

Pavemetrics

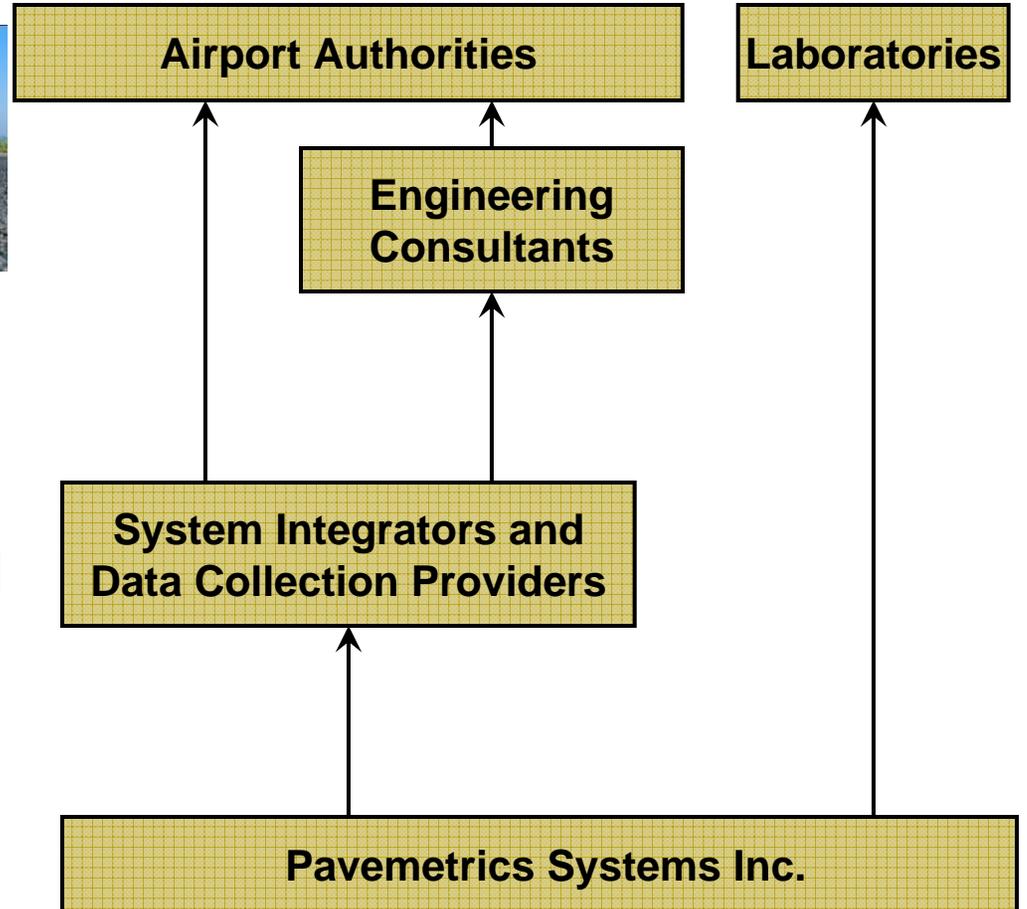
SWIFT 2011 - Laser Crack Measurement System (Barcelona Airport survey)

Vision Technology for Inspection of Transportation Infrastructures

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Countries using Pavemetrics systems for road inspection

- **80% of USA state DOTs**
- **Canada**
- **Australia**
- **New Zealand**
- **England**
- **France**
- **Italy**
- **Switzerland**
- **Denmark**
- **Spain**
- **Netherlands**
- **Korea**
- **China**
- **India**
- **Brazil**
- **South Africa**
- **Mexico**
- **Poland**
- **Koweit**
- **United Arab Emirates**
- **Ireland**
- **Nigeria**
- **Israel**
- **Chile**
- **Sweden**

World wide Users and Integrators

- Dynatest (Denmark)
- Fugro- Roadware (Canada)
- Trimble – Geo 3D (Canada)
- Mandli (USA)
- ICC (USA)
- Vectra (France)
- LCPC (France)
- Colas (France)
- Transport Research Lab (UK)
- WDM (UK)
- Yotta (UK)
- SNC Lavalin (Canada)
- Romdas (New Zealand)
- Euroconsult (Spain)
- AEPO (Spain)
- RWW (Netherlands)
- TipTop (China)
- Faropt (China)
- Ramboll (Sweden)
- Ontario Ministry of Transportation
- KICT (Korea)
- Kohat (Korea)
- Trimble – Geo 3D
- Semic (Mexico)
- Infralab (Switzerland)
- Sineco(Italy)
- Stantec (USA)
- Infrastructure Management Group (Australia)
- ARRB (Australia)
- Saskatchewan Highways (Canada)
- Manitoba Highways (Canada)
- Quebec Ministry of Transport (Canada)
- University Georgia Tech.
- University of Alabama
- University of Manitoba
- Porto Rico DOT
- City of Los Angeles
- City of New York
- City of Tucson
- **Abu Dhabi Airport**

TimeLine and sensors history

R&D project with the MTQ to develop a laser rutting system

Roadware is the first integrator to embrace the LRMS technology

A technological revolution: a prototype of a 3D crack detection system is developed and tested on the road (**LCMS 140Hz**)

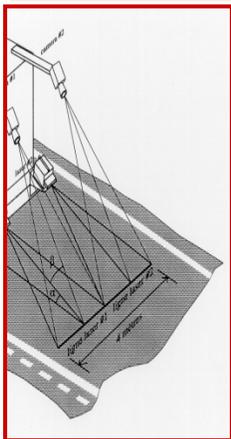
Acquisition rate of the **LCMS** is decupled to 1400Hz. Development of the algorithms.

The MTQ tests the **LCMS** 1400Hz on a survey level: 15 000 km of roads are collected.

The **LCMS** 11,200Hz version is tested in Holland for the detection of ravelling in porous asphalt.



1995...



MTQ operates the first LRSM. It collects 4m transverse profiles at 25Hz



2000



2002



LRMS is now faster : High Speed version now captures 3D profiles at 150Hz



2004



2006



2008



LRIS is introduced. 1mm road images with crack enhancement is now possible!

2009



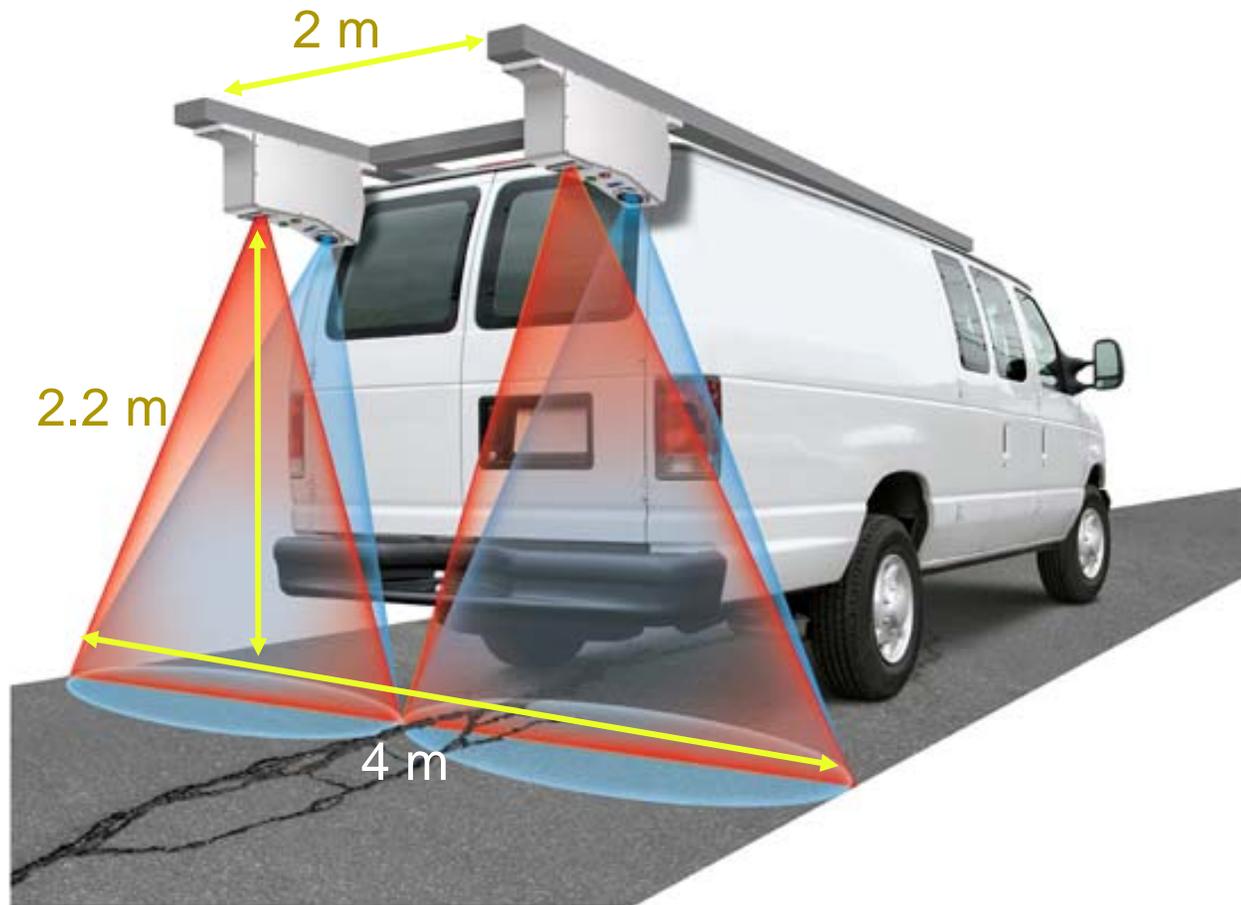
2010



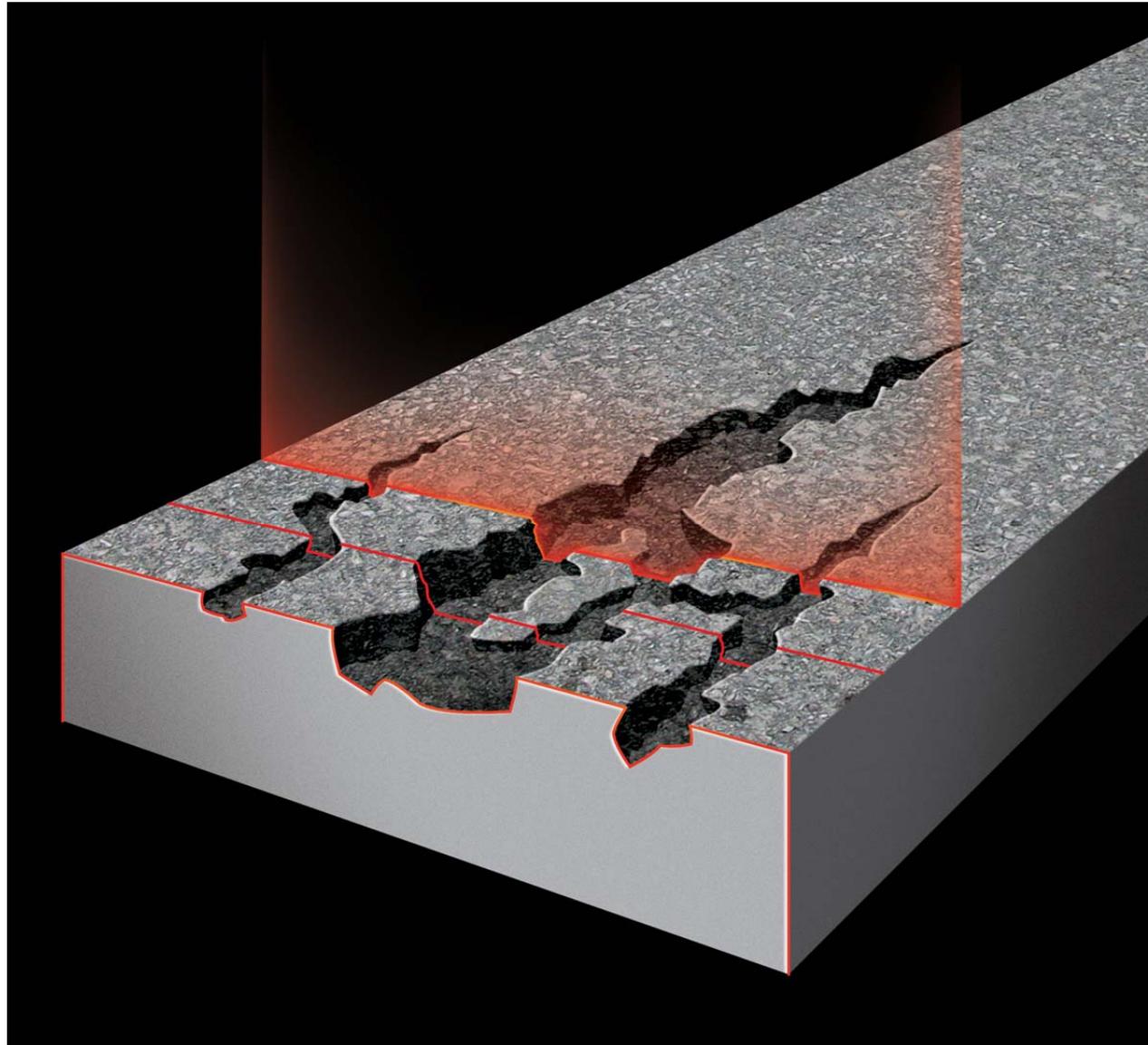
2011



LCMS 5600Hz is commercialized. Let the latest generation our 3D road sensor surprise you!

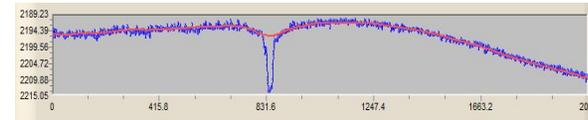
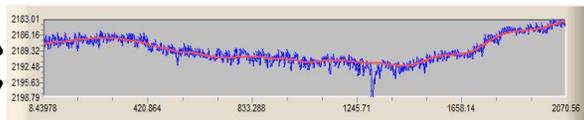


Laser profiling (principle)



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

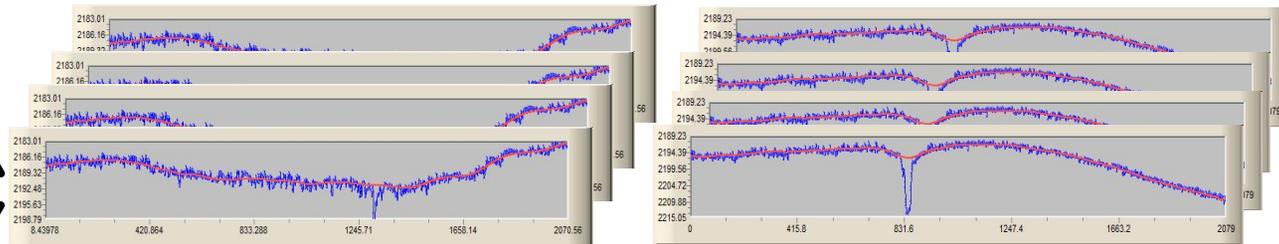
Excellent 3D Accuracy



Good Lateral Resolution

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

Excellent 3D Accuracy



High Acquisition Rate

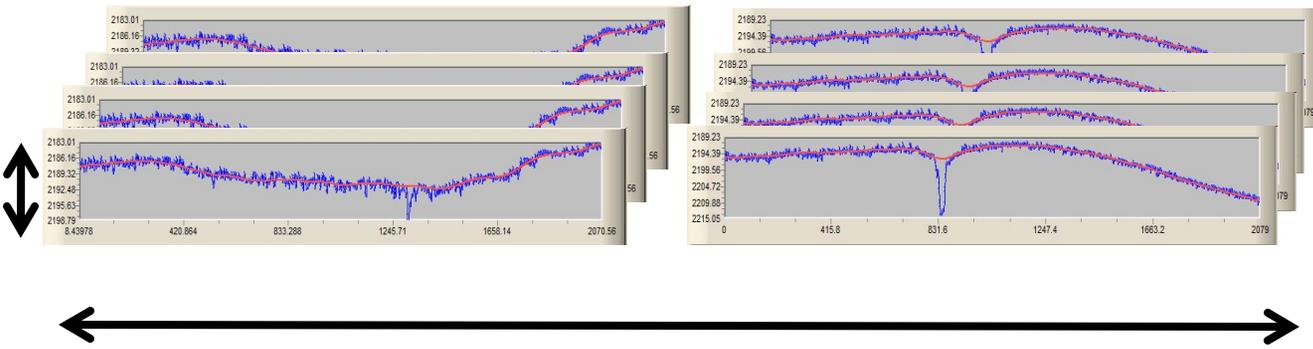


Good Lateral Resolution



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

Excellent 3D Accuracy



High Acquisition Rate

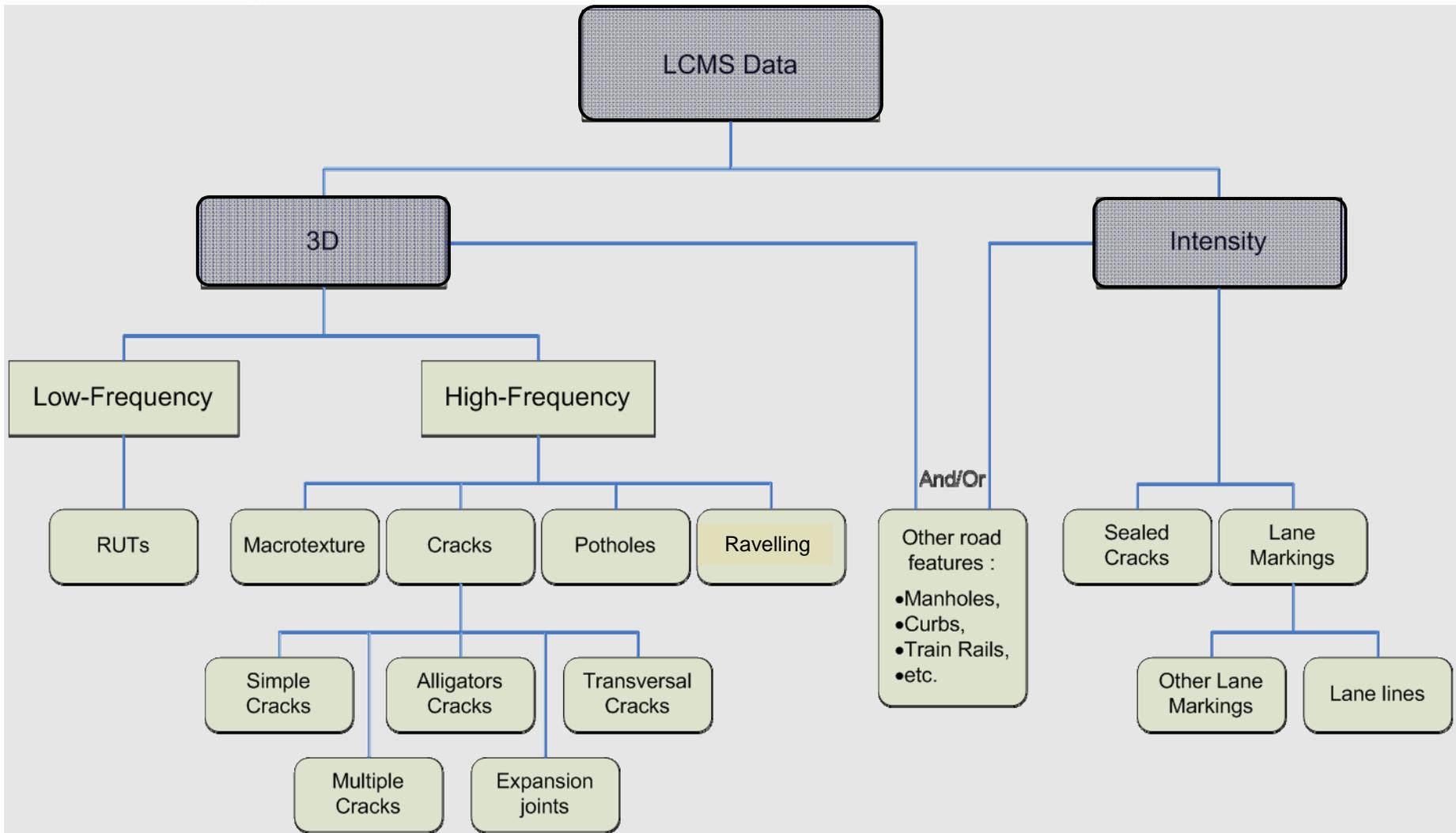
Good Lateral Resolution



LCMS Specifications

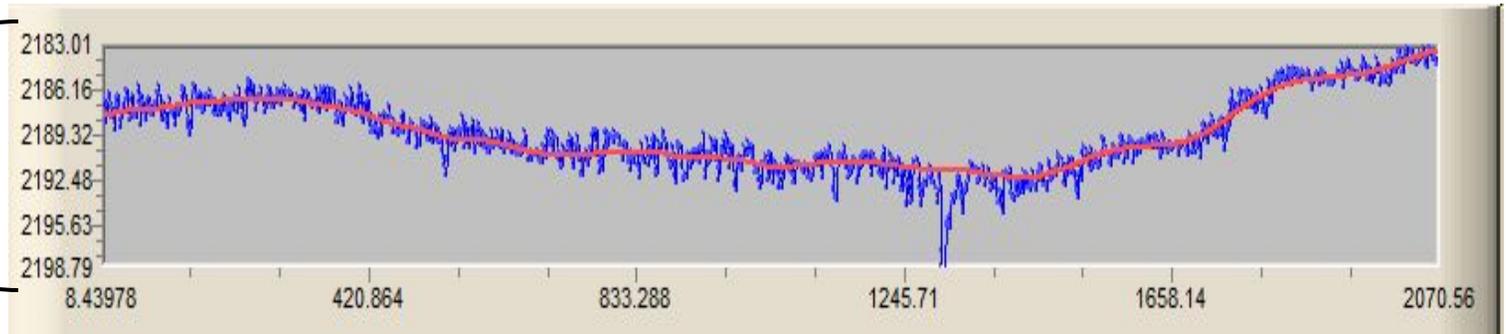
Acquisition Rate	11,200 profiles/s
Range Accuracy	0.5mm
Lateral Resolution	1mm (FOV = 4m)

