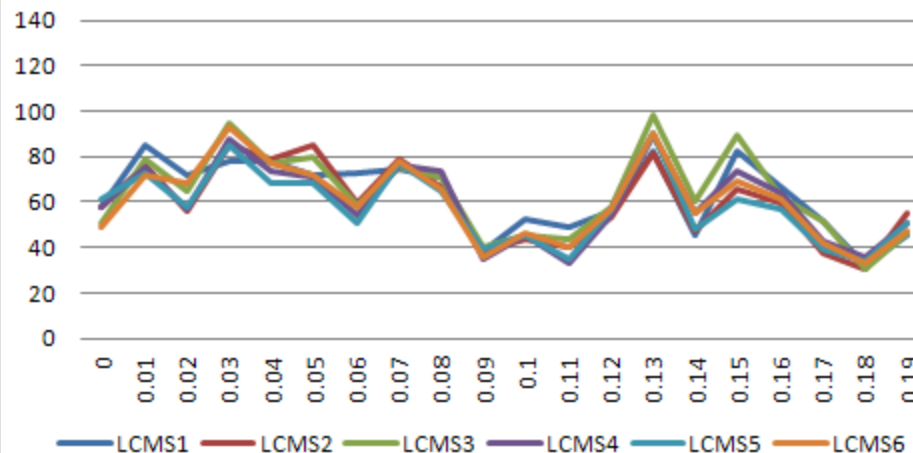
Does it work?