LCMS Data Processing Tree



Single Road Profile (2 meter)

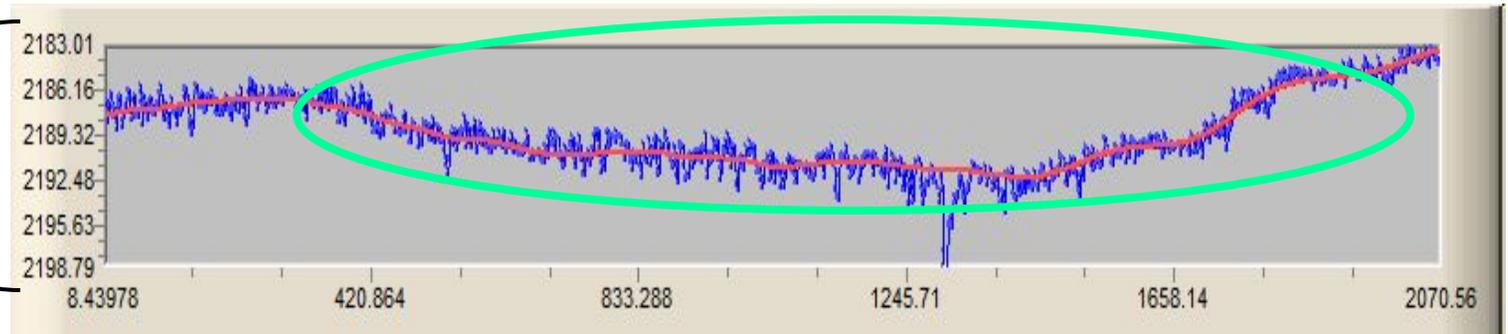
Distance
between Sensor
and ground
(in mm)



Single Road Profile (2 meter)

Rut

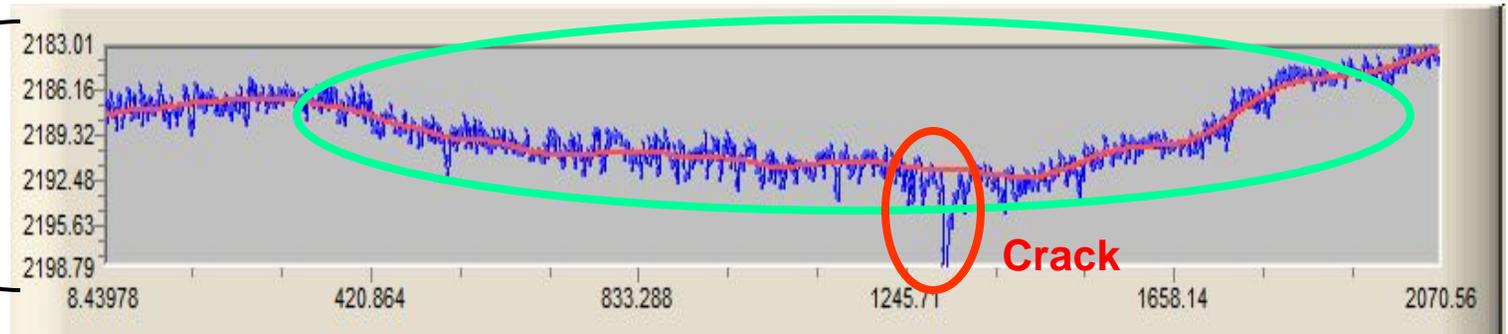
Distance
between Sensor
and ground
(in mm)



Single Road Profile (2 meter)

Rut

Distance
between Sensor
and ground
(in mm)

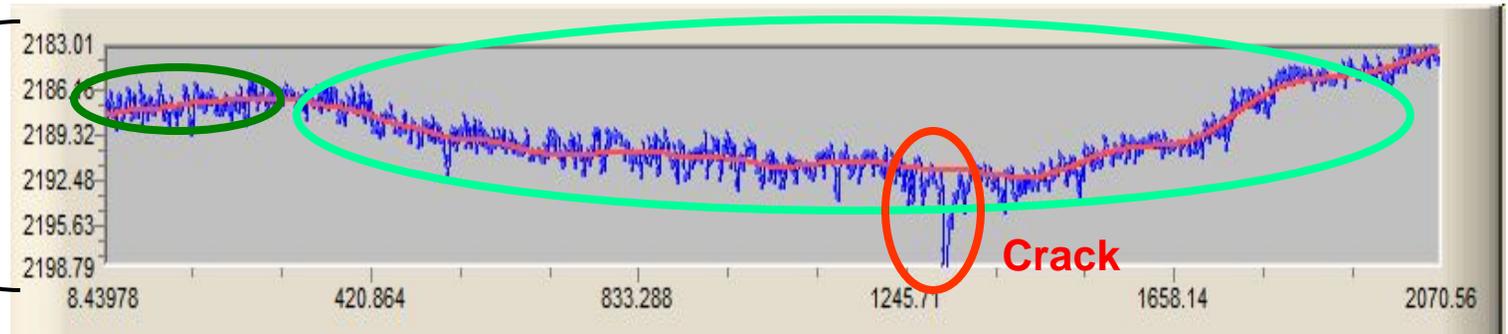


Single Road Profile (2 meter)

Macro-texture

Rut

Distance
between Sensor
and ground
(in mm)

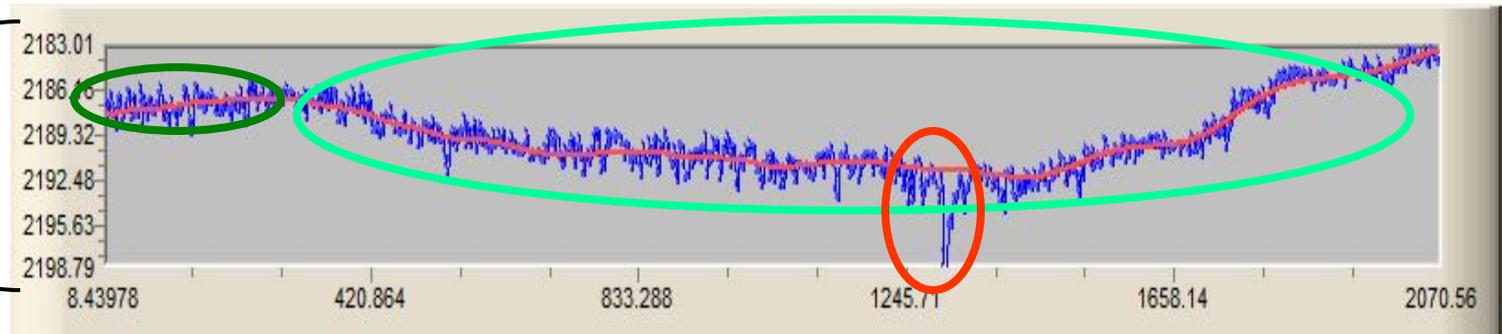


Single Road Profile (2 meter)

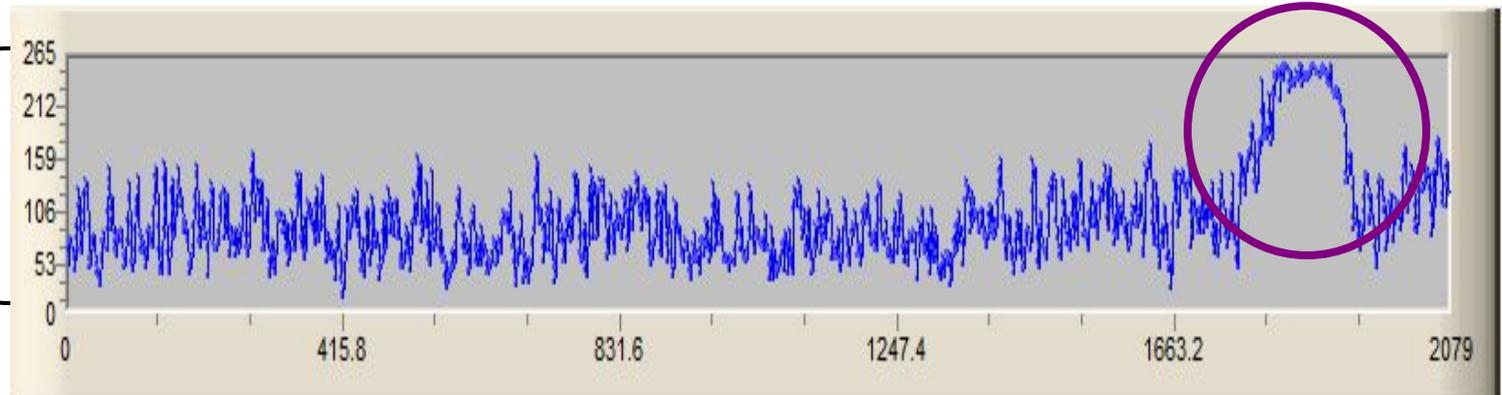
Macro-texture

Rut

Distance
between Sensor
and ground
(in mm)



Laser intensity
(black = 0,
white = 255)



Right Lane
Marking

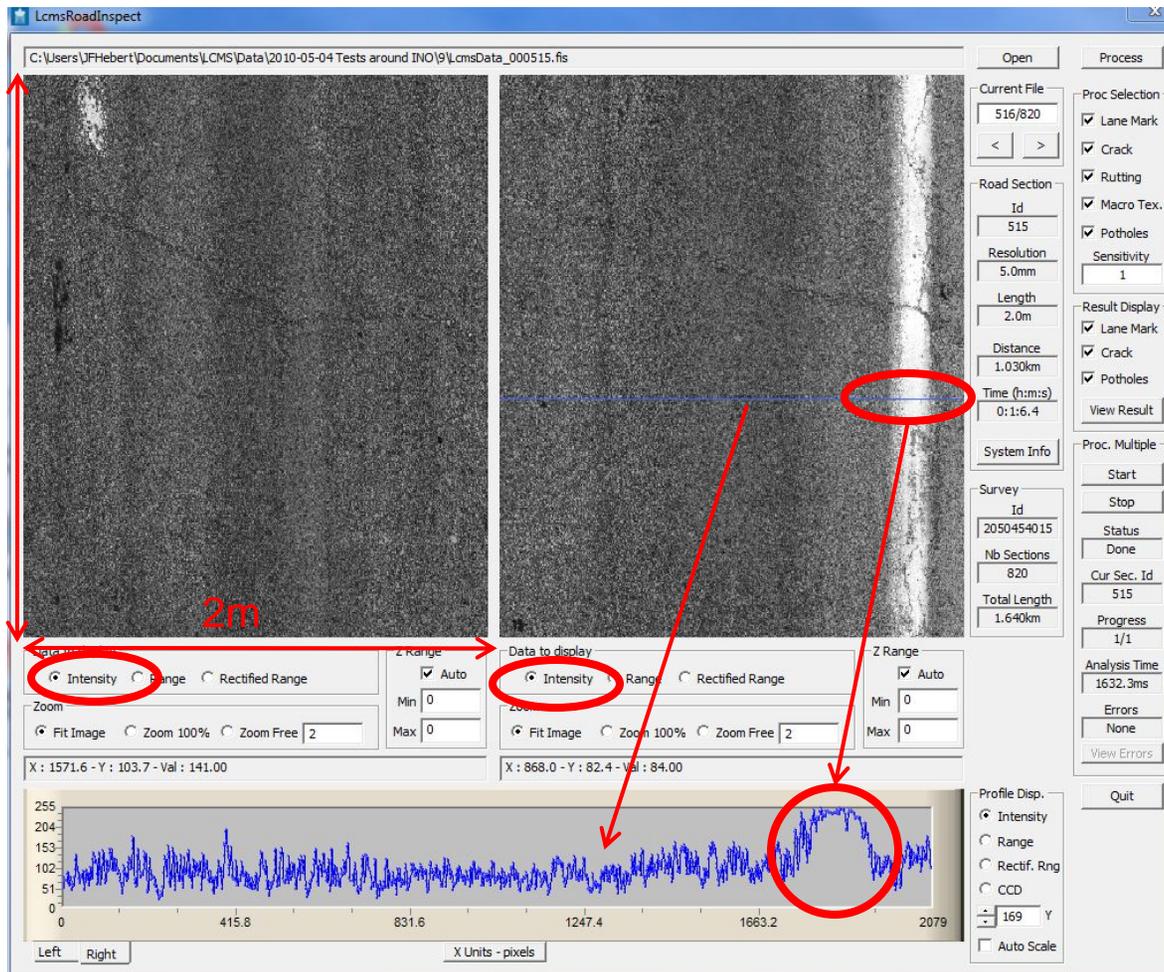
Range + Intensity = 3D !

The screenshot displays the Pavemetrics software interface, which is used for processing and analyzing pavement data. The interface is divided into several panels:

- Top Left Panel:** Shows a 2D grayscale image of a pavement surface with a prominent crack. The 'Data to display' section is set to 'Rectified Range'. The 'Z Range' is set to 'Auto' with a minimum of 2166.27 and a maximum of 2206.27. The 'Zoom' is set to 'Fit Image' with a zoom factor of 2. The coordinates are X: 1432.9 - Y: 82.4 - Val: 2189.01.
- Top Right Panel:** Shows a 3D perspective view of the same pavement surface, where the crack is clearly visible as a deep depression. The 'Data to display' section is set to 'Intensity'. The 'Z Range' is set to 'Auto' with a minimum of 0 and a maximum of 0. The 'Zoom' is set to 'Zoom Free' with a zoom factor of 2. The coordinates are X: 1663.2 - Y: 169.
- Central Panel:** Contains various control options:
 - Open / Process:** Buttons for file operations.
 - Current File:** 516/820.
 - Road Section:** Id: 515, Resolution: 5.0mm, Length: 2.0m, Distance: 1.030km, Time (h:m:s): 0:1:6.4.
 - Proc Selection:** Checkboxes for Lane Mark, Crack, Rutting, Macro Tex., and Potholes. Sensitivity is set to 1.
 - Result Display:** Checkboxes for Lane Mark, Crack, and Potholes. A 'View Result' button is present.
 - Proc. Multiple:** Start, Stop, Status (Done), Cur Sec. Id (515), Progress (1/1), Analysis Time (1632.3ms), Errors (None), and View Errors buttons.
 - Quit:** A button to exit the application.
- Bottom Panels:** Both the left and right panels feature a 'Profile Disp.' section with radio buttons for Intensity, Range, Rectif. Rng, and CCD. The left panel has a '193 Y' scale, while the right panel has a '169 Y' scale. Both include a small graph showing the profile data across the X-axis.

Road Section: Intensity Data

400 road profiles captured every 5 mm = 2m road section



Definition:
A Road Section is a set of profiles merged together.

Can be viewed in:

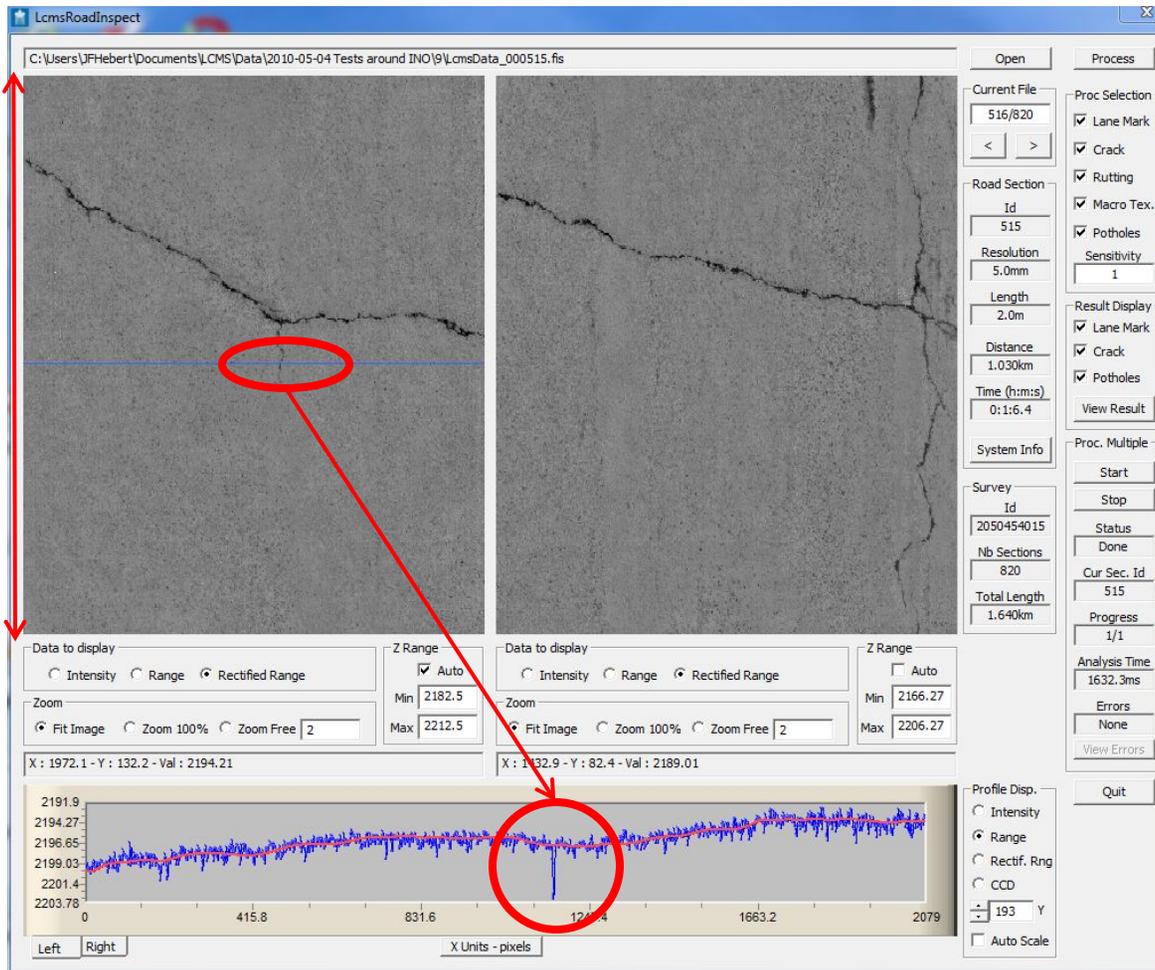
- Intensity
- Range

Intensity:

- Depends on the reflective properties of the surface.

Road Section: Range Data

400 road profiles captured every 5 mm = 2m road section



Range:

- Gives the distance to the ground.

Mapping to 2D Viewer:

- Darker points = further away
- Gray points = on-surface
- White points = closer

Cracks:

- Notch in the profile
- Appear darker in range image

Crack detection example

Current File: 516/820

Road Section Id: 515

Resolution: 5.0mm

Length: 2.0m

Distance: 1.030km

Time (h:m:s): 0:1:6.4

Proc Selection:

- Lane Mark
- Crack
- Rutting
- Macro Tex.
- Potholes

Sensitivity: 0.95

Result Display:

- Lane Mark
- Crack
- Potholes

View Result

Proc. Multiple:

Start

Stop

Status

Done

Cur Sec. Id: 515

Progress: 1/1

Analysis Time: 991.4ms

Errors: None

View Errors

Quit

Item Info:

Key Id: 0454015

Sections: 820

Total Length: 640km

File Disp.:

Intensity Range

Rectif. Rng

CCD: 200 Y

Auto Scale

Intensity Range

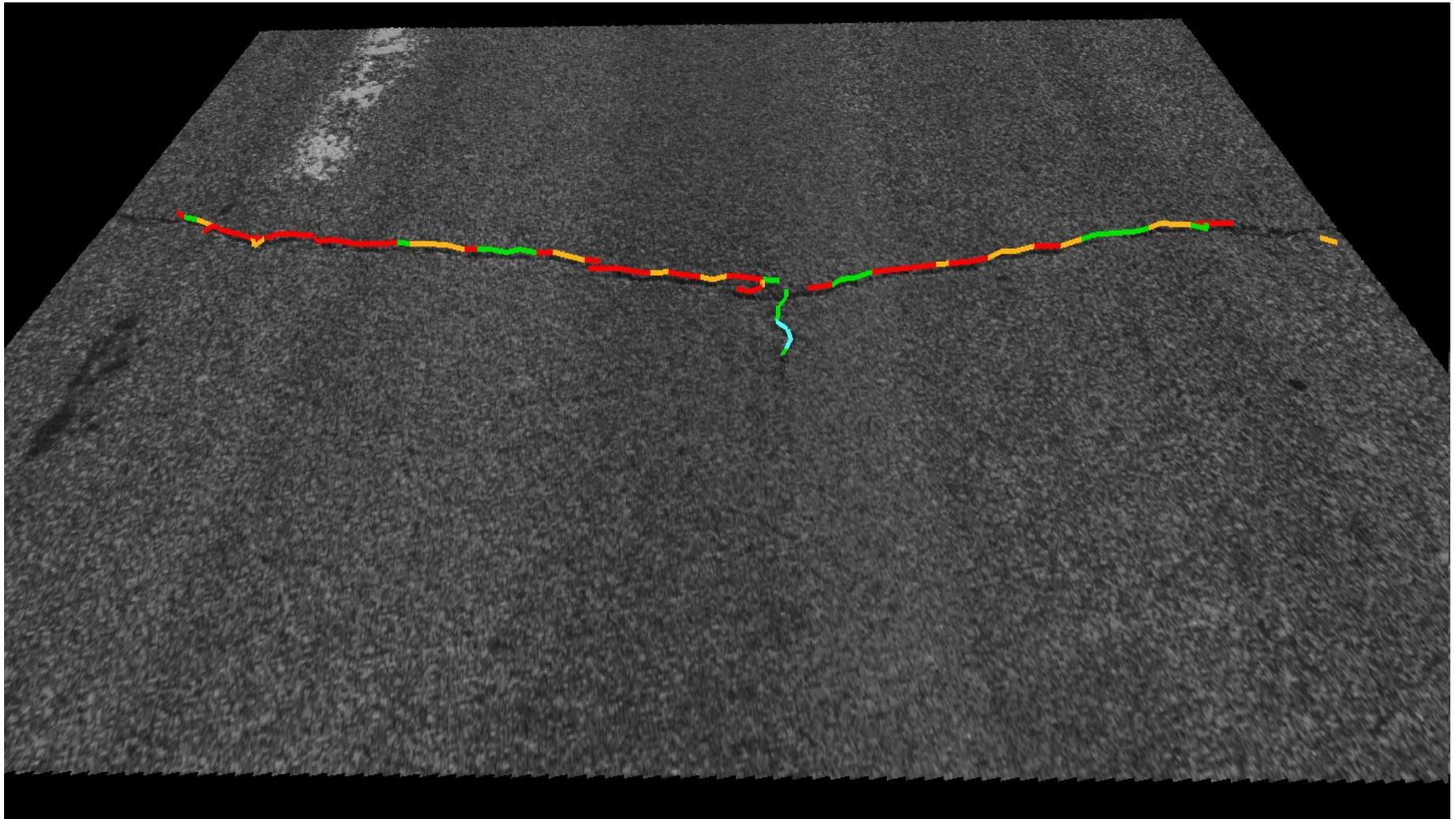
2-3 points = 2-3mm

Range + Intensity = 3D !



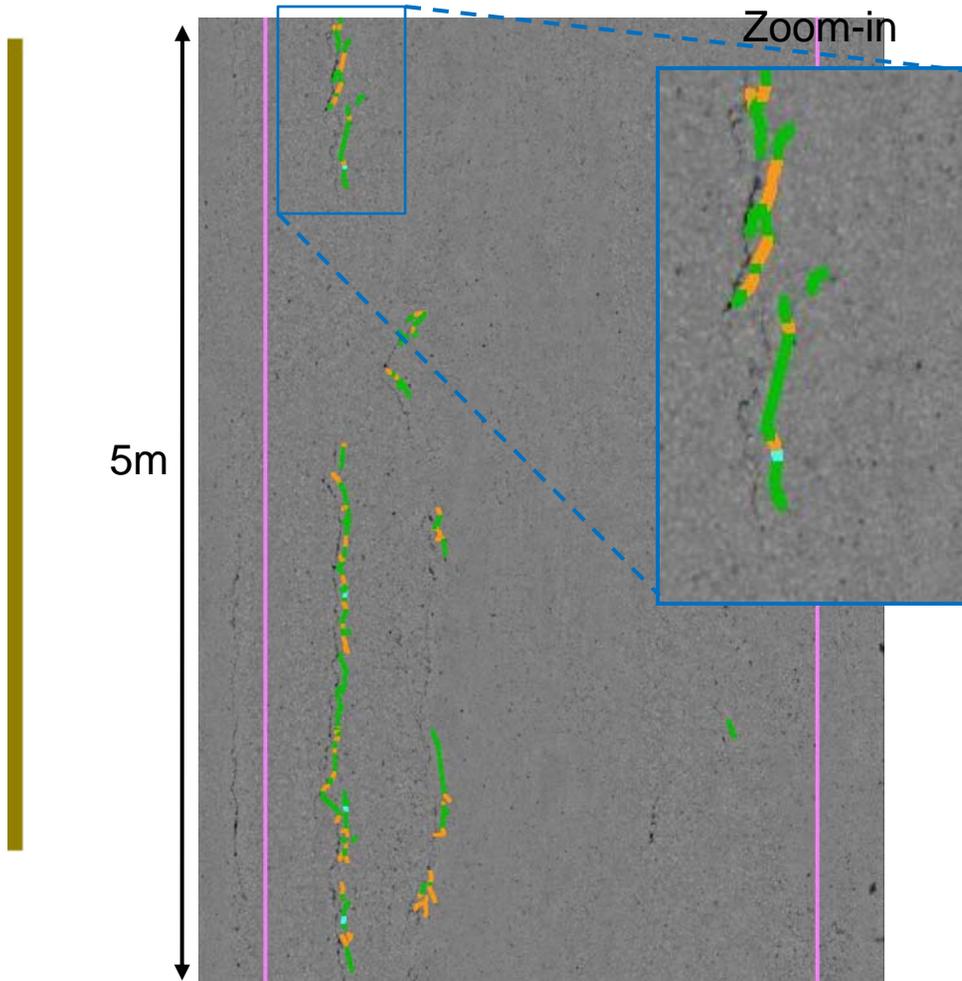


Automatic Crack Detection Length, Type, Severity

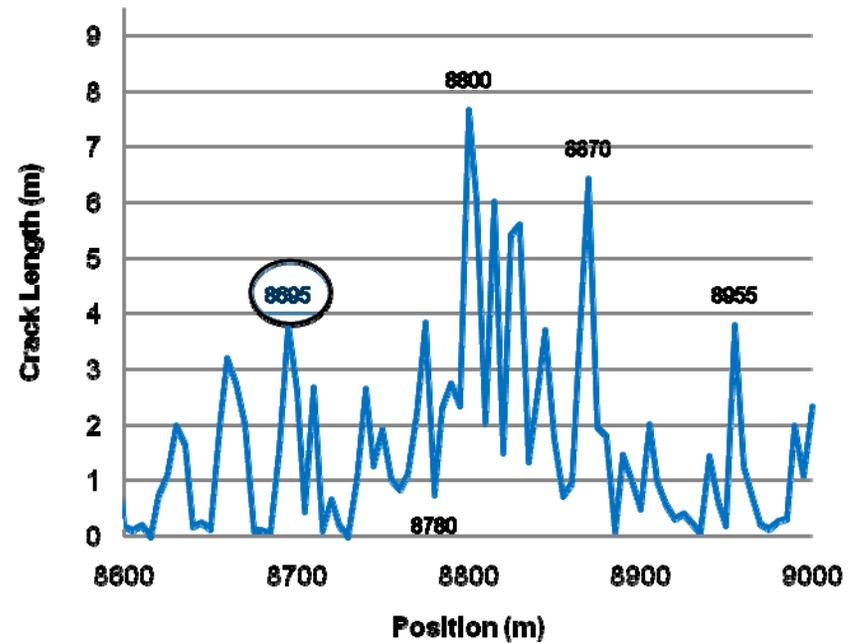


Crack example: 8695m

(Osaka data file 1739.jpg)

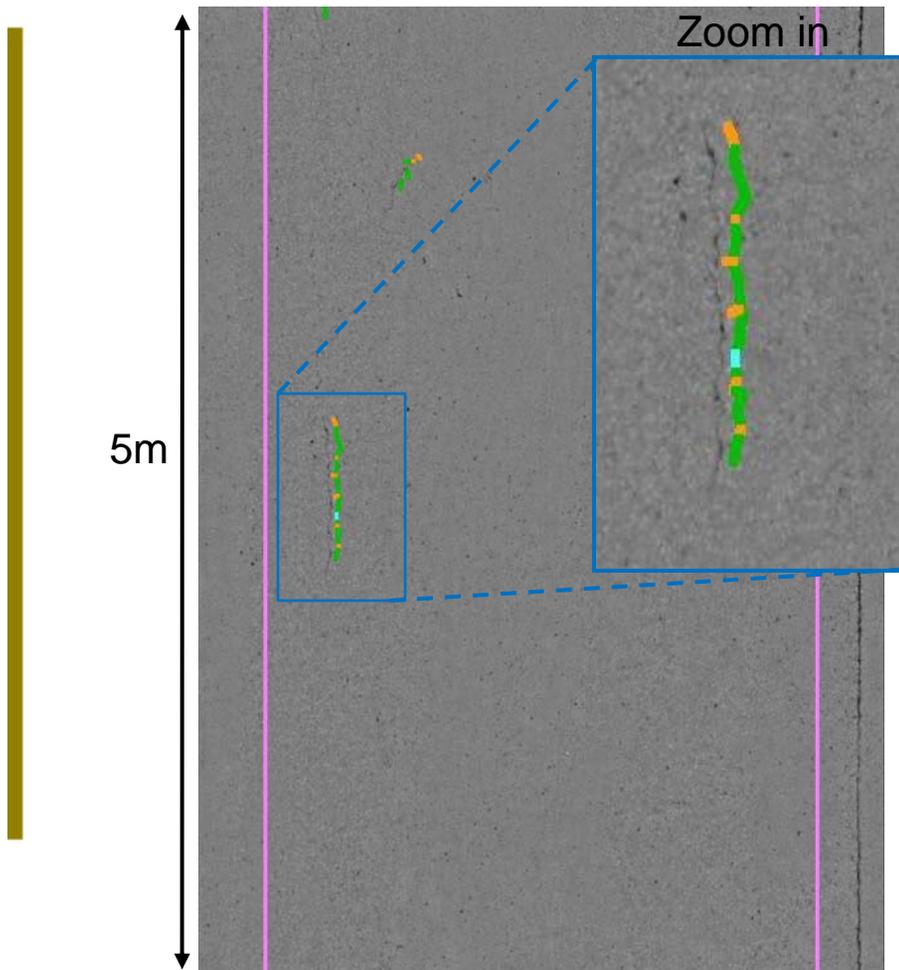


Crack length (per road section) between 8.6km and 9.0 km for Osaka Data
(files 1720.jpg-1800.jpg)

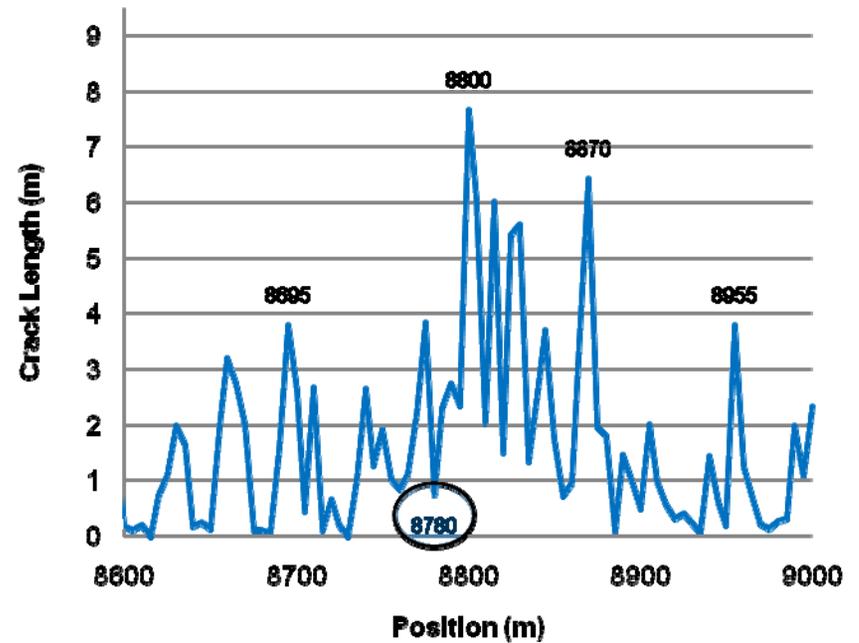


Crack example: 8780m

(Osaka data file 1756.jpg)

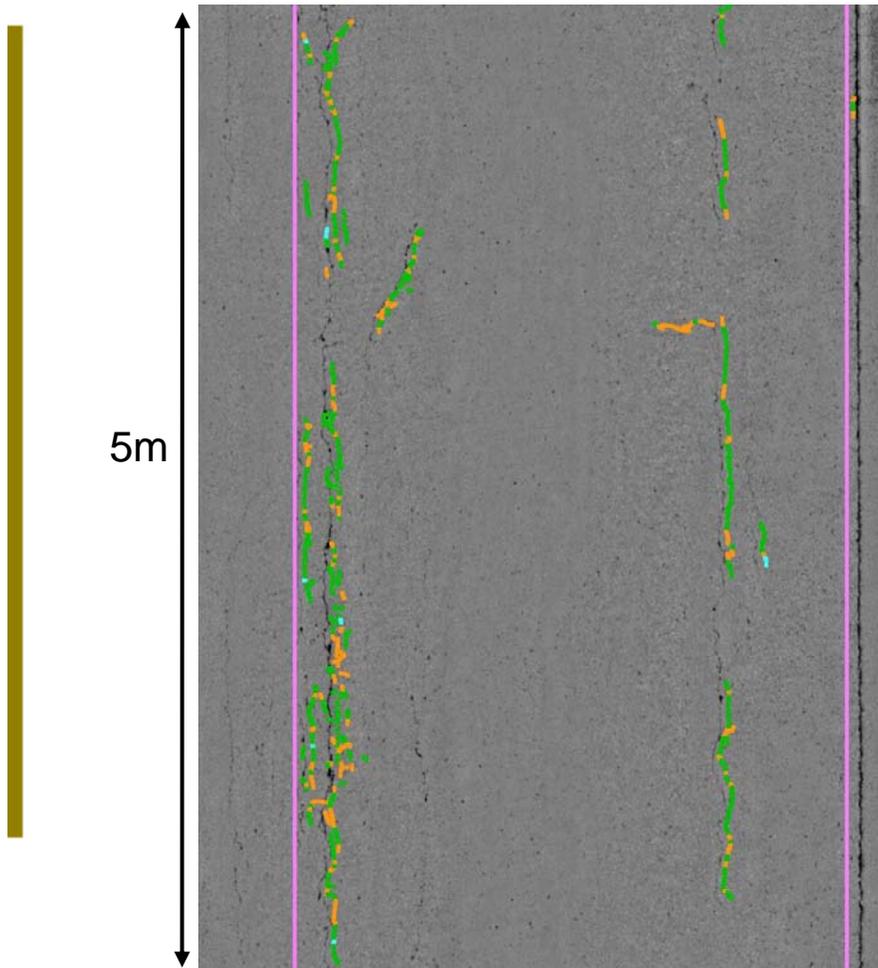


Crack length (per road section) between 8.6km and 9.0 km for Osaka Data
(files 1720.jpg-1800.jpg)

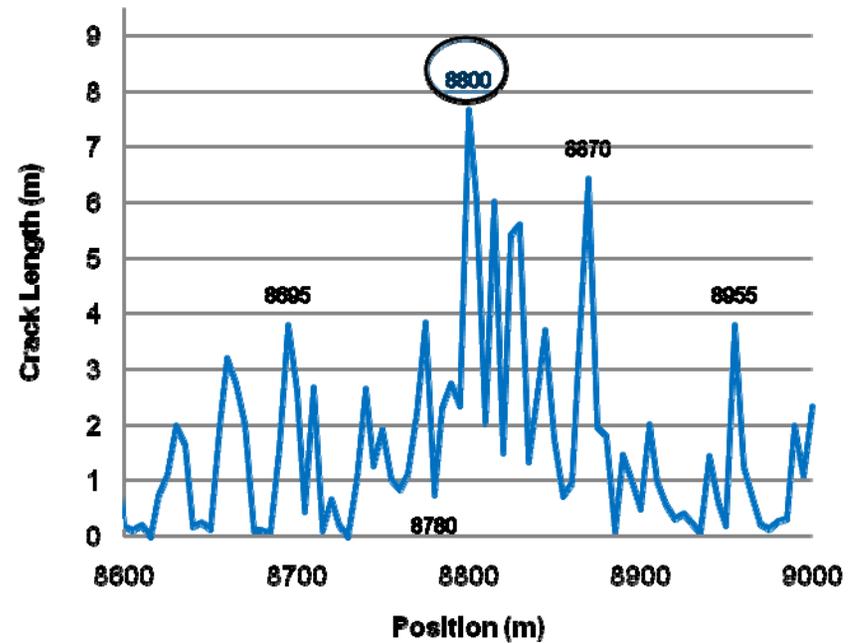


Crack example: 8800m

(Osaka data file 1760.jpg)



Crack length (per road section) between 8.6km and 9.0 km for Osaka Data
(files 1720.jpg-1800.jpg)



Pavemetrics

MTQ - Network level testing Summer 2008



MTQ – LCMS Network level validation tests

- 990 000 images of 10m sections were visually evaluated
 - In all 9 900 km of road network was evaluated
 - Visual results were separated into 4 classes:

Good

OK

Bad

NA = other

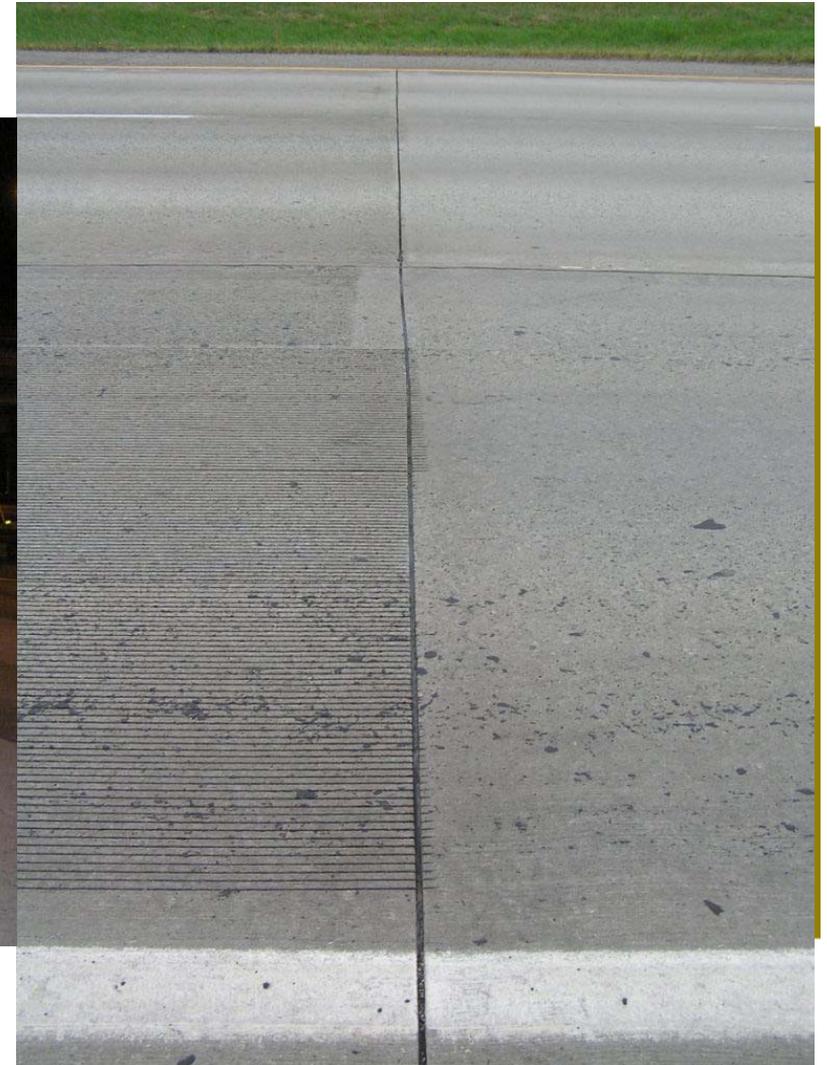
Results – network level visual evaluation

District #	Total (sections)	Results (manual classification)							
		Number of images (10m sections)				Proportion (%)			
		Good	Average	Bad	NA	Good	Average	Bad	NA
84	35288	34144	310	144	690	96,8	0,9	0,4	2,0
85	4243	4101	53	51	38	96,7	1,2	1,2	0,9
86	147903	144040	516	1520	1827	97,4	0,3	1,0	1,2
87	149926	138453	1170	5728	4575	92,3	0,8	3,8	3,1
88	189097	183010	1064	2002	3021	96,8	0,6	1,1	1,6
89	125003	121835	442	2015	711	97,5	0,4	1,6	0,6
90	123653	116930	2980	2434	1309	94,6	2,4	2,0	1,1
91 & 92	215513	213142	197	956	1218	98,9	0,1	0,4	0,6
Total	990626	955655	6732	14850	13389	96,5	0,7	1,5	1,4