UTAH DOT – Test sites

SLC Test Site 6-15 Left IRI

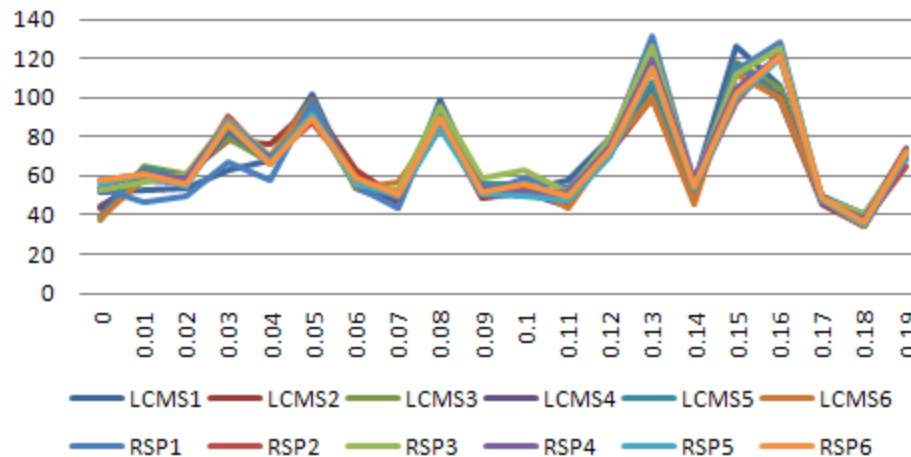


SLC Test Site 6-15 Right IRI

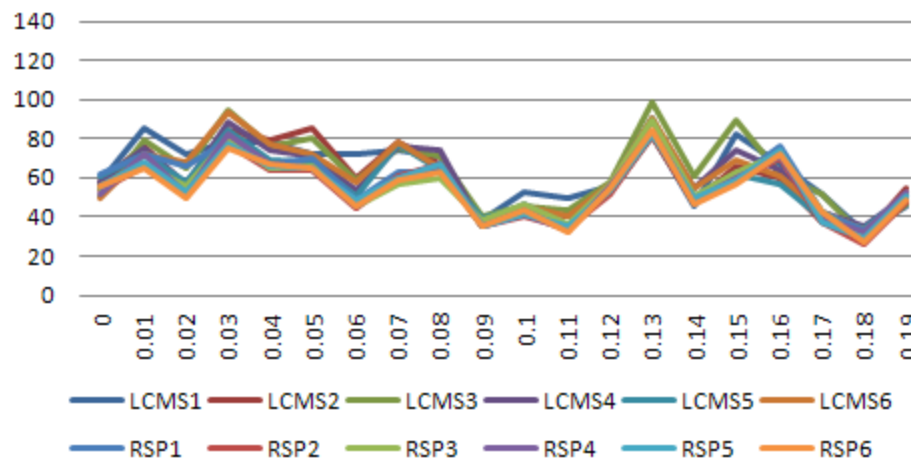


UTAH DOT – Test sites

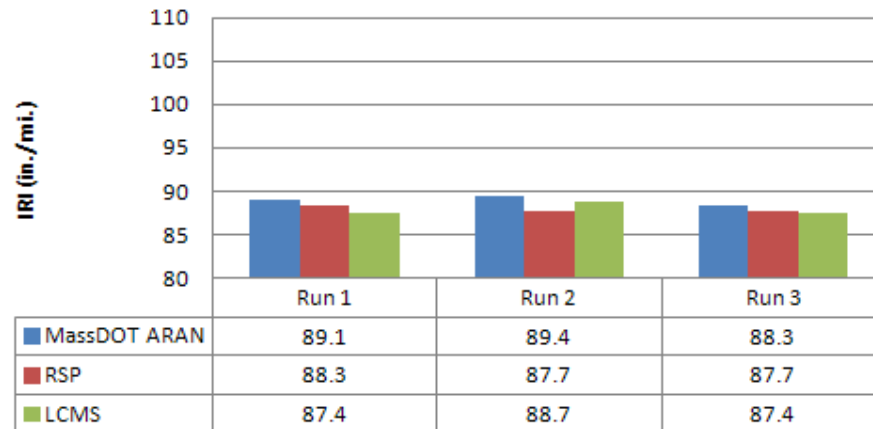
SLC Test Site 6-15 Left IRI



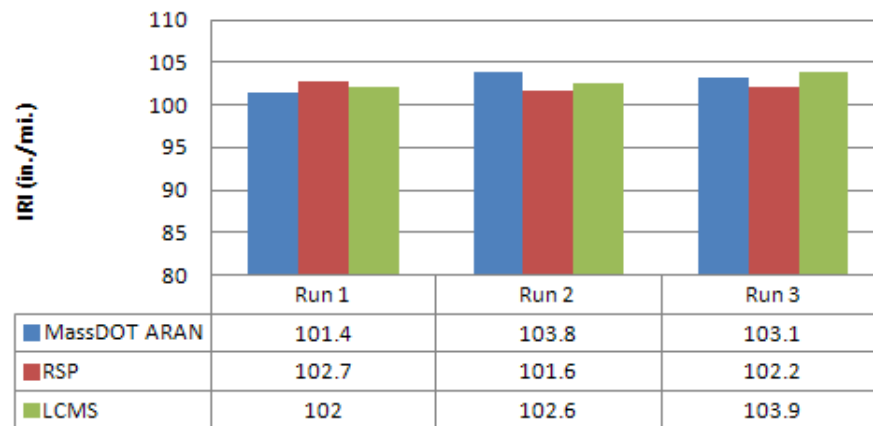
SLC Test Site 6-15 Right IRI



MassDOT IRI Repeatability Runs (Left)



MassDOT IRI Repeatability Runs (Right)



Does it work?

LCMS vs Surpro

IRI values calculated for 4 LCMS runs on a 400m validation test track

Run	IRI Left (m/km)	IRI Right (m/km)
1	1.19	1.64
2	1.16	1.51
3	1.19	1.54
4	1.21	1.55
Mean	1.19	1.56
Standard deviation	0.02	0.06
Surpro	1.21	1.54

- IRI values are stable and close to the values obtained with the reference instrument (Surpro).

LCMS passes Profiler certification in PROVAL

[Untitled] * - ProVAL 3.2

Close Project Add Files Save Report Viewer Editor Analysis PCM Analysis Profile Selection Show Events Use Mileposts Units Display Options Screenshot Help Template Analysis

Profiler Certification

Validation Analyze

Inputs

Maximum Offset (ft) 25

Minimum Repeatability (%) 92

Minimum Accuracy (%) 90

Basis Filter [Butterworth High-pass \(300.00 ft\)](#)

Comparison Filter [Butterworth High-pass \(300.00 ft\)](#)

File	Profiles	Basis	Run	Sample Interval (in)
<input checked="" type="checkbox"/> data_lwp_forward	Left	<input checked="" type="checkbox"/>		11.811020
<input checked="" type="checkbox"/> data_rwp_forward	Right	<input checked="" type="checkbox"/>		11.811020
<input checked="" type="checkbox"/> LcmsLongProfile_3101741479_B0_0m_L390_0mL	Left	<input type="checkbox"/>	1	9.842520
<input checked="" type="checkbox"/> LcmsLongProfile_3101741479_B0_0m_L390_0mR	Right	<input type="checkbox"/>	4	9.842520
<input checked="" type="checkbox"/> LcmsLongProfile_3101741685_B0_0m_L390_0mL	Left	<input type="checkbox"/>	2	9.842520
<input checked="" type="checkbox"/> LcmsLongProfile_3101741685_B0_0m_L390_0mR	Right	<input type="checkbox"/>	5	9.842520
<input checked="" type="checkbox"/> LcmsLongProfile_3101741804_B0_0m_L390_0mL	Left	<input type="checkbox"/>	3	9.842520
<input checked="" type="checkbox"/> LcmsLongProfile_3101741804_B0_0m_L390_0mR	Right	<input type="checkbox"/>	6	9.842520

Repeatability - Left Correlations

Run	2	3	4	5	6
1	98	97	NaN	NaN	NaN
2		96	NaN	NaN	NaN
3			NaN	NaN	NaN
4				NaN	NaN
5					NaN

Repeatability - Right Correlations

Run	2	3	4	5	6
1	NaN	NaN	NaN	NaN	NaN
2		NaN	NaN	NaN	NaN
3			NaN	NaN	NaN
4				97	99
5					97

Repeatability - Left Offsets (ft)

Run	2	3	4	5	6
1	-4.5	-2.9	NaN	NaN	NaN
2		1.2	NaN	NaN	NaN
3			NaN	NaN	NaN
4				NaN	NaN
5					NaN

Repeatability - Right Offsets (ft)

Run	2	3	4	5	6
1	NaN	NaN	NaN	NaN	NaN
2		NaN	NaN	NaN	NaN
3			NaN	NaN	NaN
4				-4.49475	-2.85433
5					1.246719

Accuracy

Run	Left	Right
1	92	95
2	92	97
3	90	95
4		
5		
6		

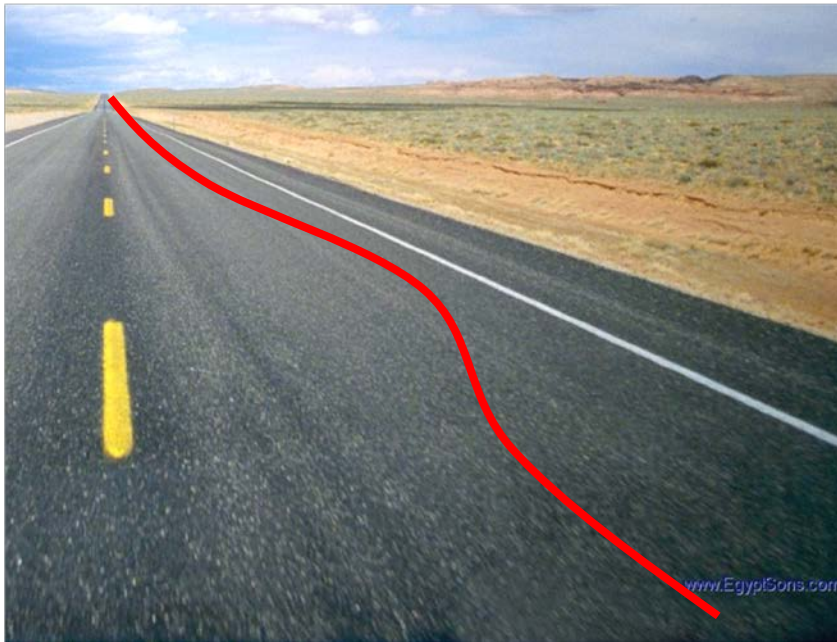
Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	3	3	3	3
% Passing	100.00	100.00	100.00	100.00
Mean	97.00	97.67	91.33	95.67
Minimum	96.00	97.00	90.00	95.00
Maximum	98.00	99.00	92.00	97.00
Standard Deviation	1.0	1.2	1.2	1.2
Grade	Passed	Passed	Passed	Passed