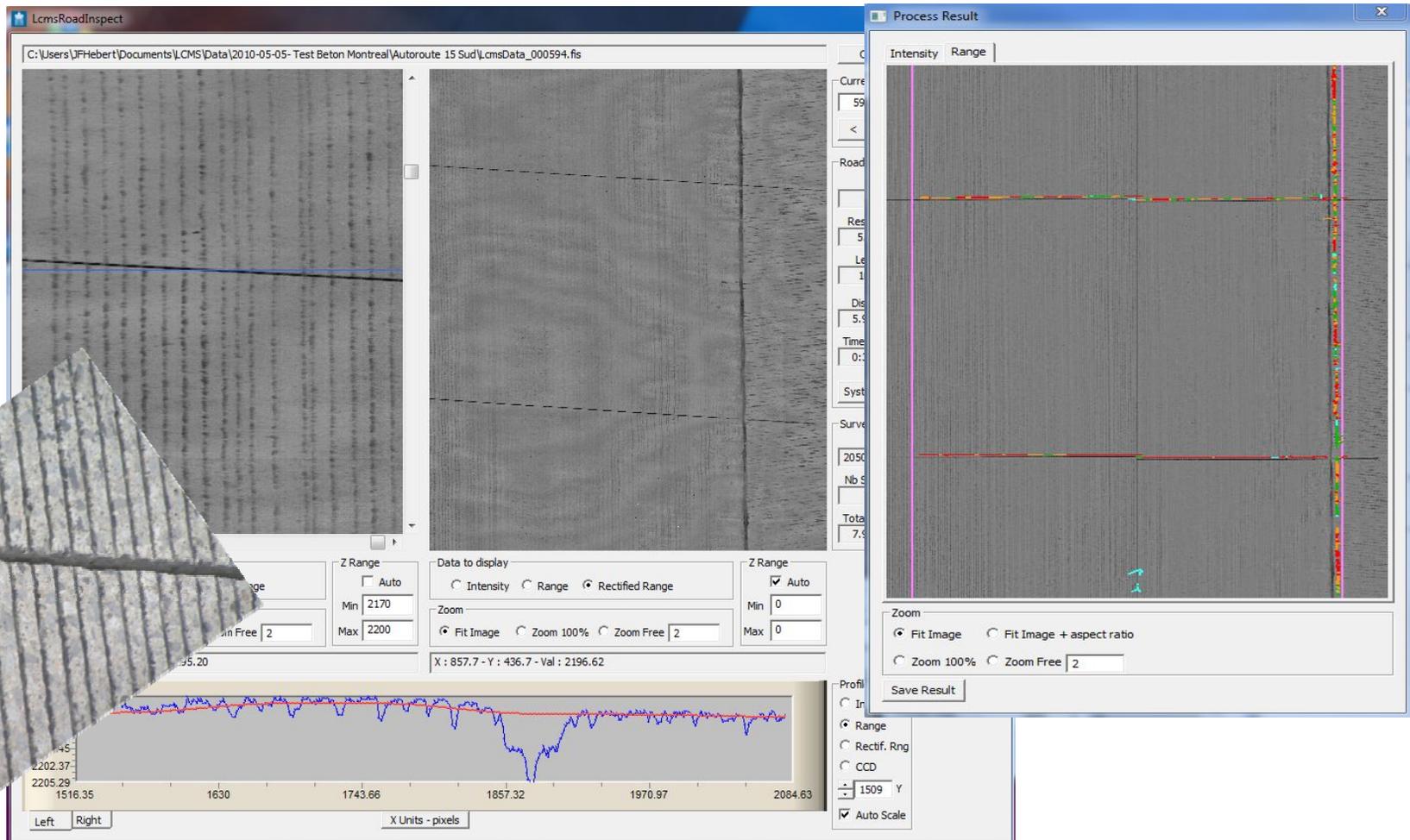
Pavemetrics



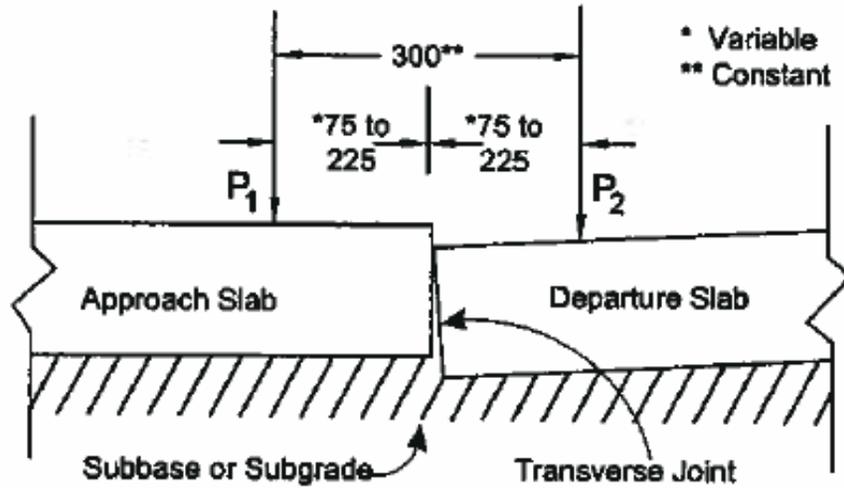
Concrete roads



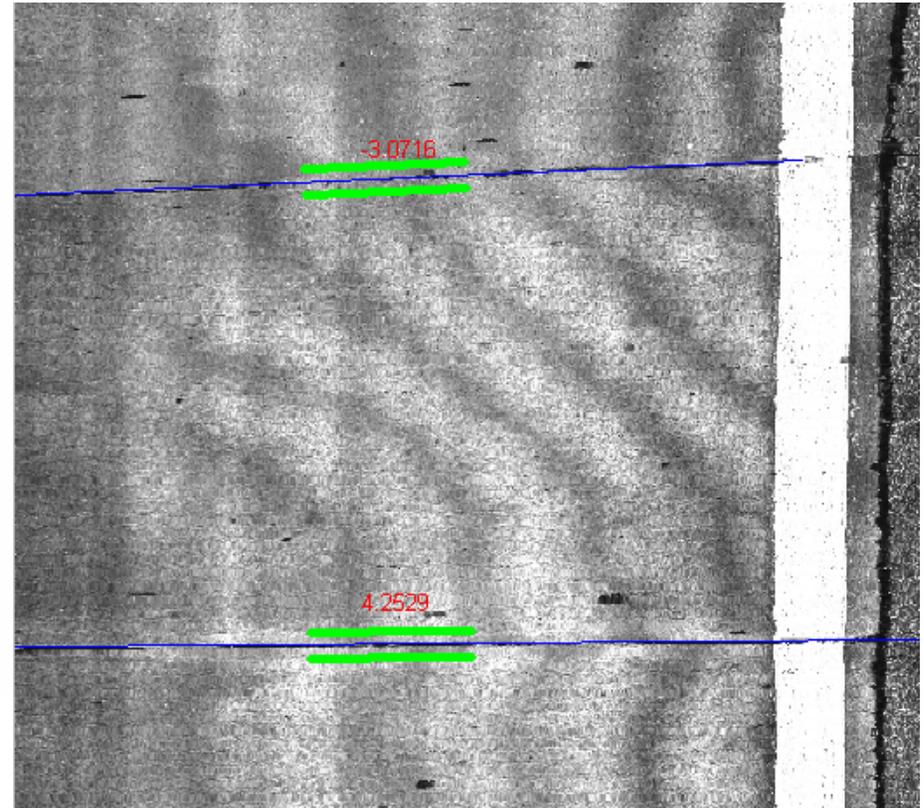
Joints, tinning and faulting



Joint detection and faulting



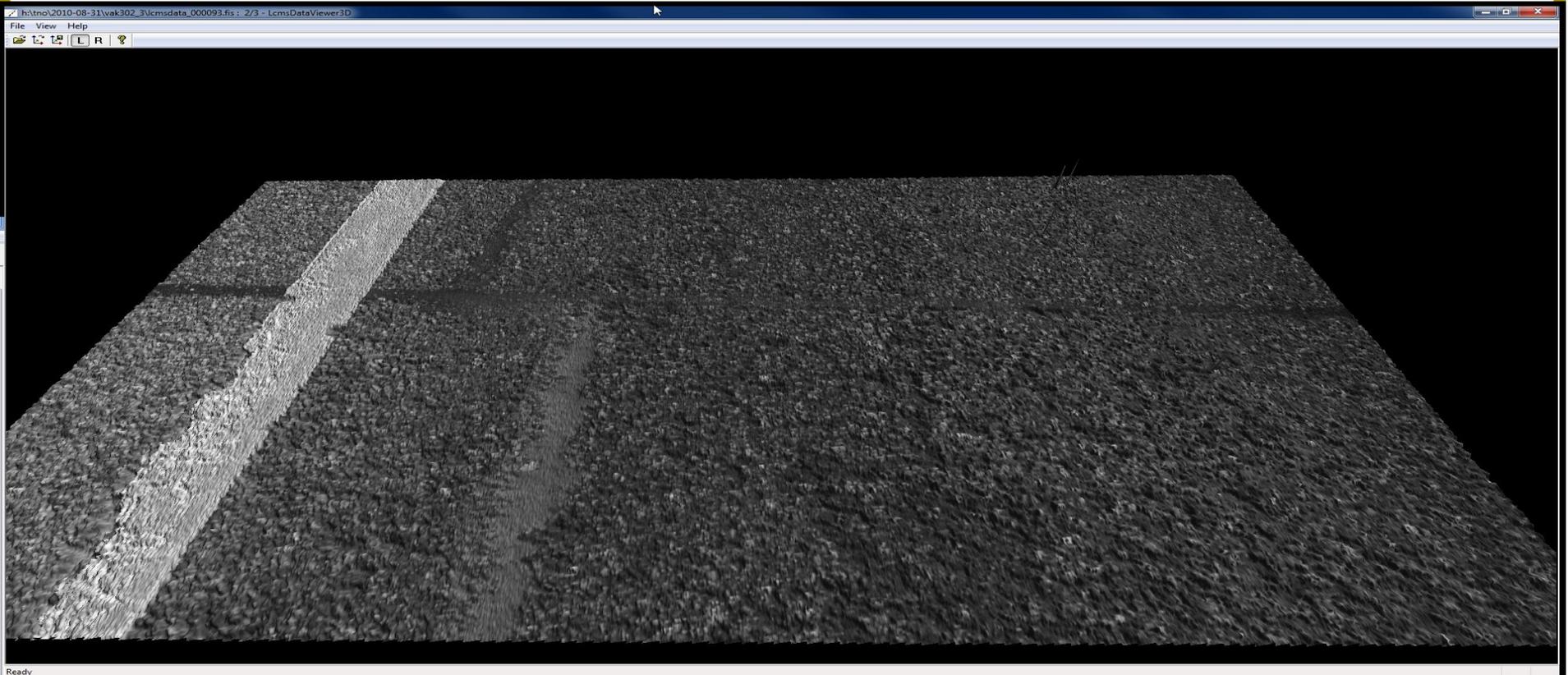
Note: All dimensions shown in millimeters unless otherwise noted.



Raveling Index (RI)

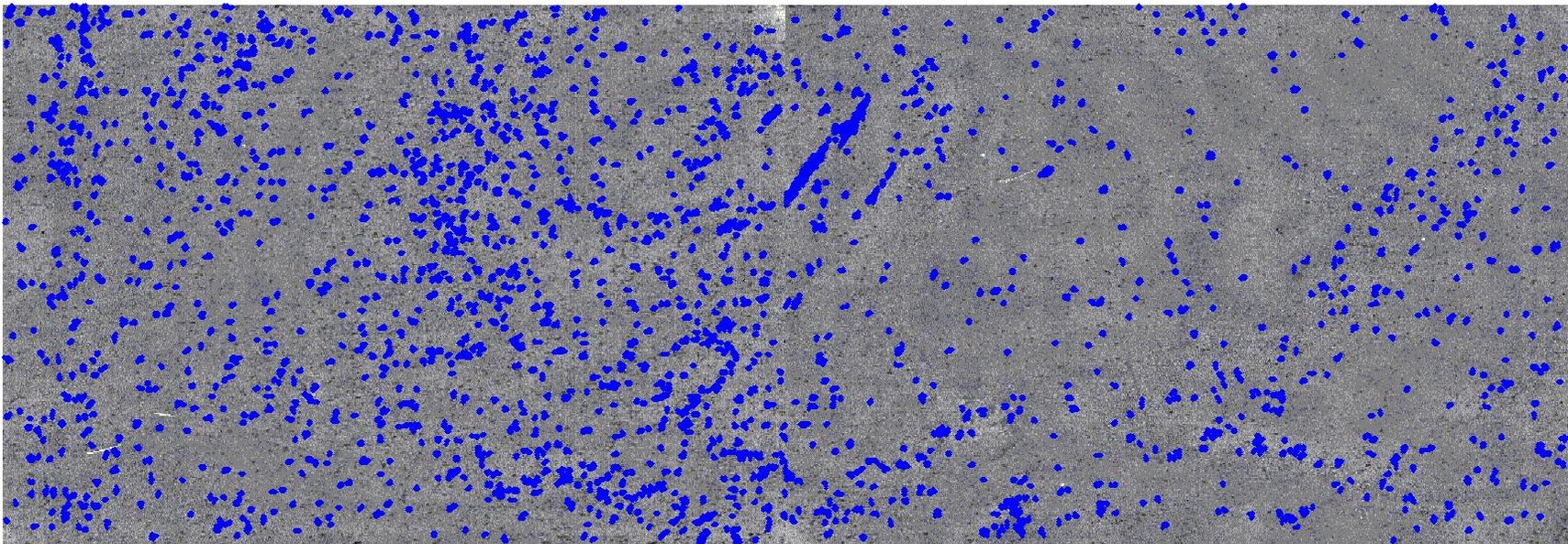
- Raveling spots (loss of aggregate) are identified from the 3D range images.
- The volume of the missing aggregate spots are measured per surface area.