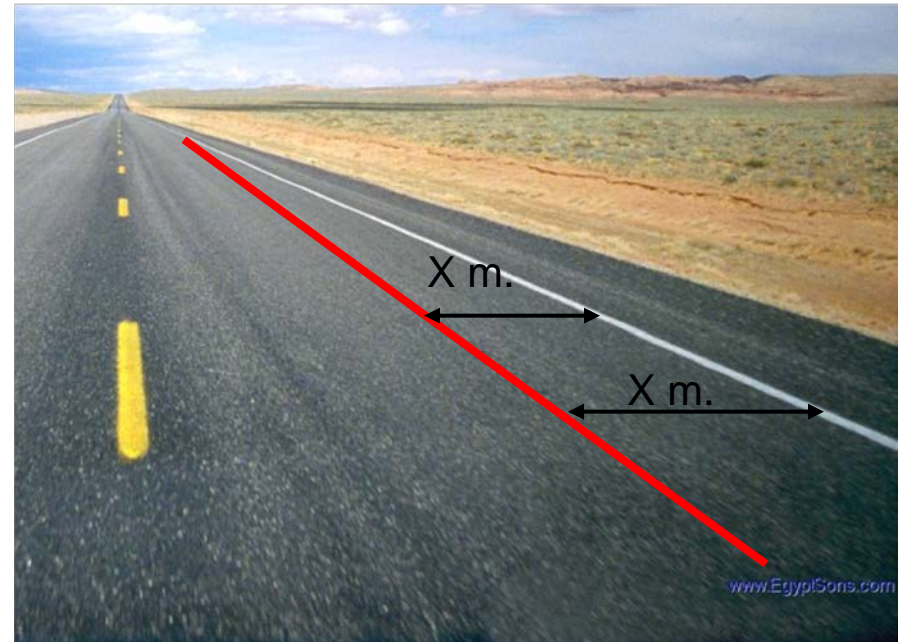
LCMS vs single point IRI



- LANE MARKINGS are used to correct profiles and compensate for driver wander.
- Simplifies certification procedures
- Eliminates the need to certify operators



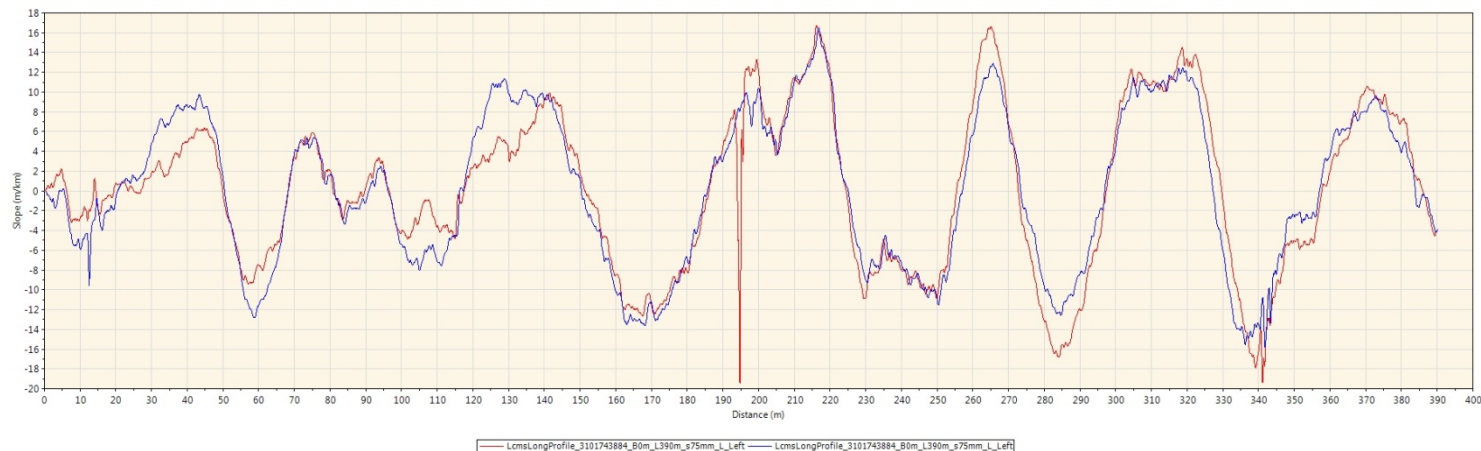
Classic system: Results depend on the trajectory of the vehicle (subject to variation based on driver's ability)