$$RI = V_{ravelling} / A_{Total}$$

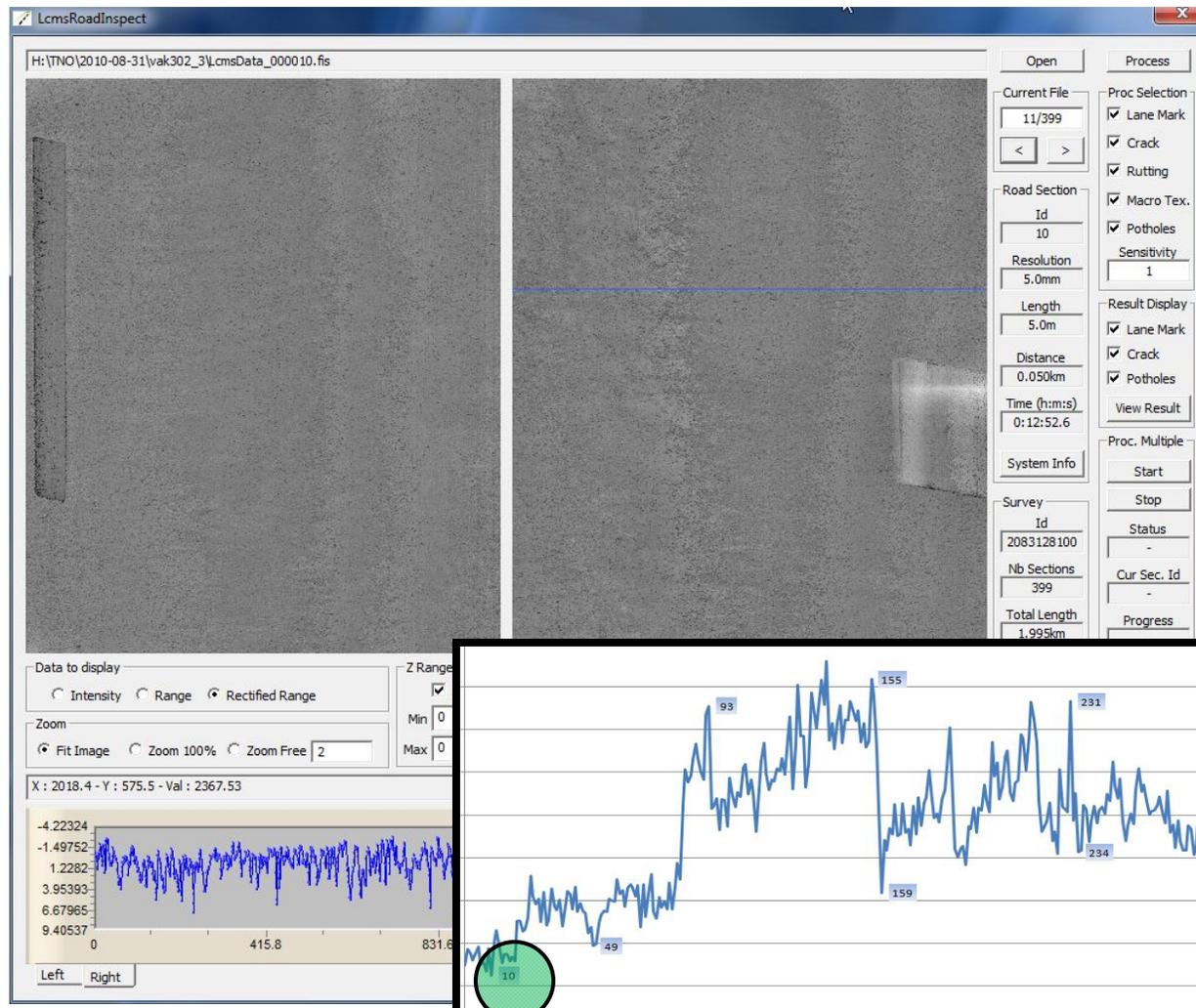




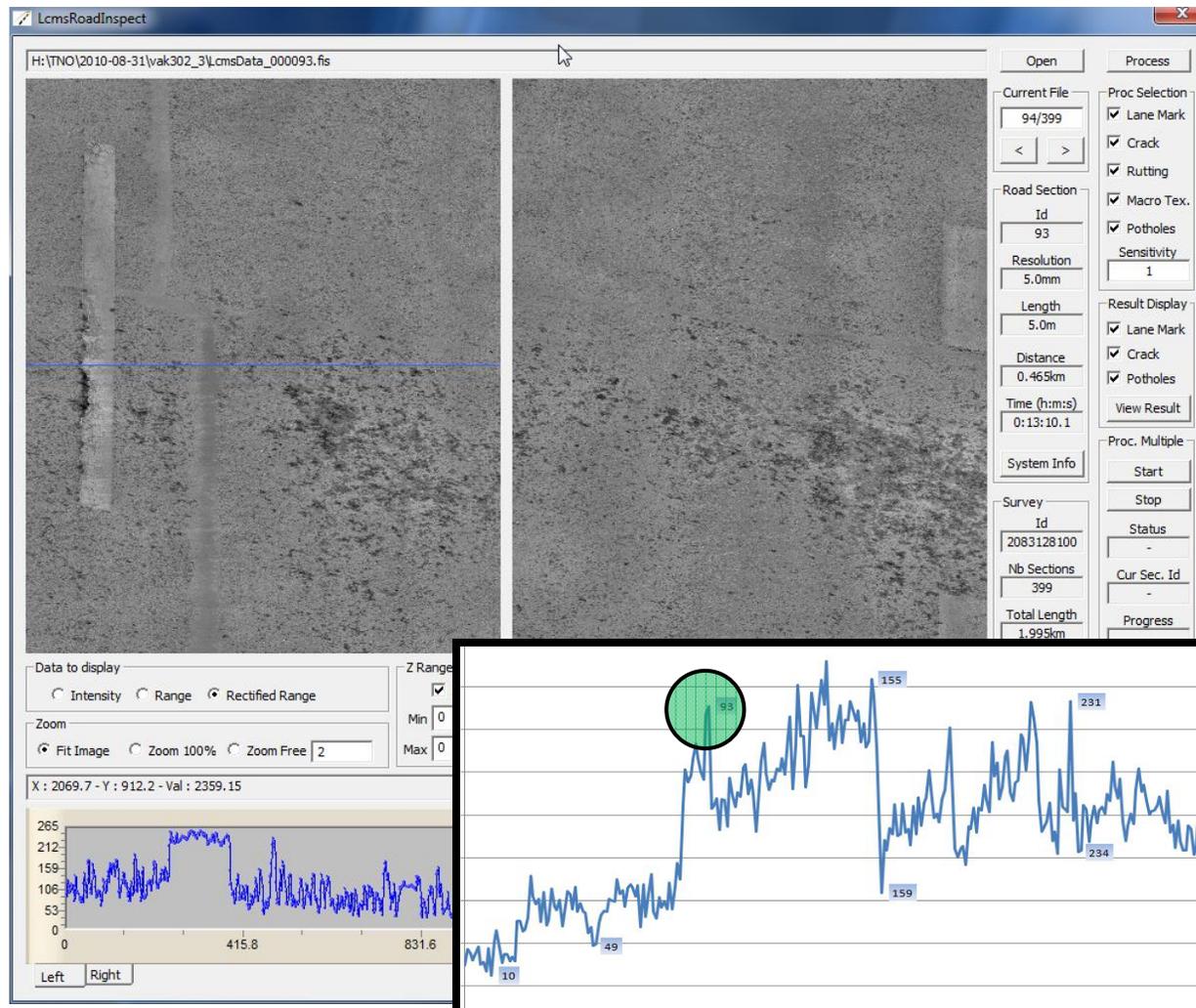
Aggregate loss detection

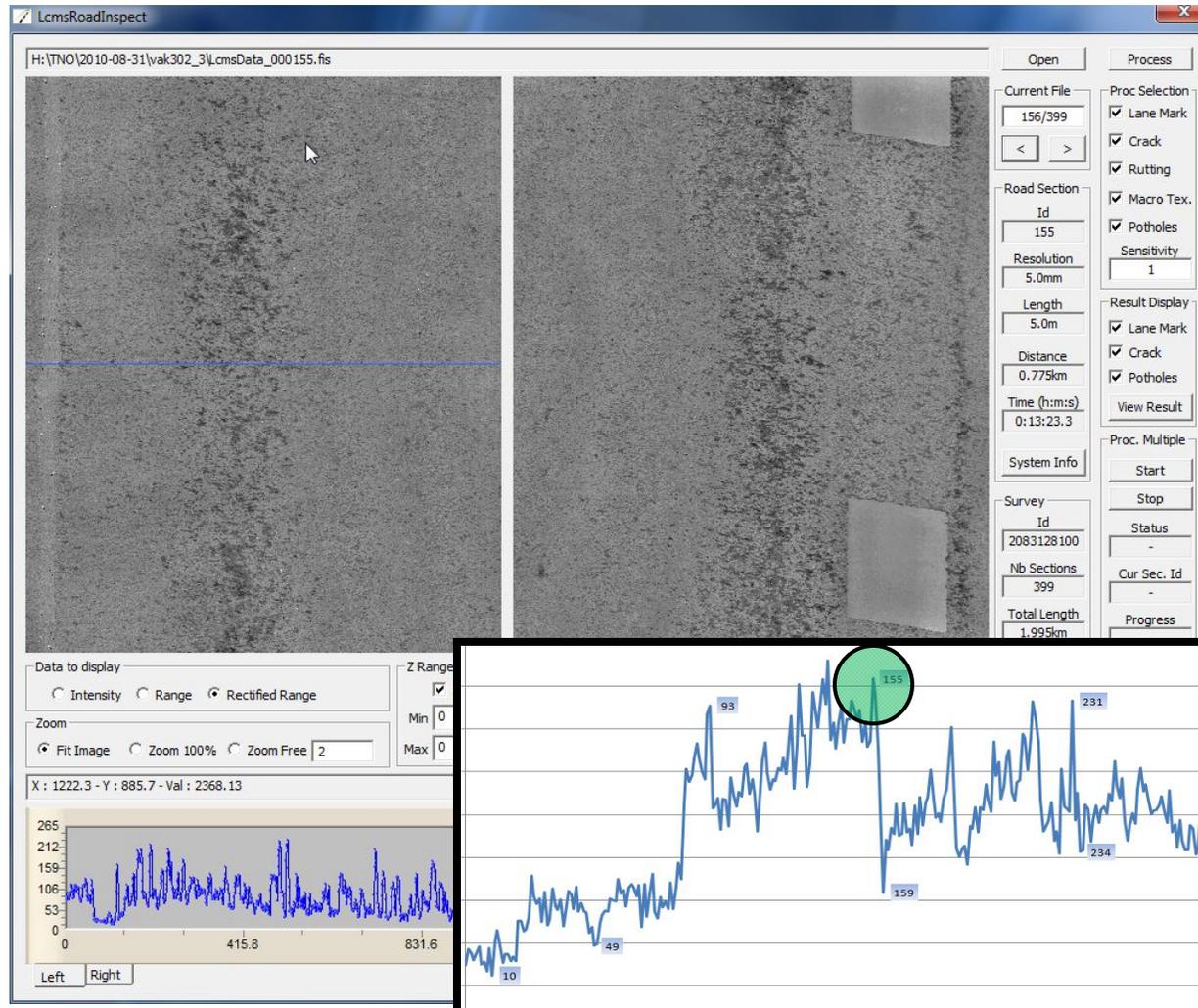


RI - Road test - Porous Asphalt in the Netherlands

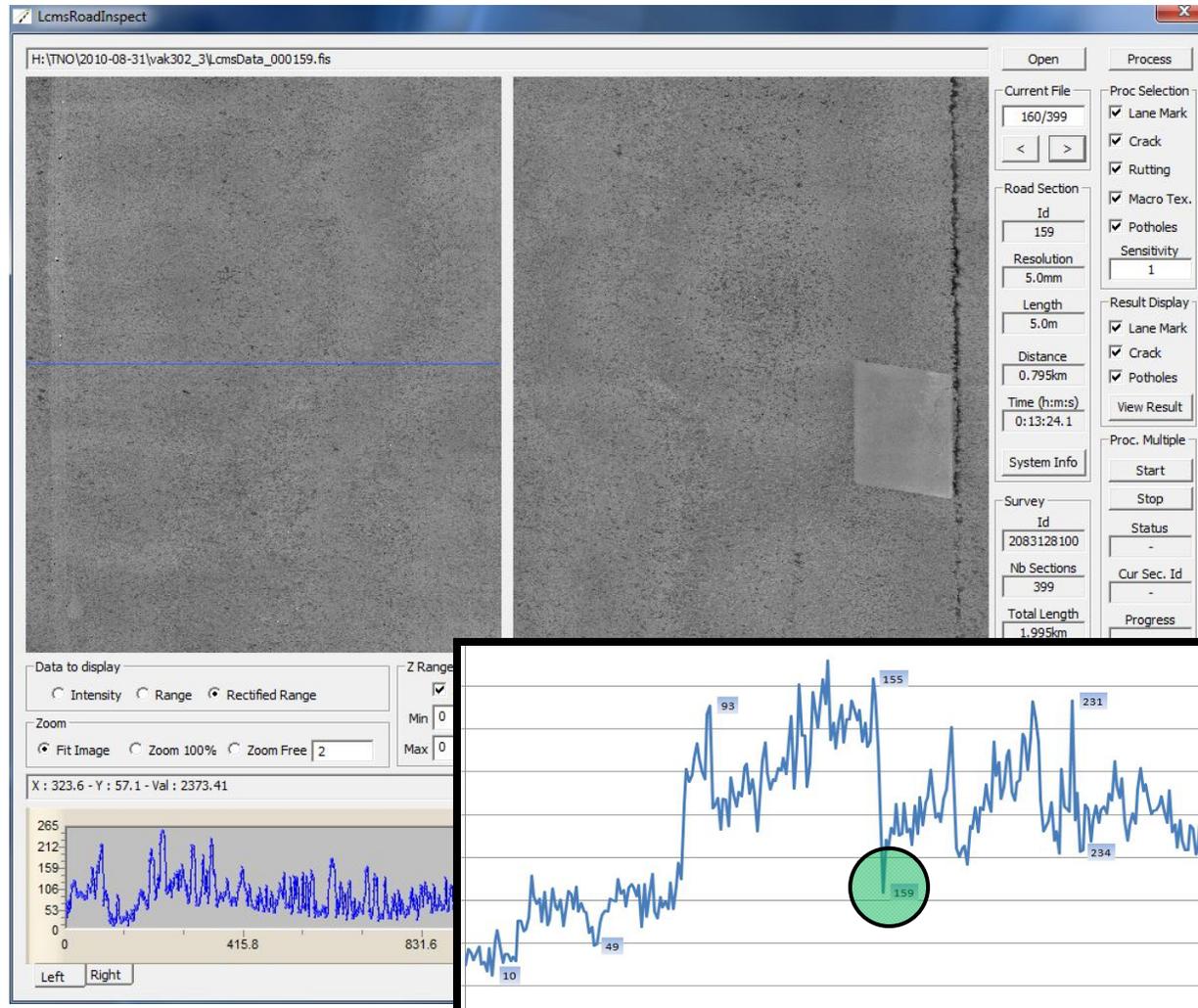


Road Section #93 : Transition between Ravelling and new pavement (Range)

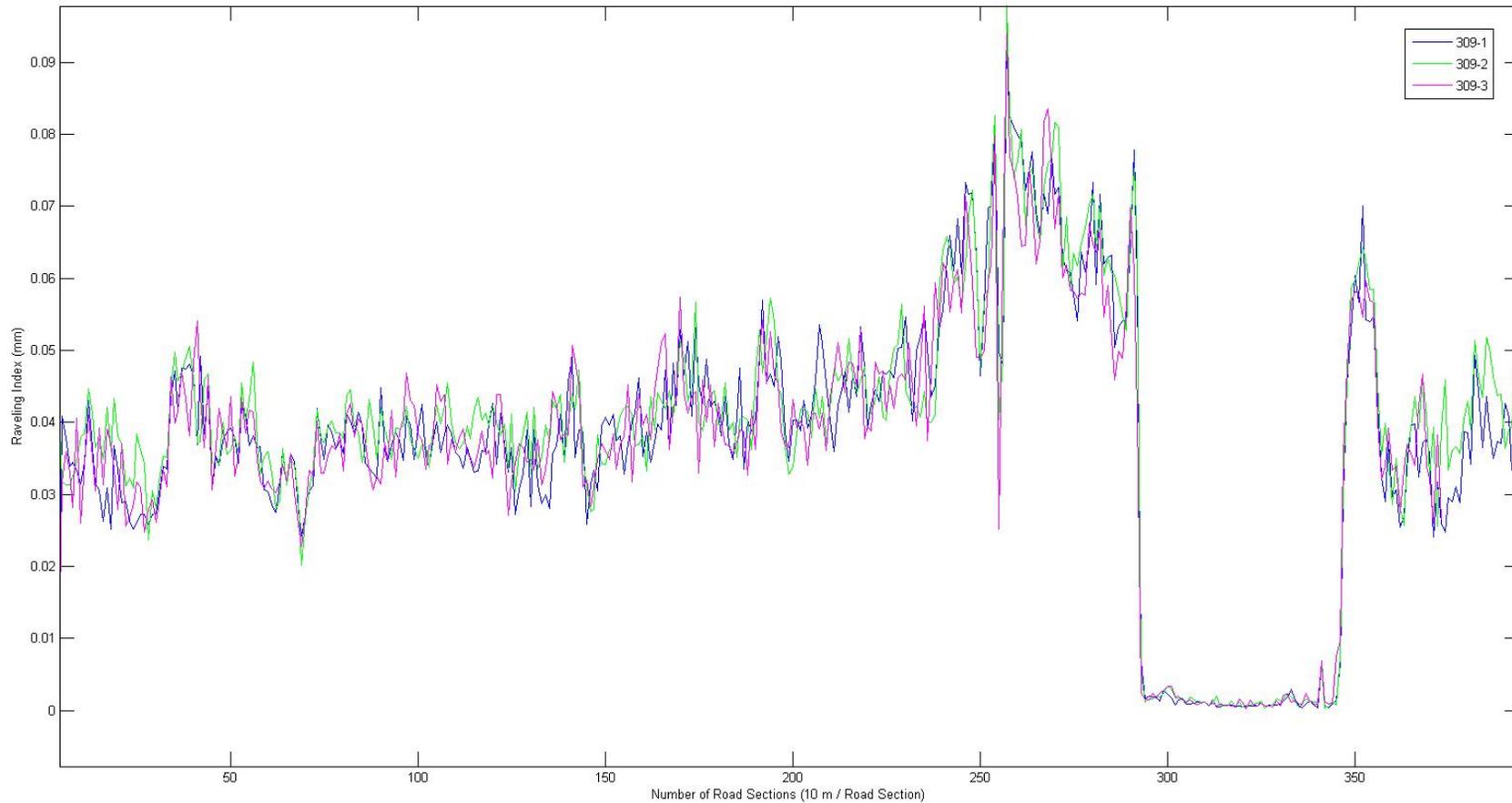




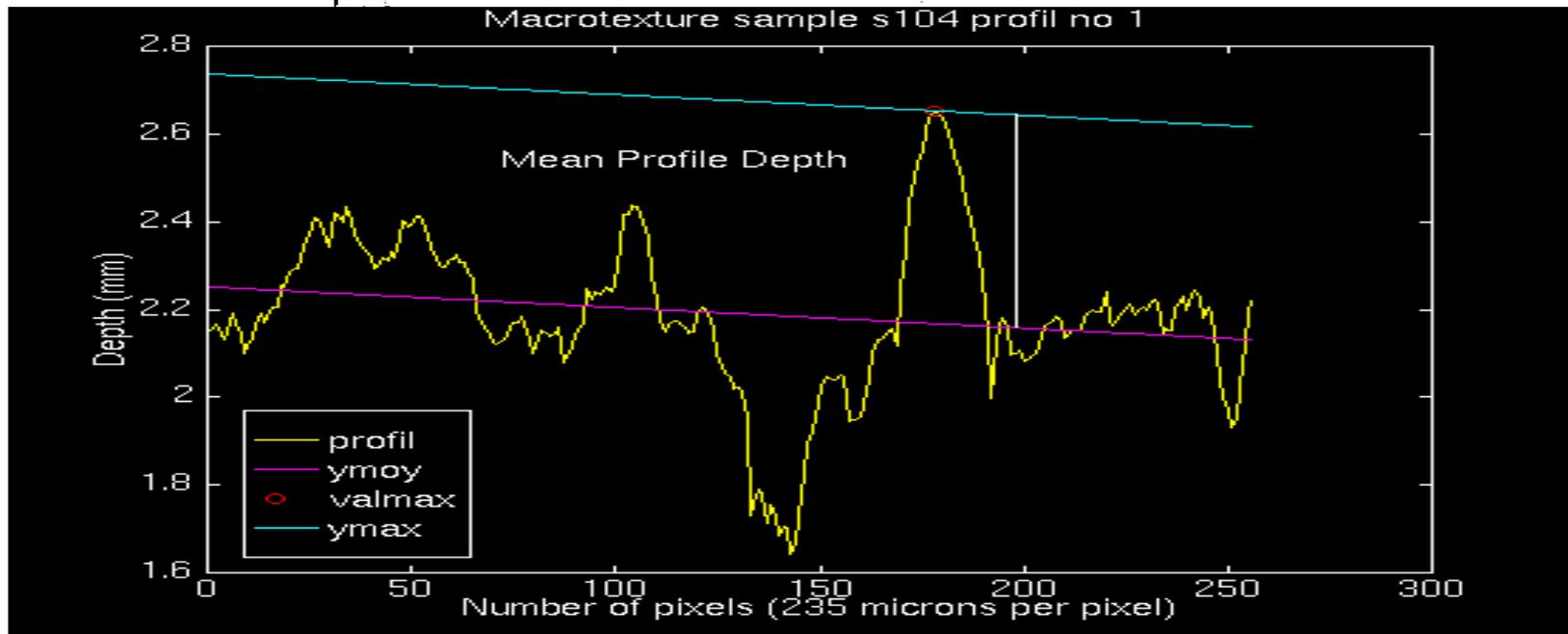
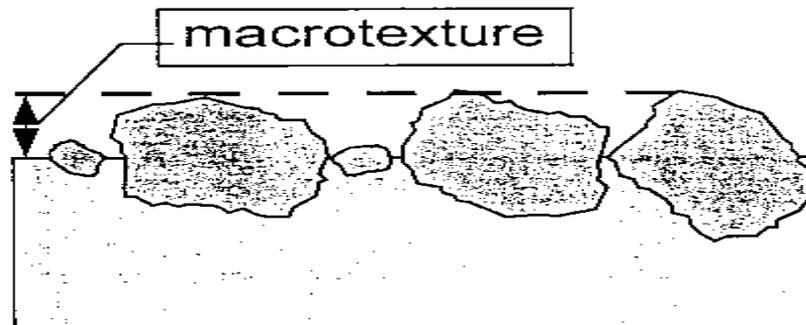
Road Section #159 : Smooth texture



Ravelling Index - Repeatability (Porous asphalt Netherlands)

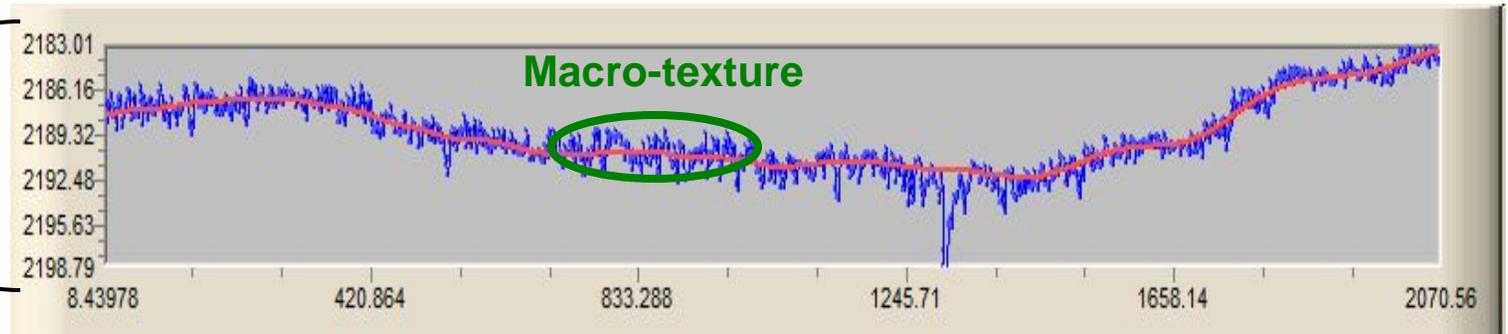


Macrotexture (MPD - ASTM E1845-01)

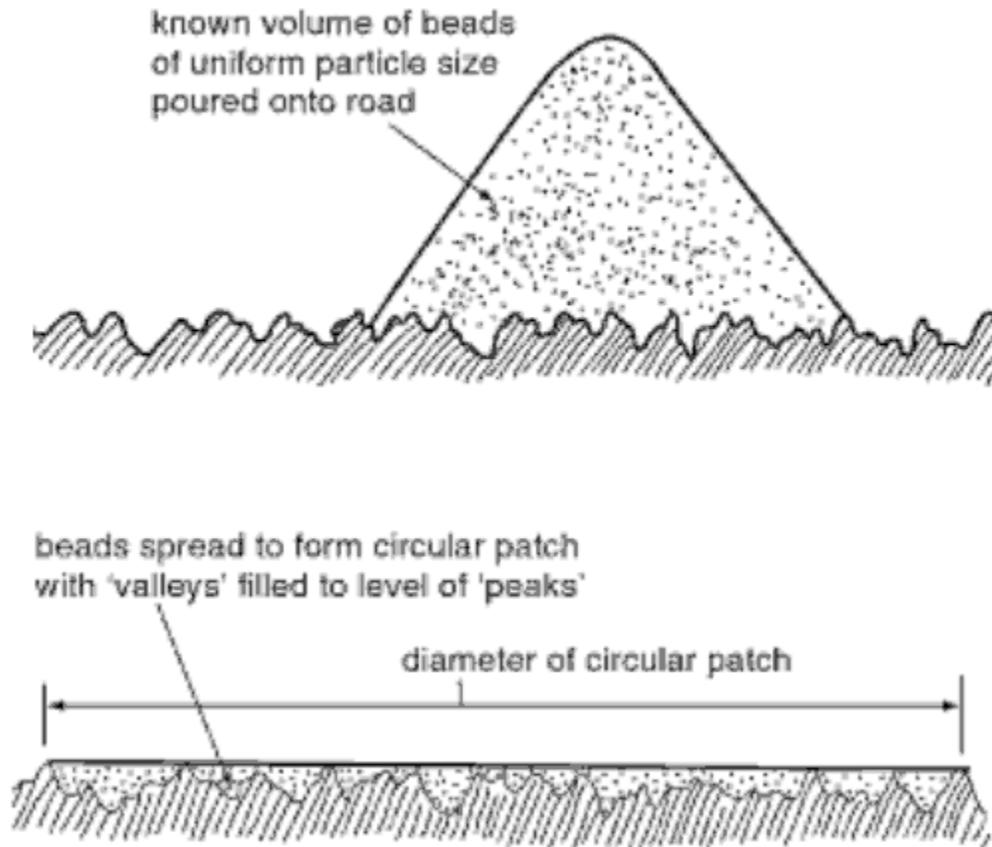


Single Road Profile (2 meter)

Distance
between Sensor
and ground
(in mm)



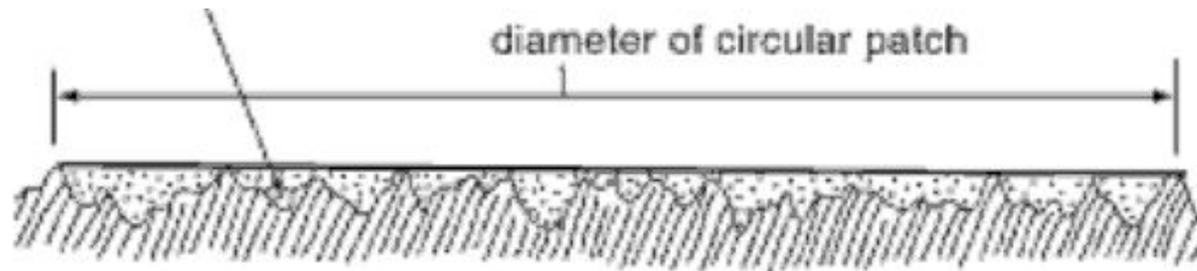
Macrotexture Sand patch method



Macrotexture - RPI

Digital Sand Patch Method

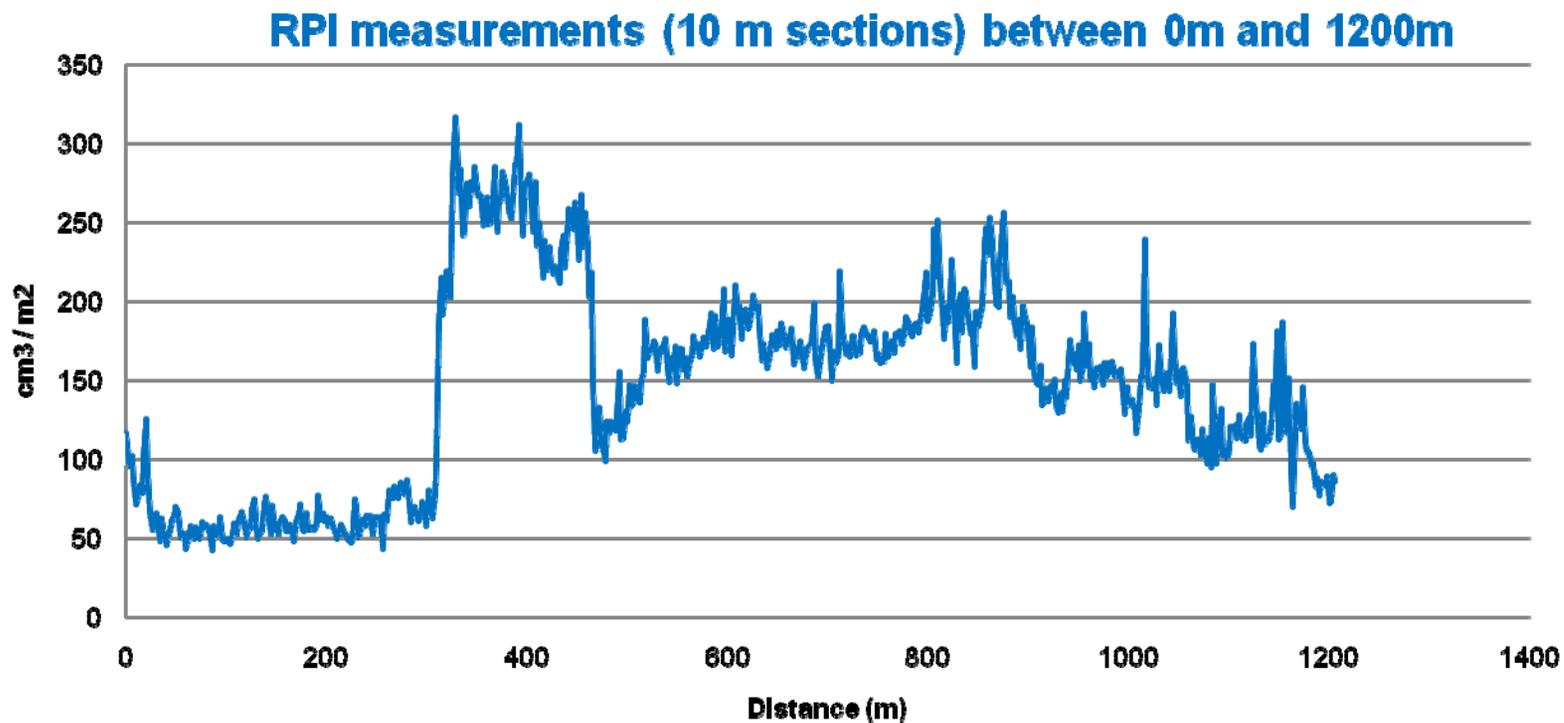
RPI - Road Porosity Index = (Volume under the surface – Ravelling - Cracks) divided by a surface area



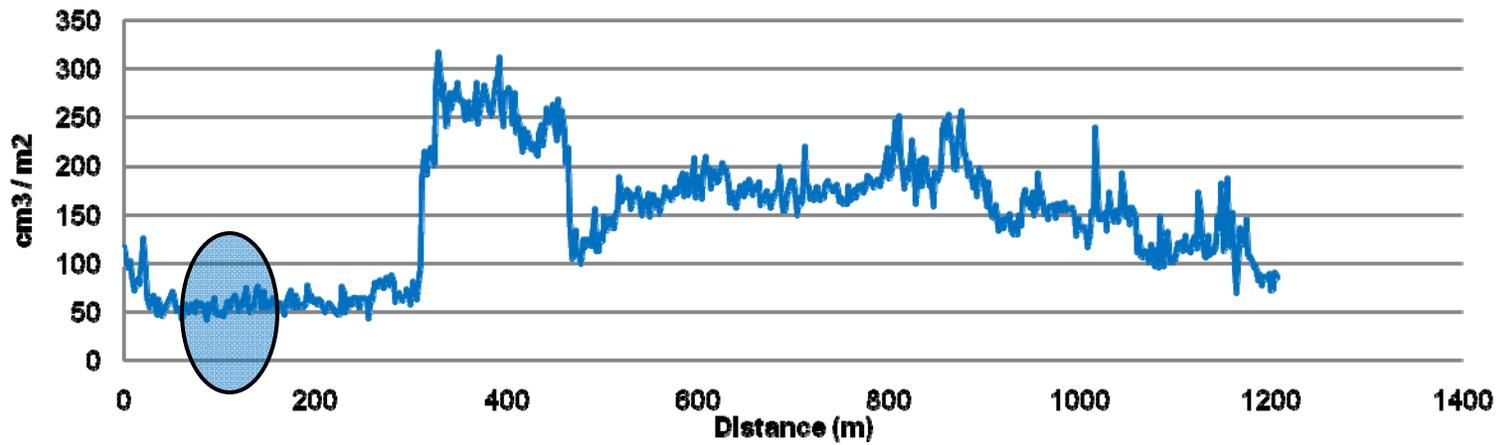
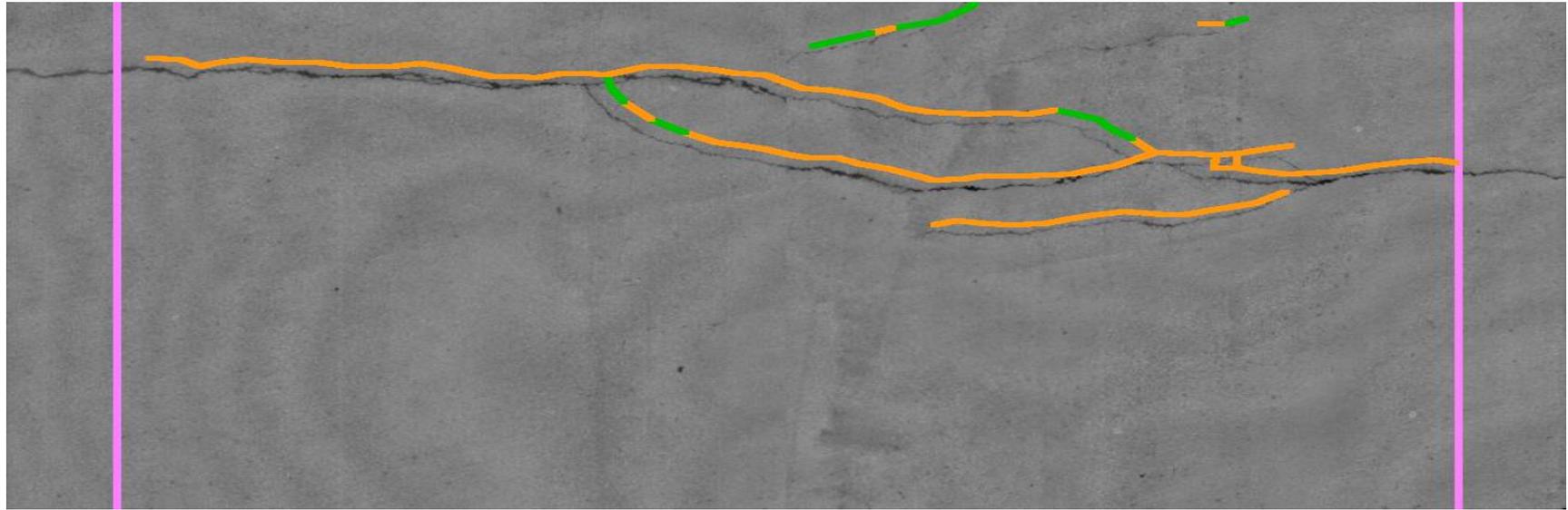
$$RPI = \frac{Vol_{air\ void} - Vol_{ravelling} - Vol_{cracks}}{Area_{Total}}$$

RPI – Road Test (Québec)

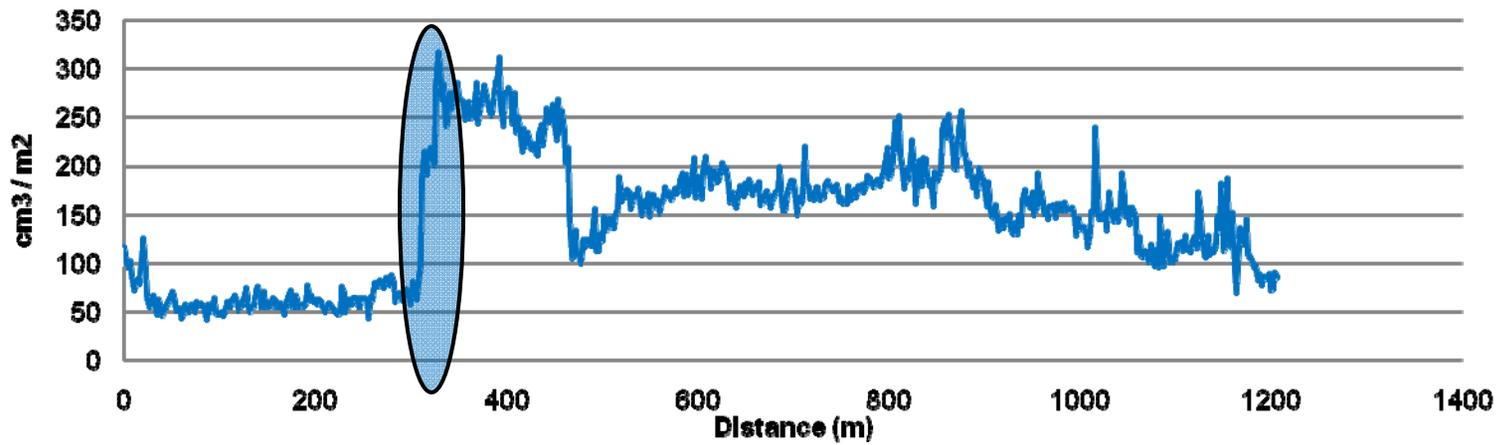
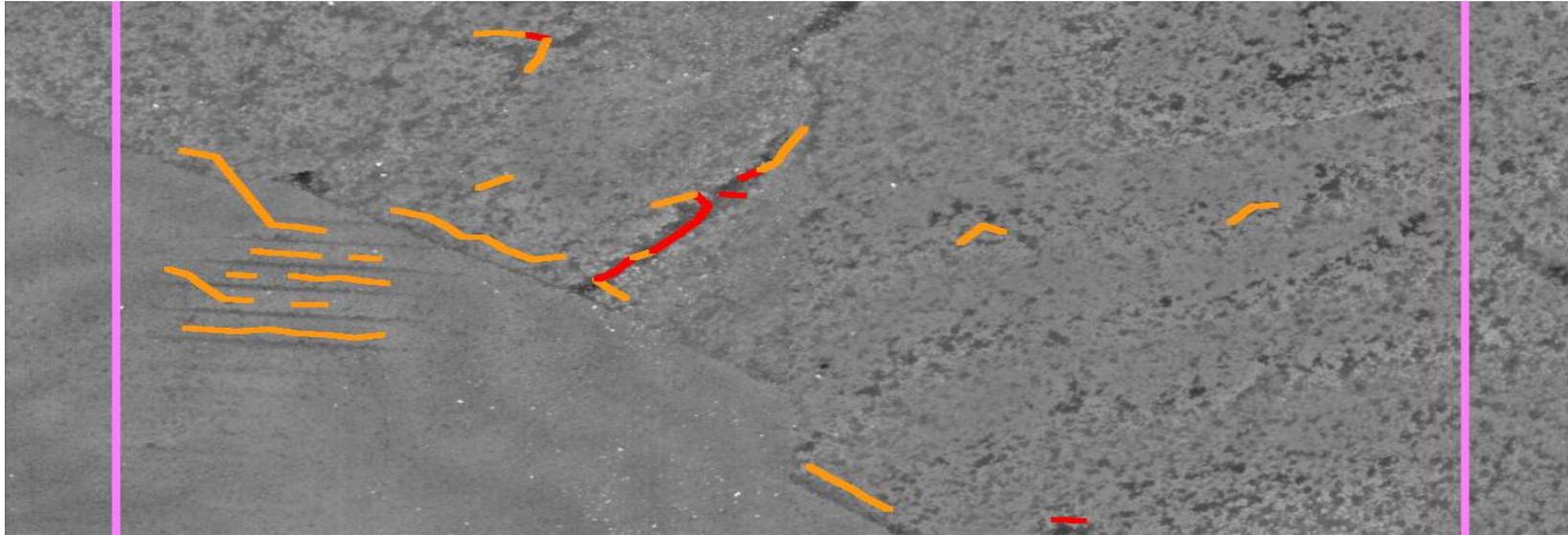
- This test section is interesting because it involves different types of pavement surfaces: Smooth, Very rough and Rough.

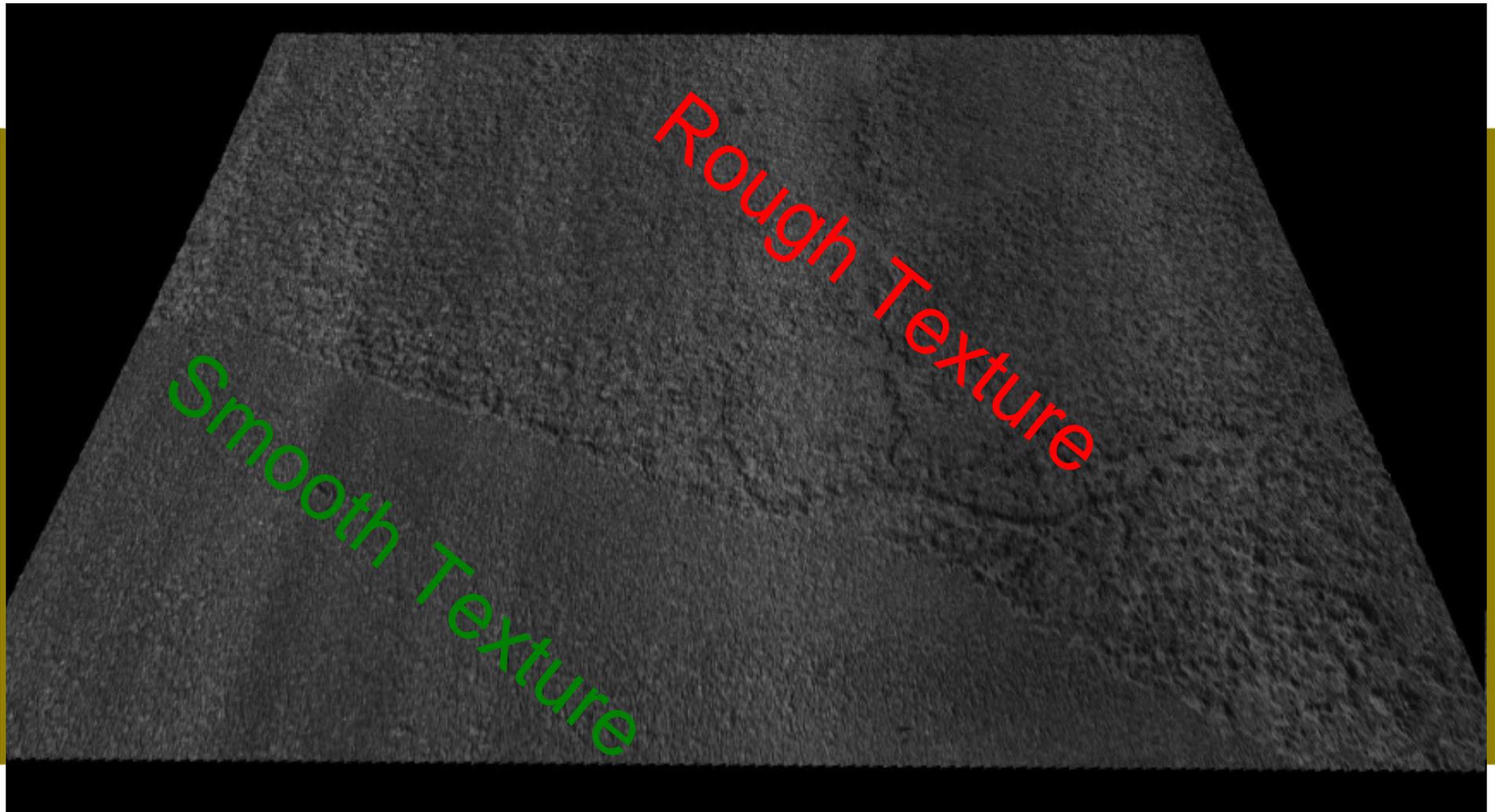


Smooth texture

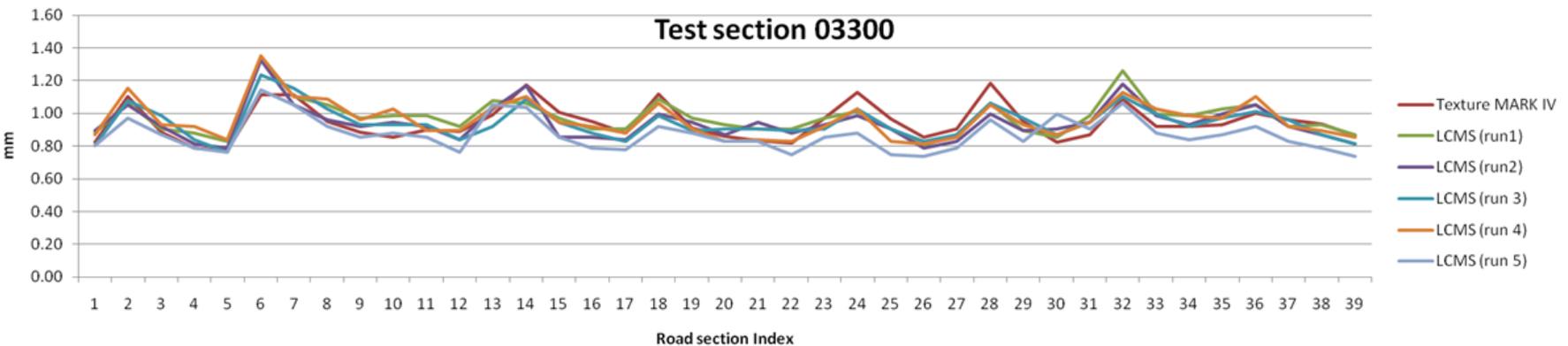
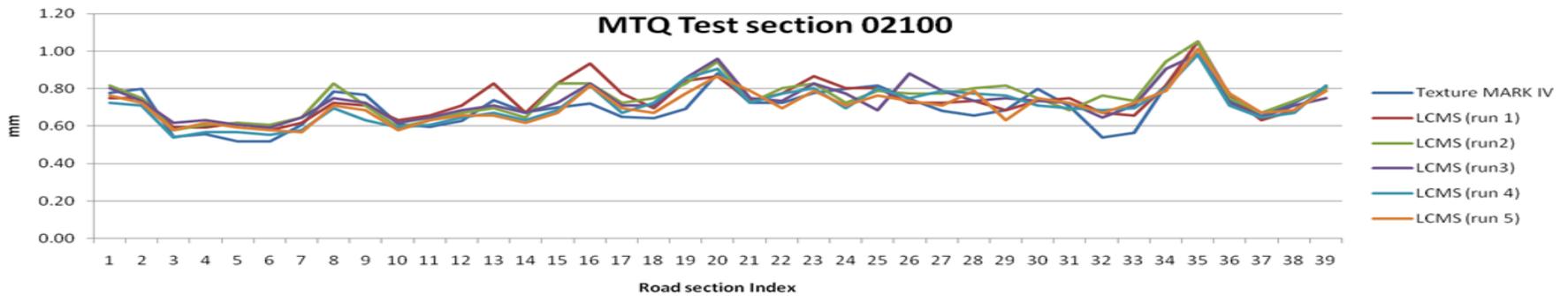
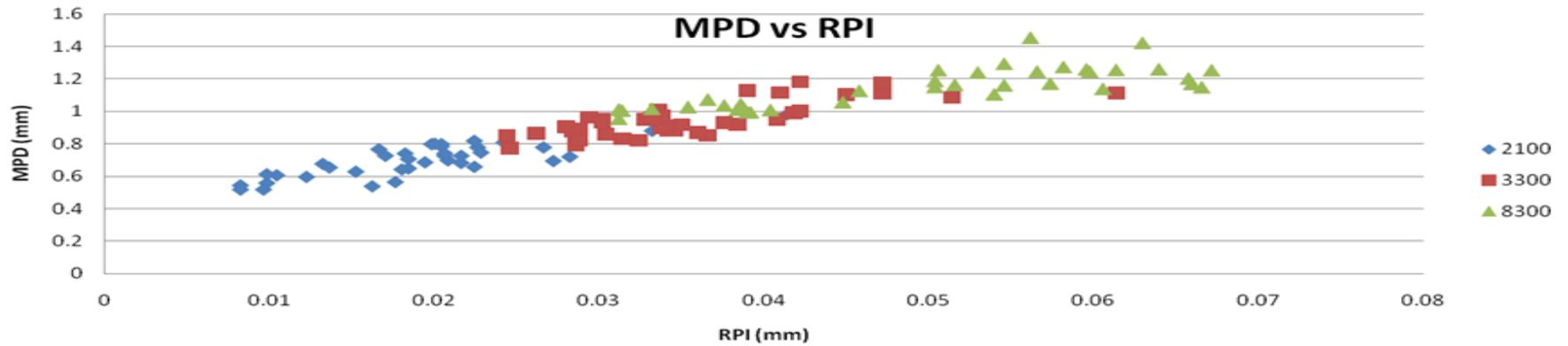