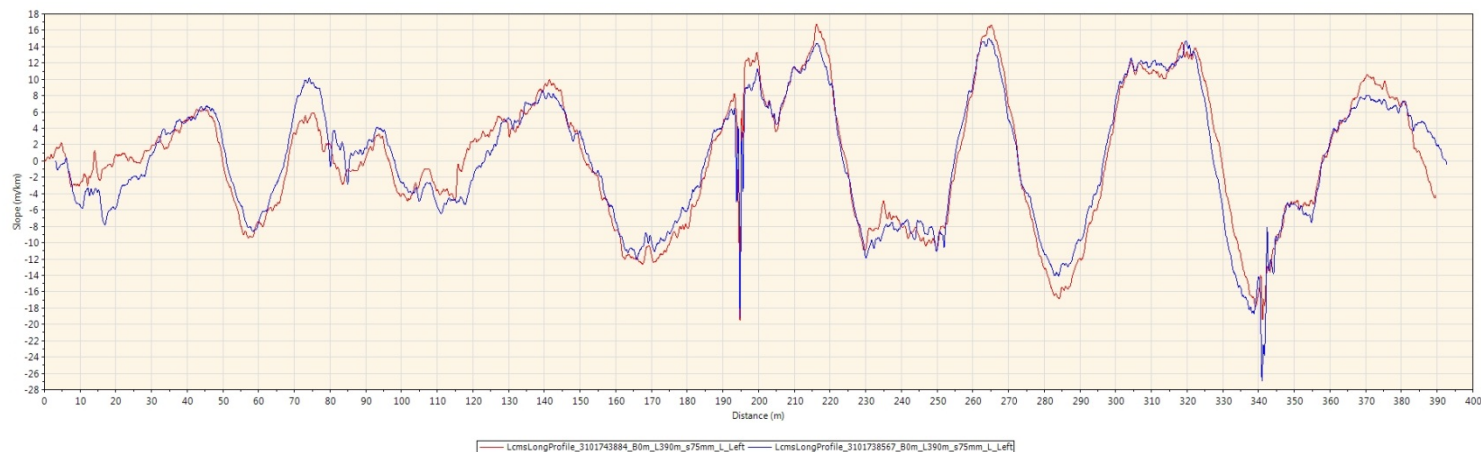
LCMS-IRI system: Erratic trajectory of the vehicle will still result in straight elevation profiles

Results: lane tracking

- Without lane tracking.



- With lane tracking.

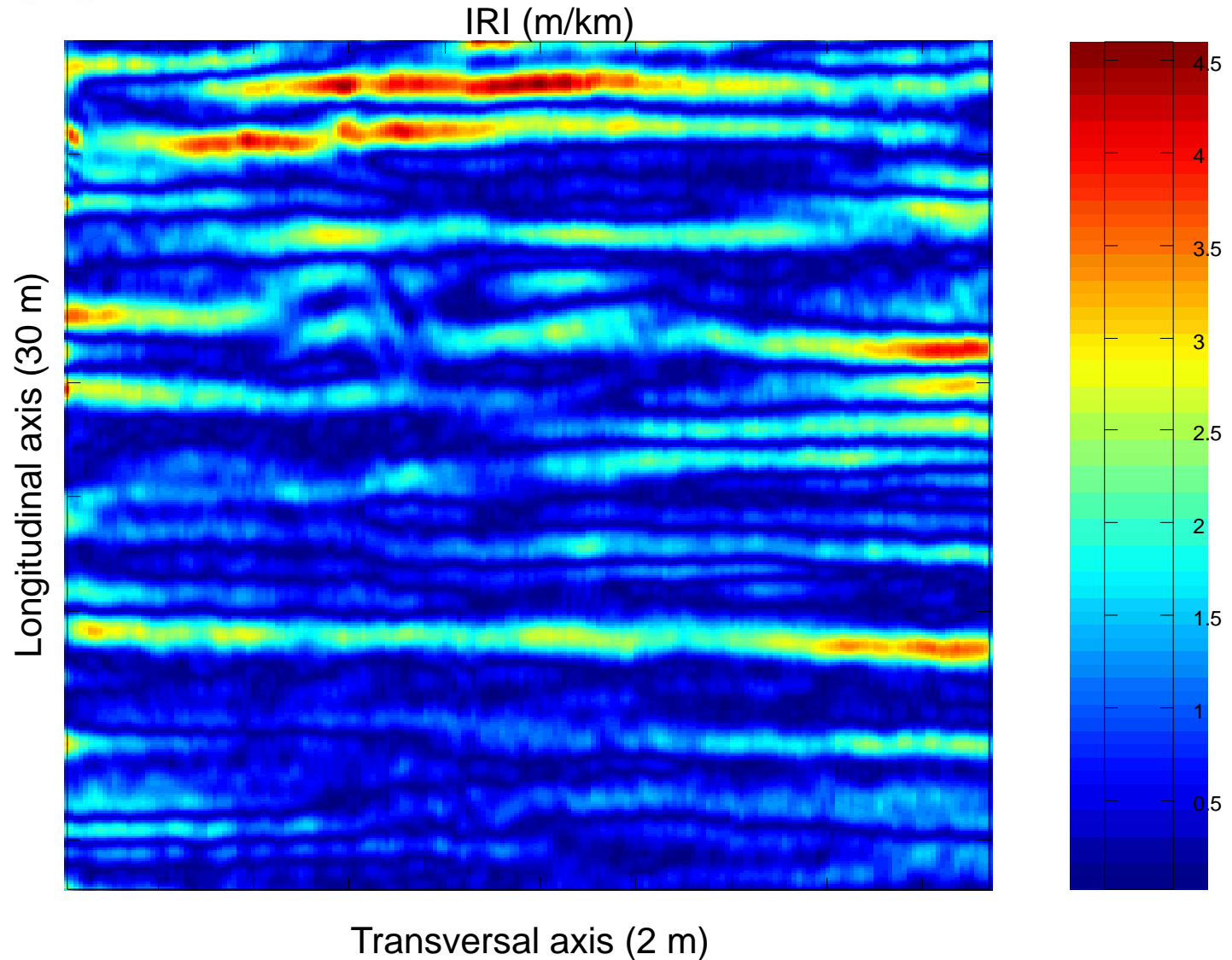


Results: lane tracking

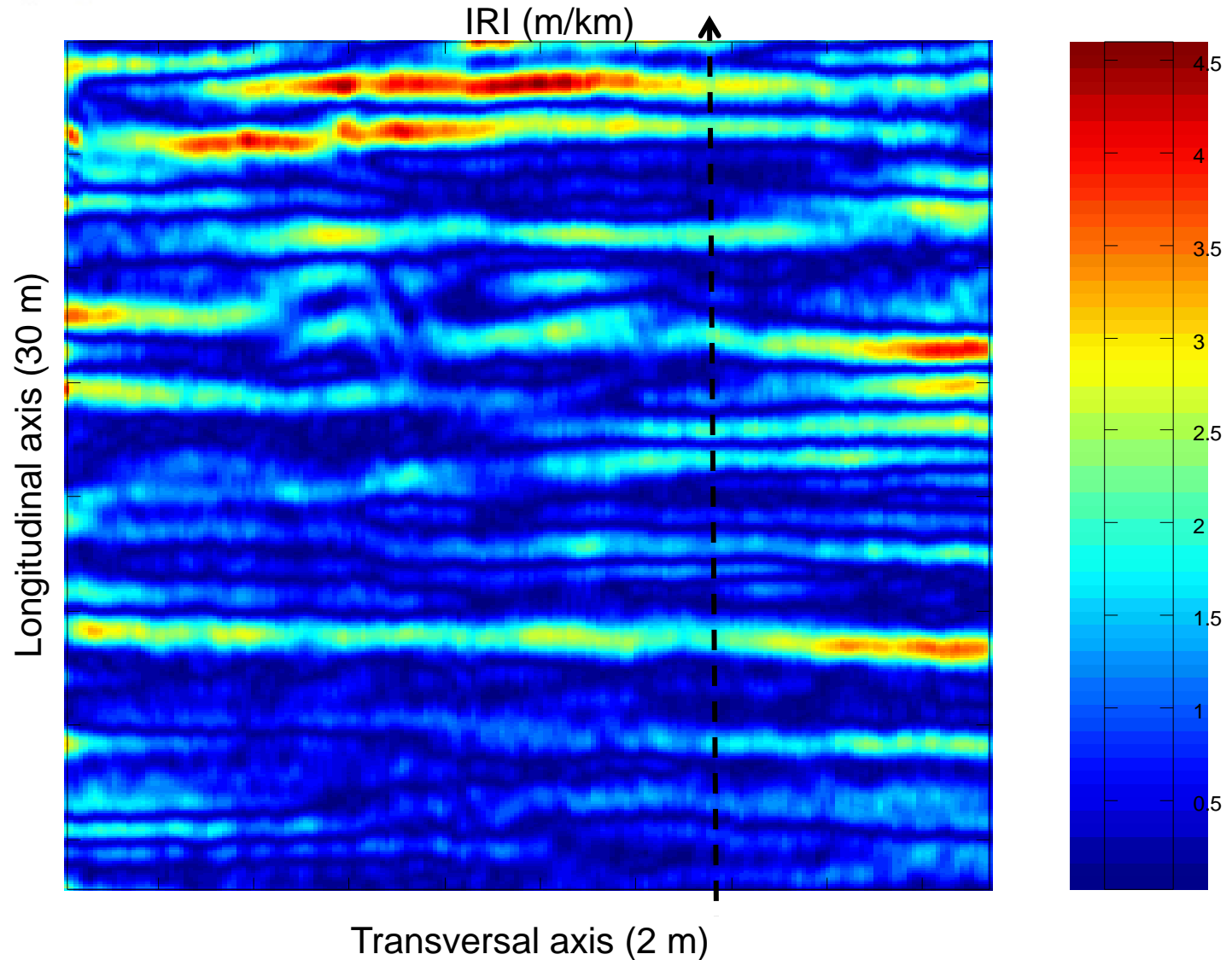
- Driver was asked to zigzag on validation track #1 (400 m).
- Elevation profiles computed with and without lane tracking.

	With lane tracking		No lane tracking	
Run	IRI Left (m/km)	IRI Right (m/km)	IRI Left (m/km)	IRI Right (m/km)
1	1.33	1.50	1.16	1.43
Reference value	1.29	1.47	1.29	1.47
Difference	3.1%	2.0%	10.1%	2.7%

Results: IRI image (2 x 30m)



Results: IRI image (2 x 30m)



Any Questions ?



Thank you.

IMPORTANT NOTICE

This slide pack is intended only for the use of the individual or entity to which it is addressed.

It contains information that is privileged, confidential and exempt from disclosure under applicable law.

If the reader of this message is not the intended recipient, or the employee or agent responsible for delivering the message to the intended recipient, you are notified that any dissemination, distribution or copying of this communication is strictly prohibited.

If you have received this communication in error, please notify security@pavemetrics.com immediately.

Thank you.