Smooth to Very Rough





RPI vs MPD



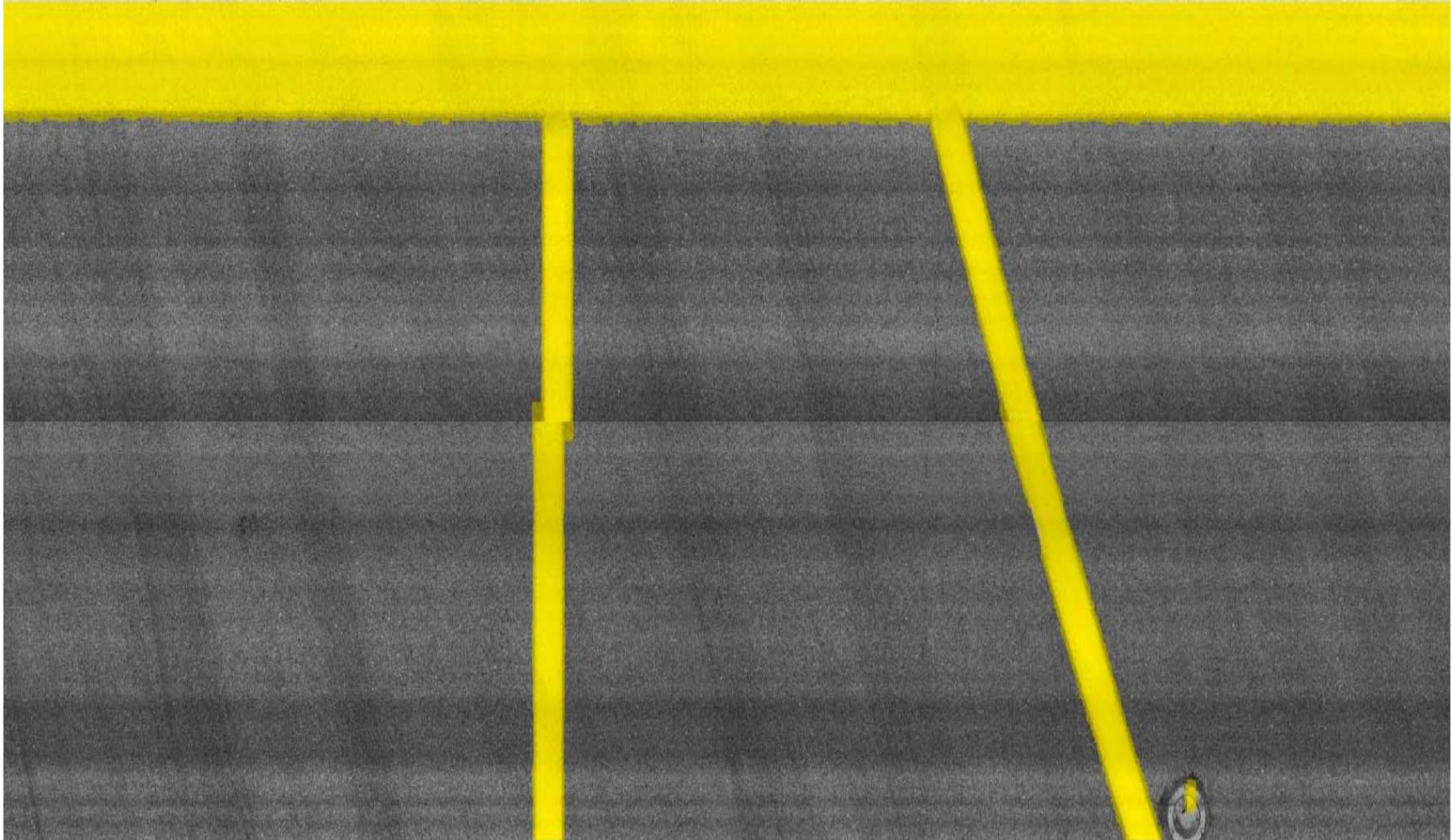
Roads vs Airports

- Lane markings
- Rubber
- Joints (sealed, unsealed)
- Rapid variations in textures
- Multiple lane passes
- Stitching required

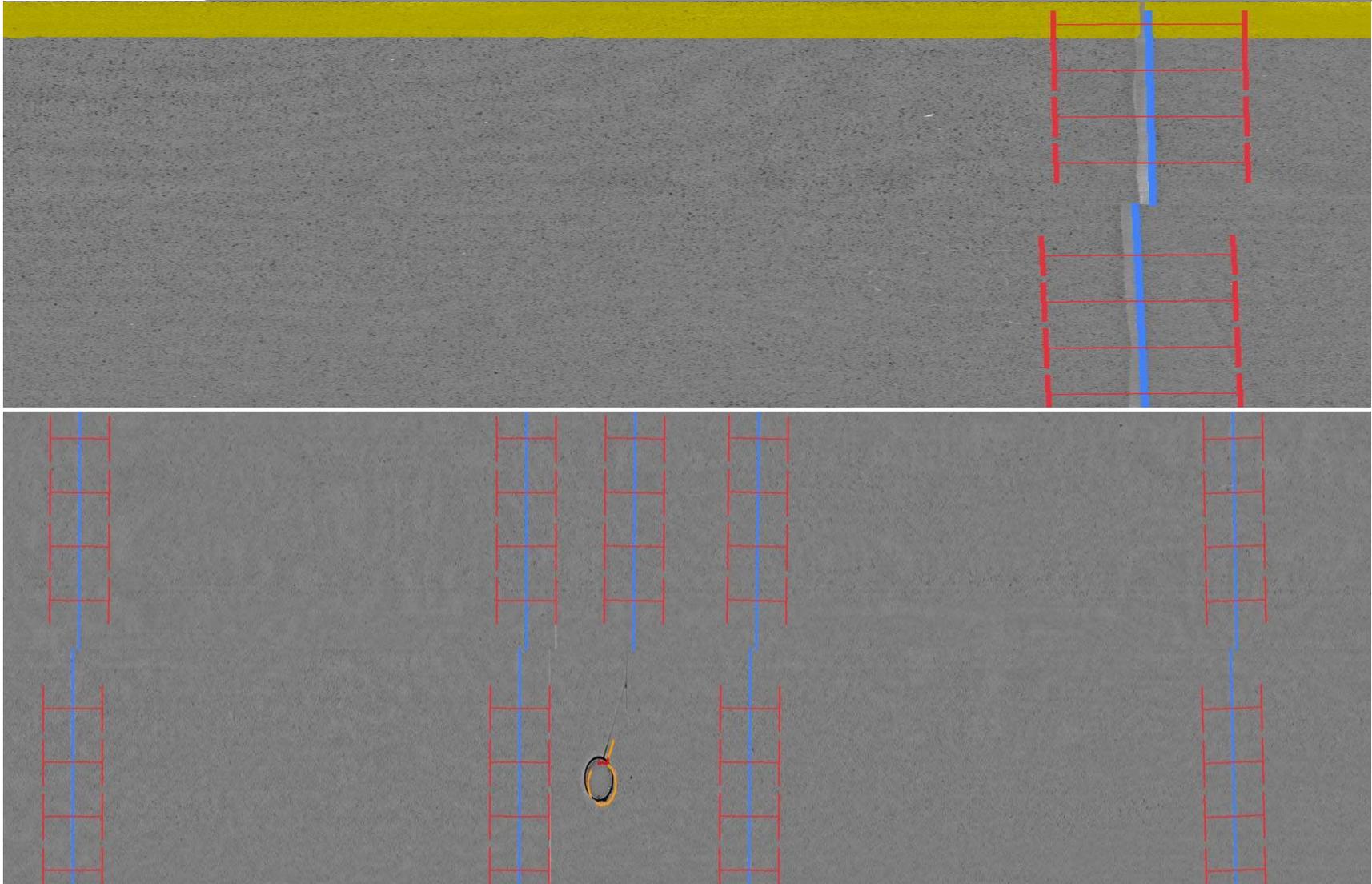




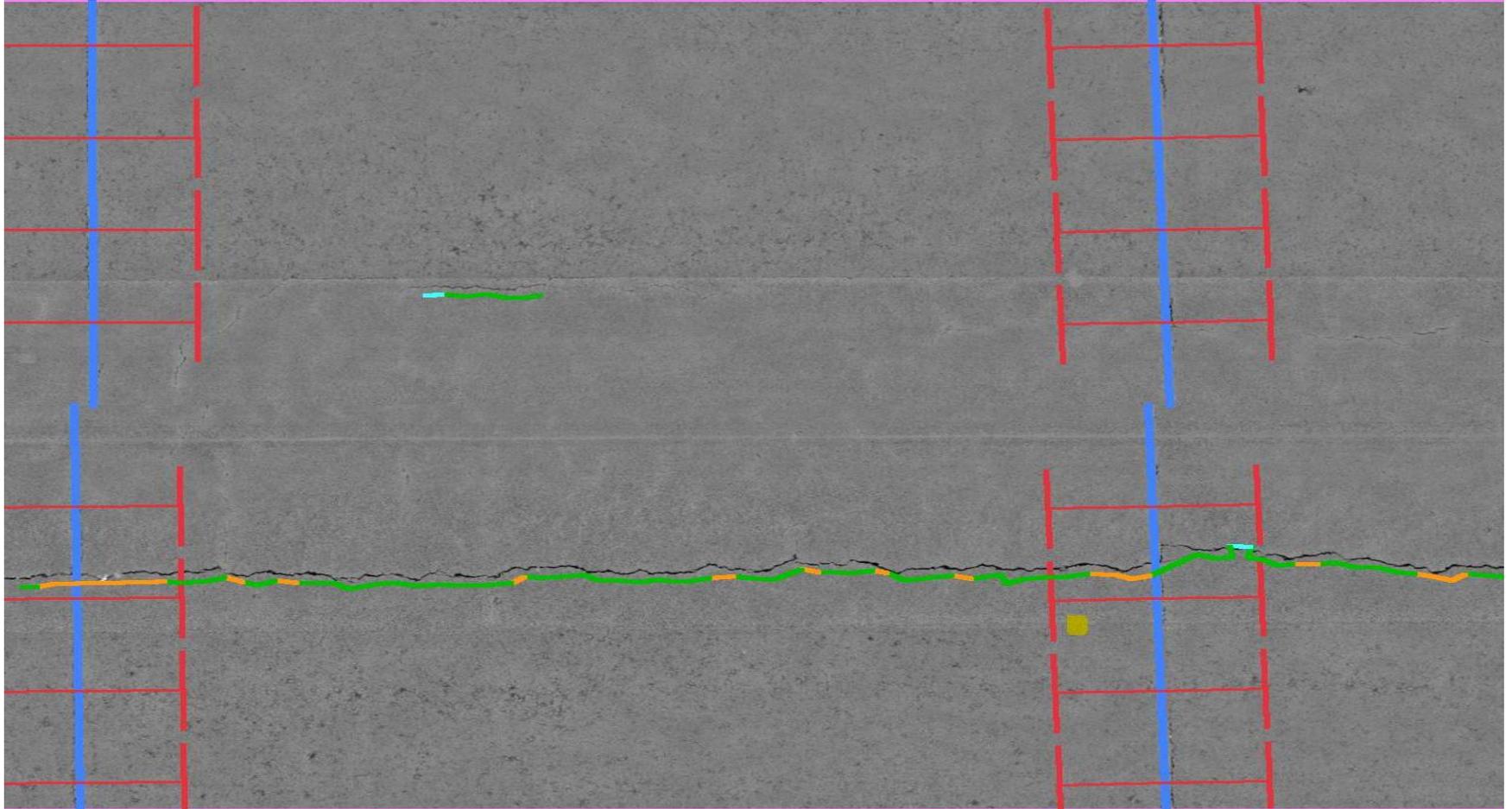
Lane Markings



Joints (sealed and unsealed)

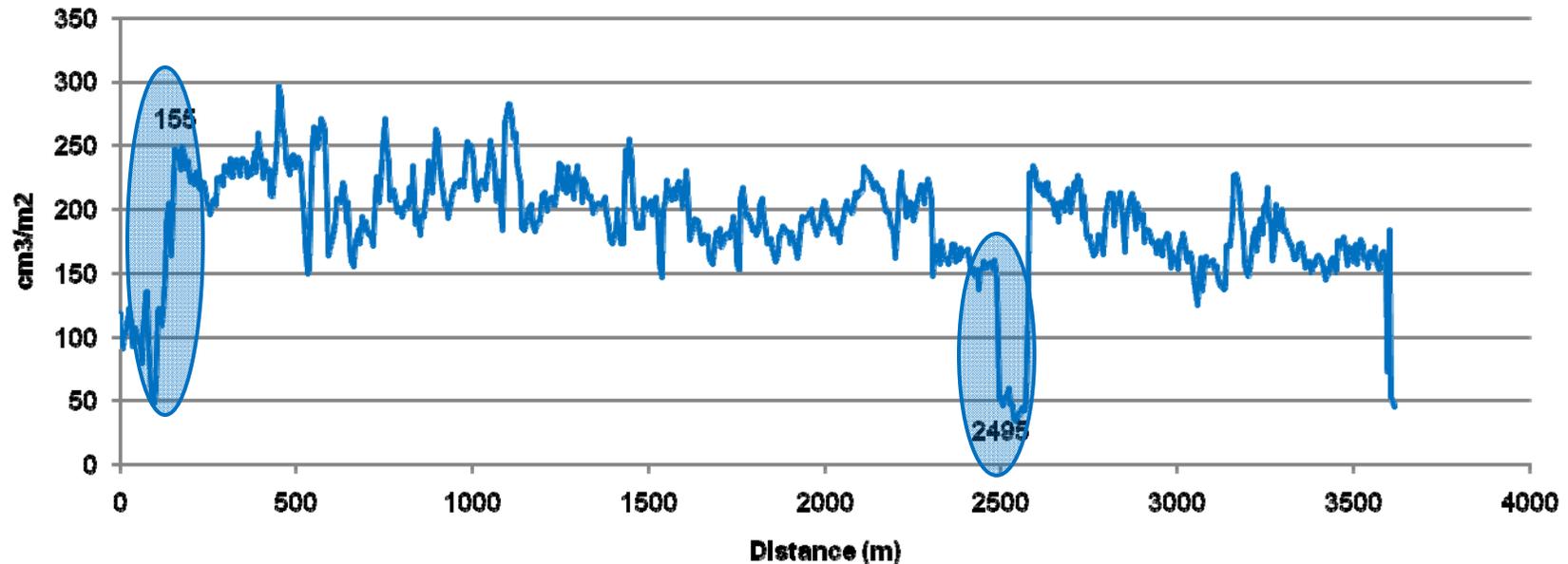


Joints and Cracks

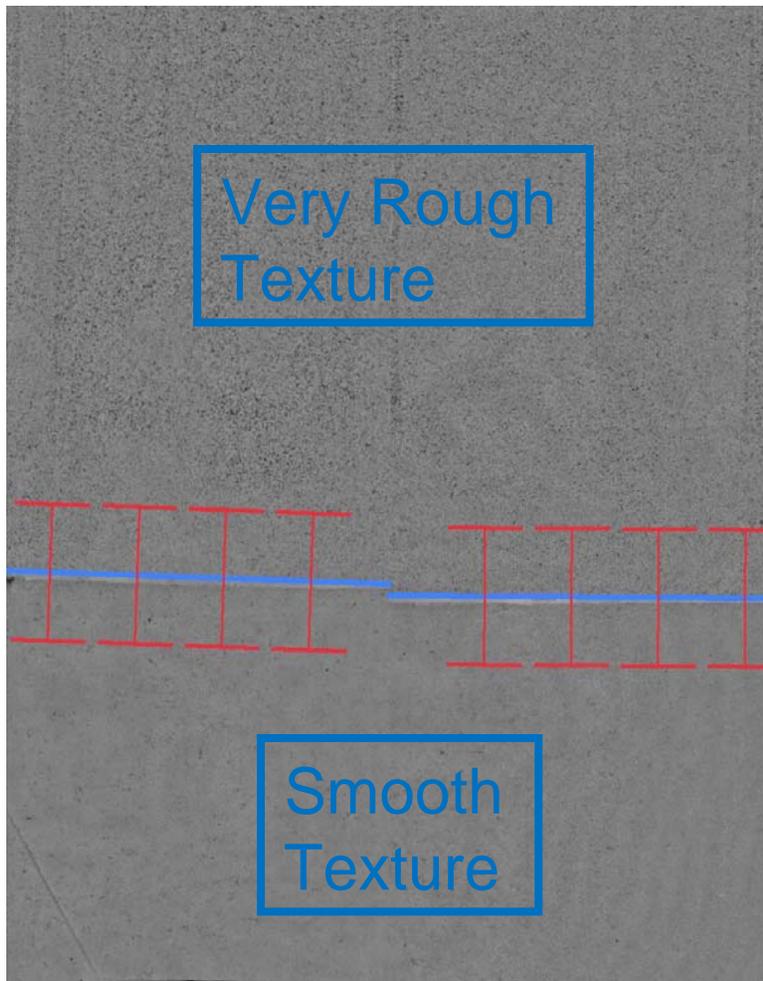


- RPI is a good indicator for texture transition.
- Abrupt asphalt texture transition at **155m**, from Smooth to Very Rough.
- Another asphalt texture transition at **2495m** (Rough to Smooth)

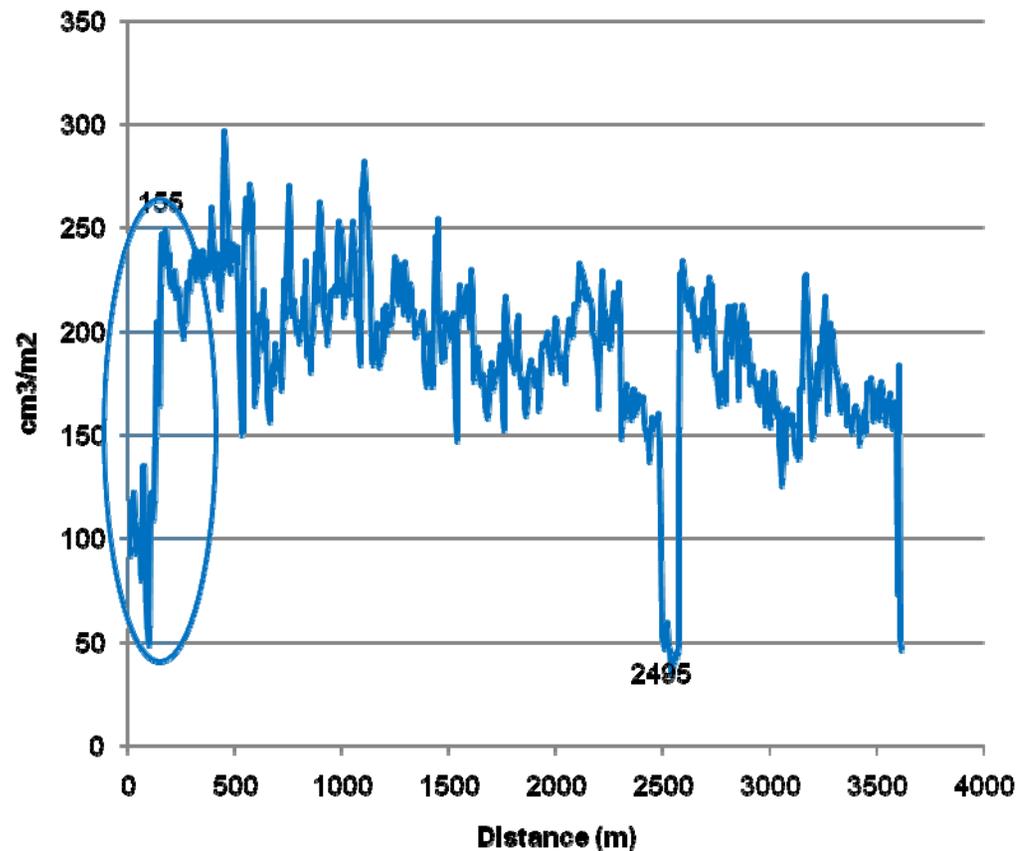
RPI per 5m road section for Lane #5



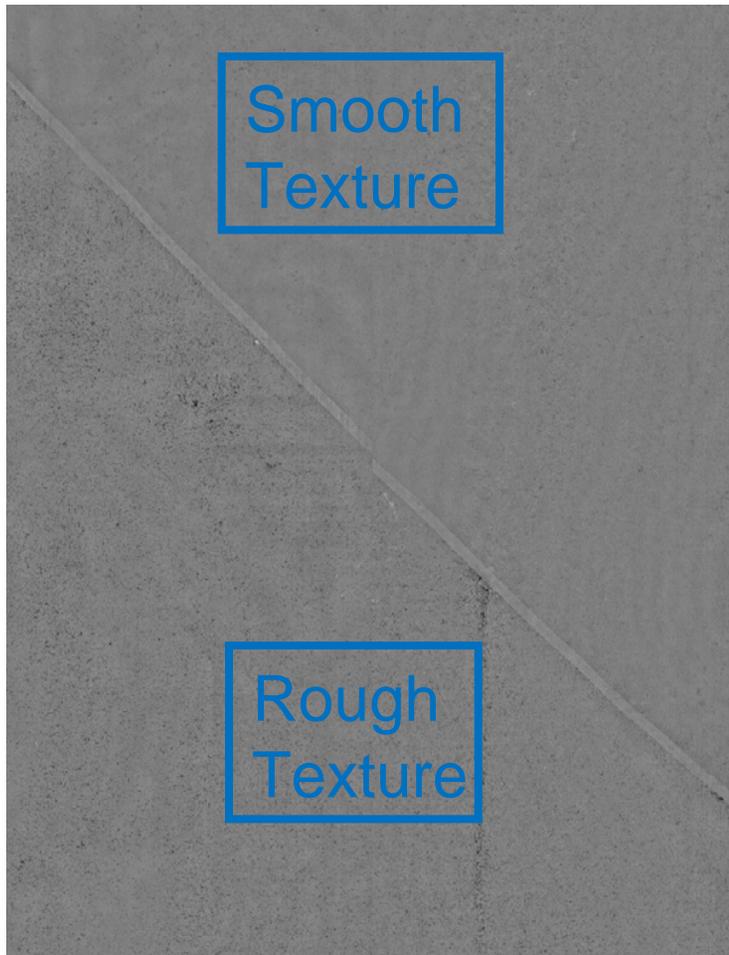
Texture transition from Smooth to Very Rough



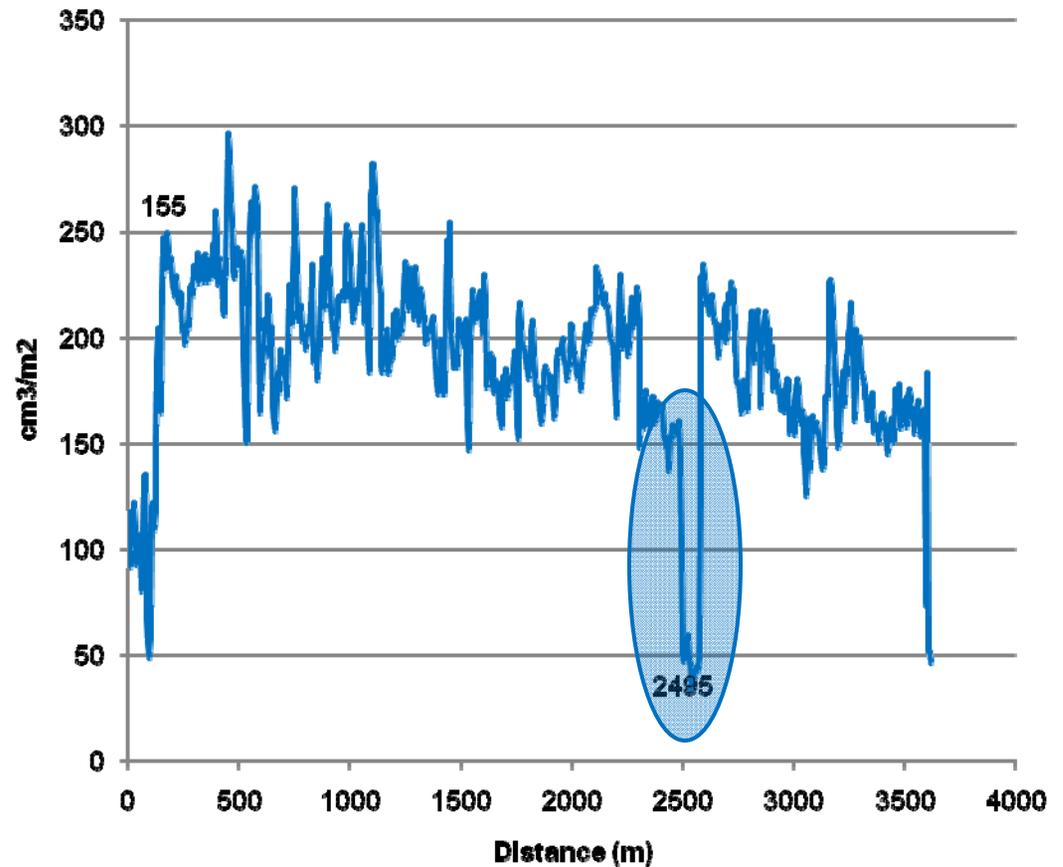
RPI per 5m road section for Lane #5



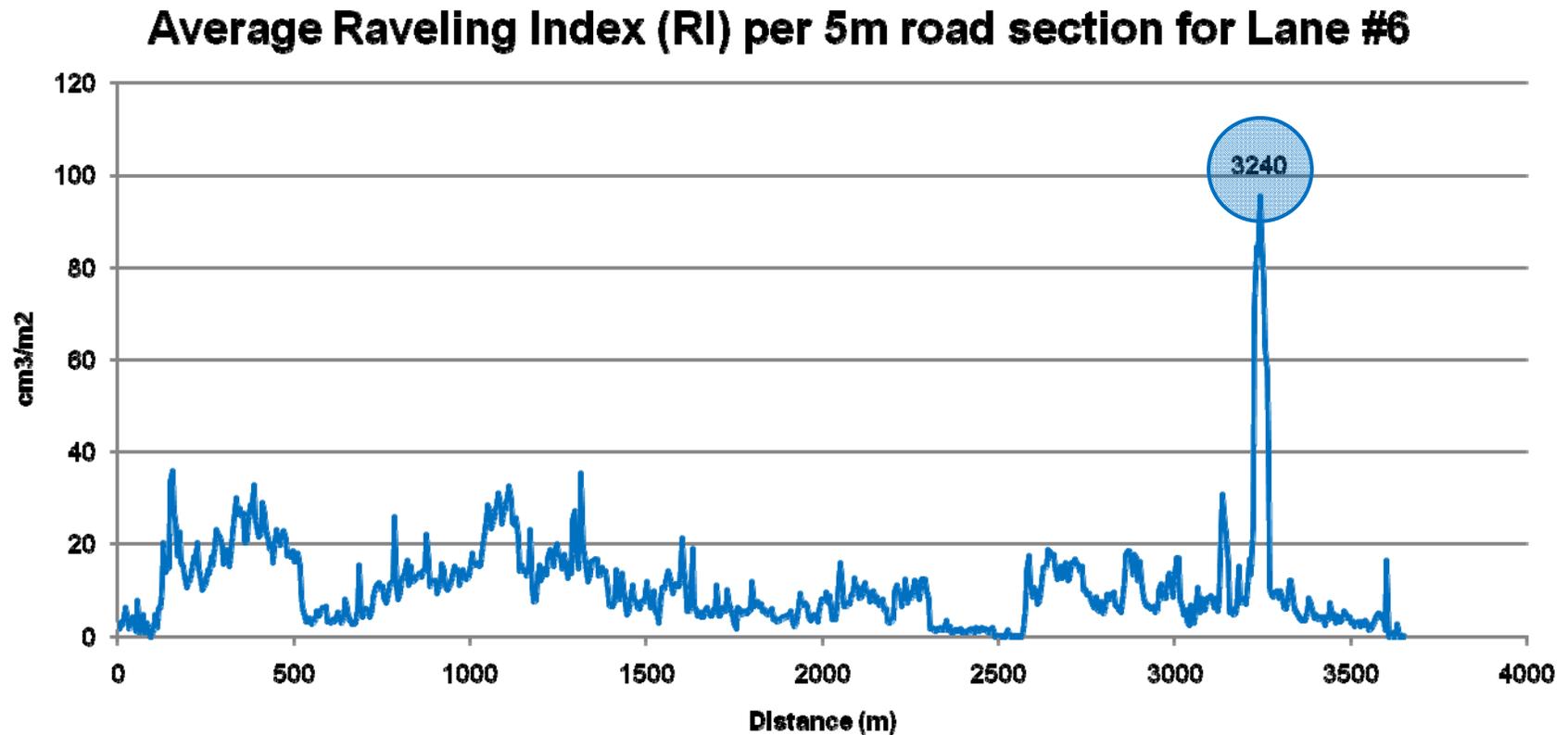
Texture transition from Rough to Smooth



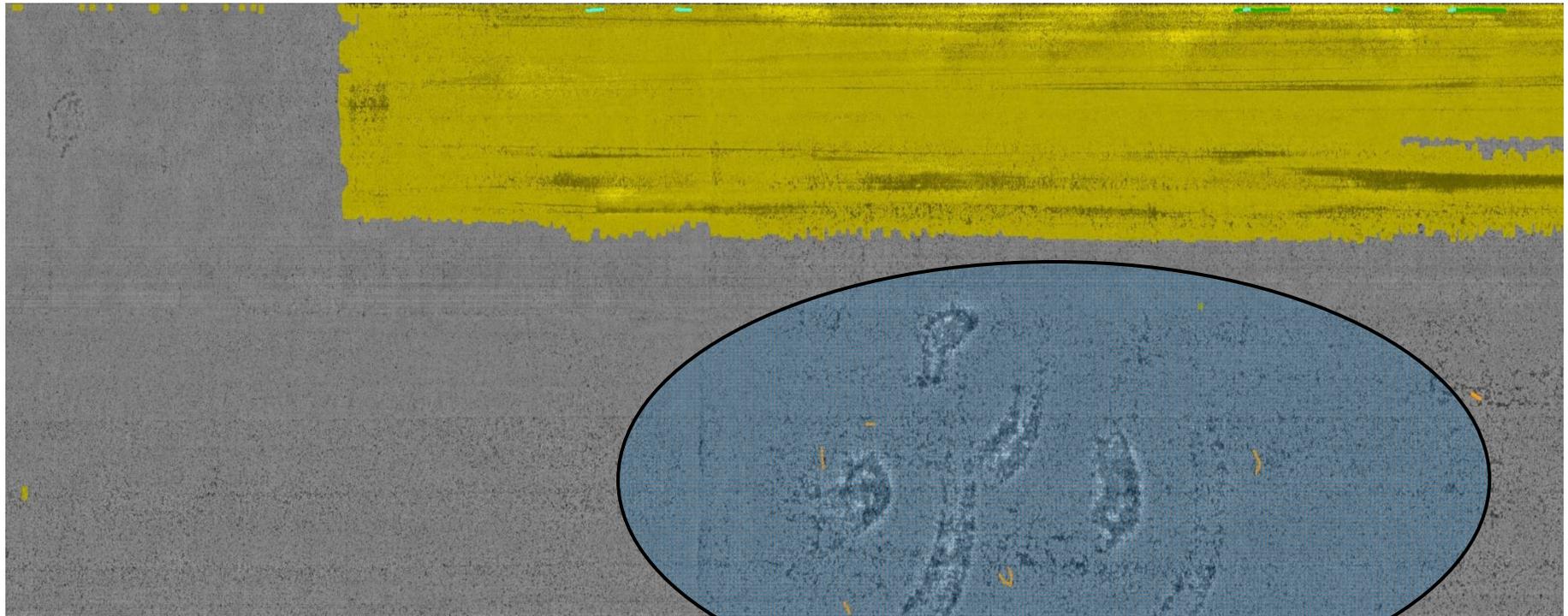
RPI per 5m road section for Lane #5



- Raveling index (RI) for Lane #6 shows a problem at distance 3240m

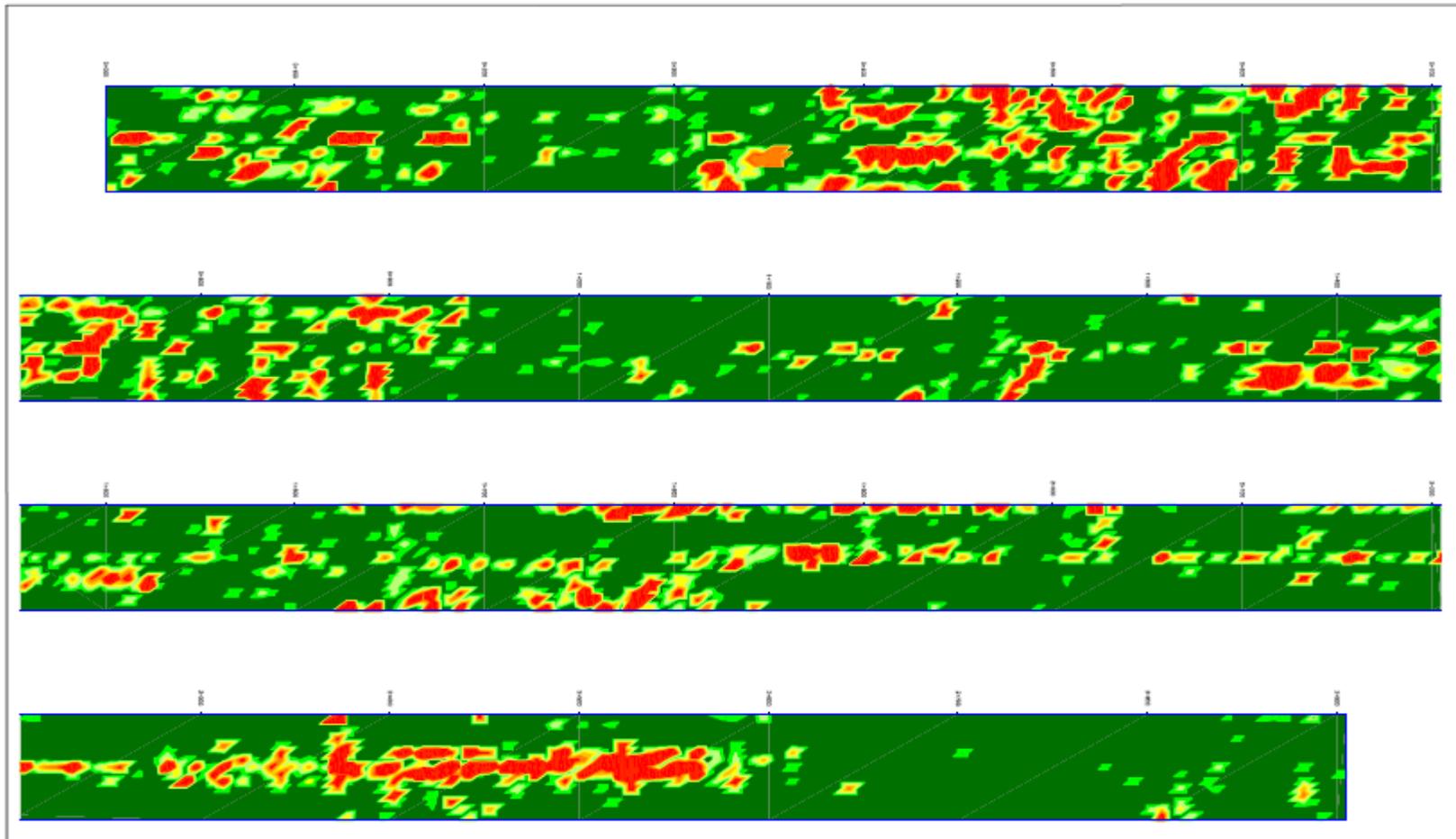


3D Range Images (3230m to 3250m)



Severe raveled section

Barcelona - Cracking



MEDICIÓN CON EQUIPO LÁSER DE FISURACIÓN

Parámetro auscultación: **FISURACIÓN TOTAL**

PISTAL

CAPA RODADURA

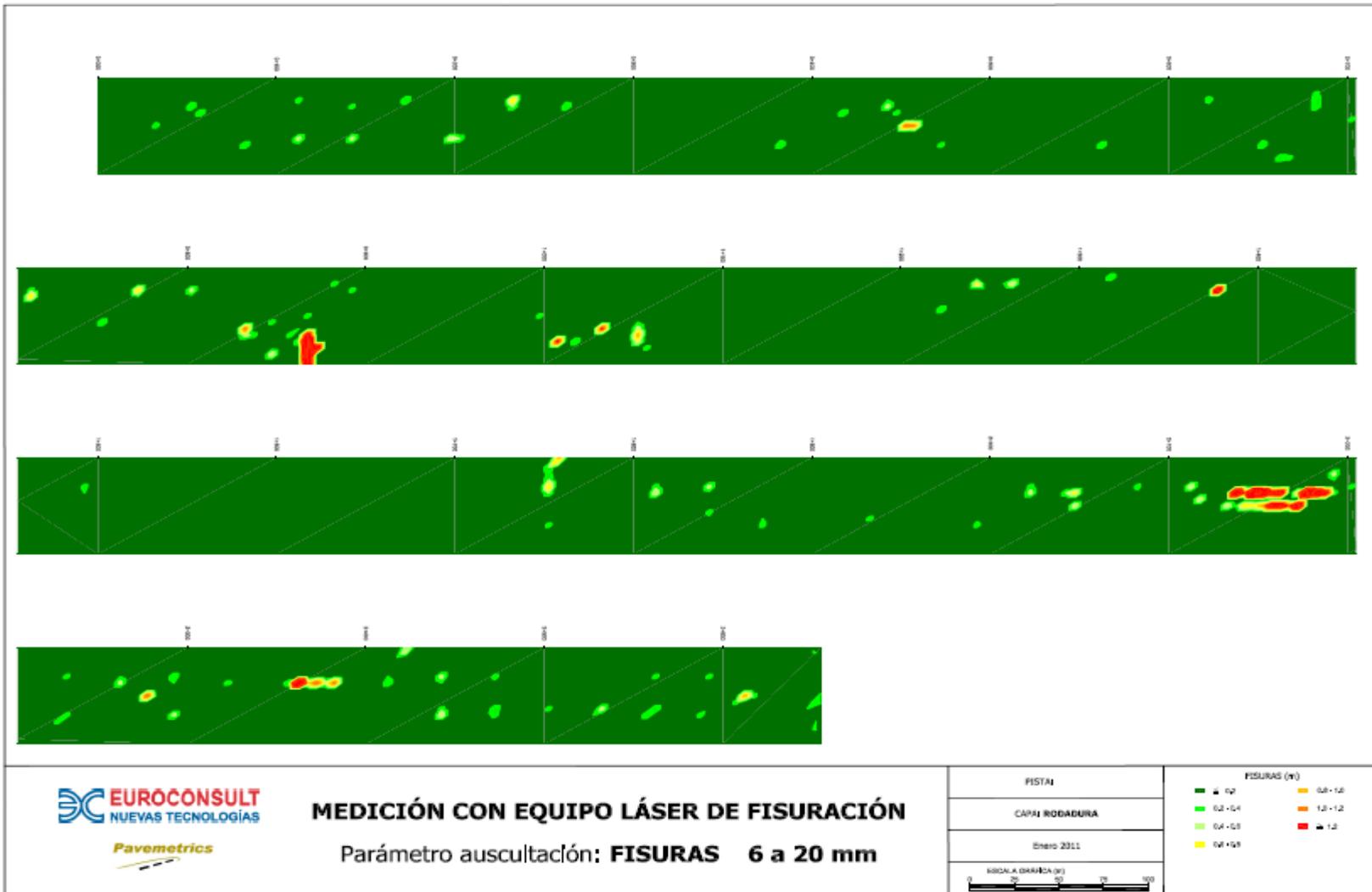
Enero 2011



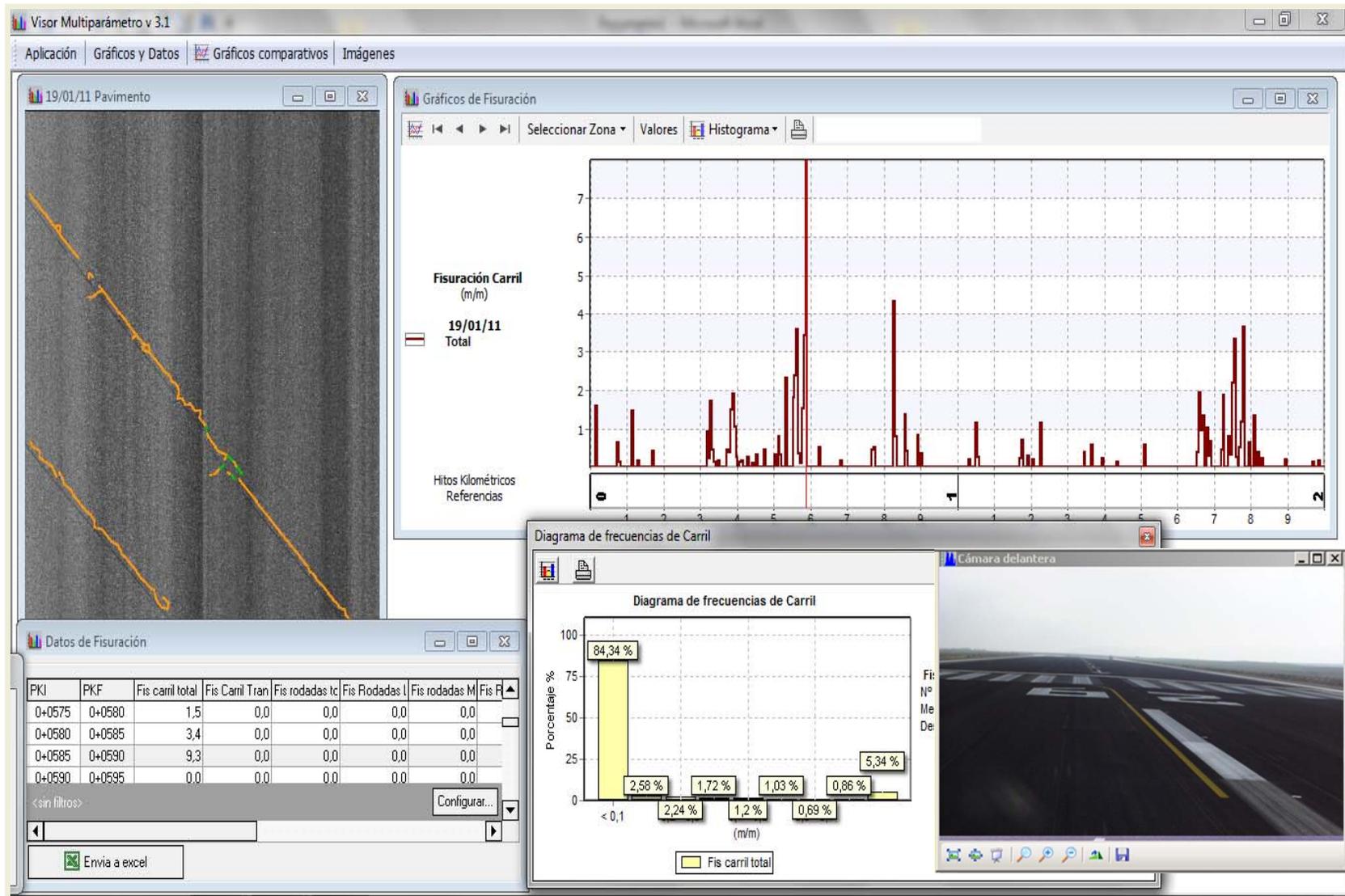
FISURA (m)



Barcelona - Cracking (6mm+)



Euroconsult – Reporting



Any Questions ?



Thank you.

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