Pavemetrics

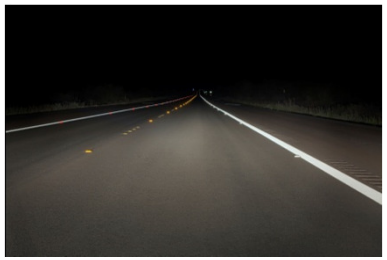
LCMS – Laser Crack Measurement System

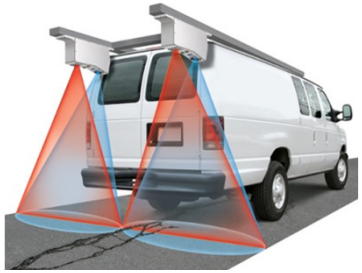
Vision Technology for Inspection of Transportation Infrastructures

John Laurent

jlaurent@pavemetrics.com

Food Chain

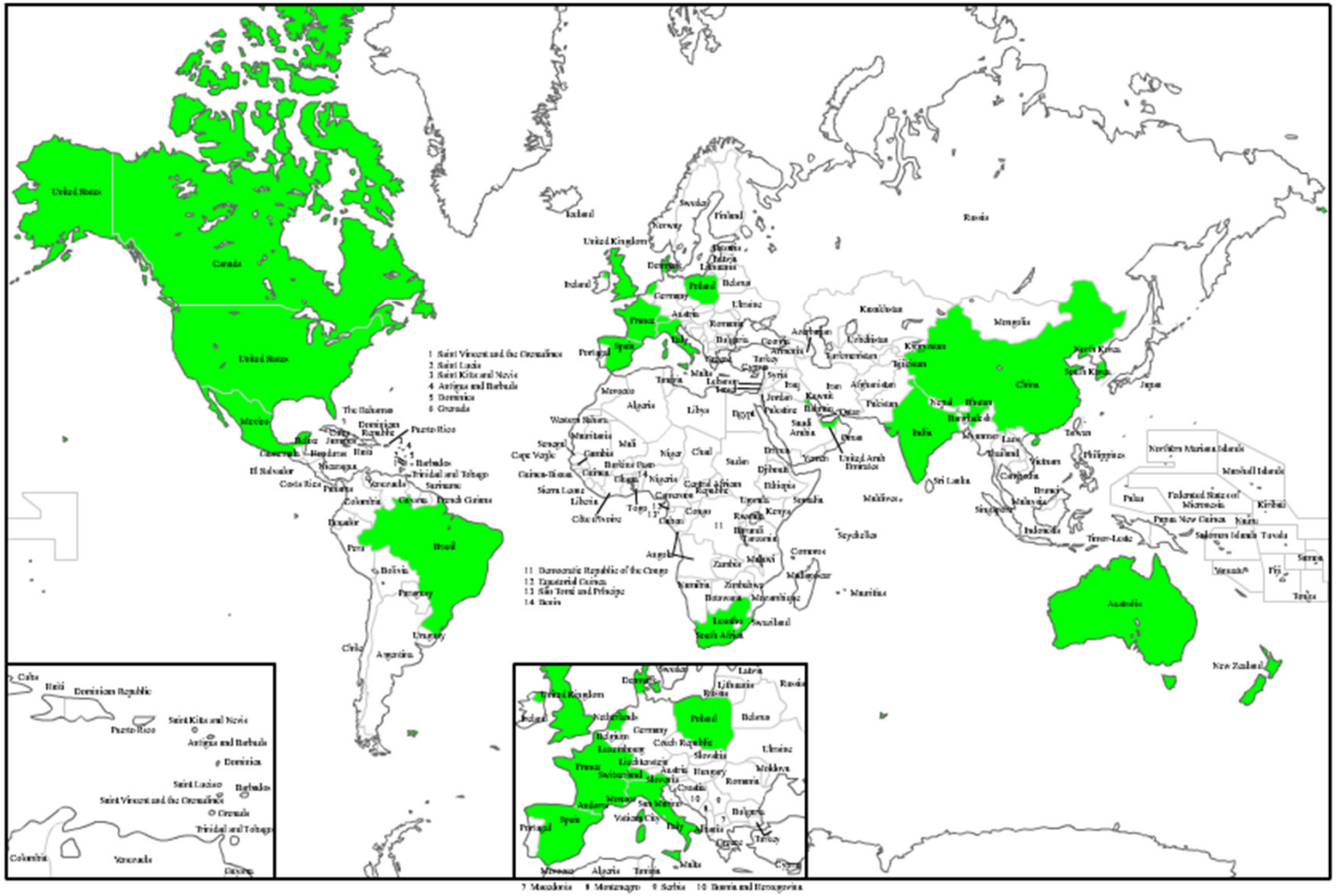




- Departments of Transportation
- Laboratories
- Data Collection Services
- System Integrators
- Pavemetrics Systems Inc.

Pavemetrics

Pavemetrics Systems Have Been Deployed World Wide



TimeLine and sensors history

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

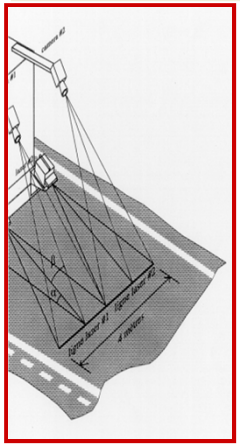
Roadware is the first integrator to embrace the LRMS technology

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.

1995... 2000 2002 2004 2006 2008 2010



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

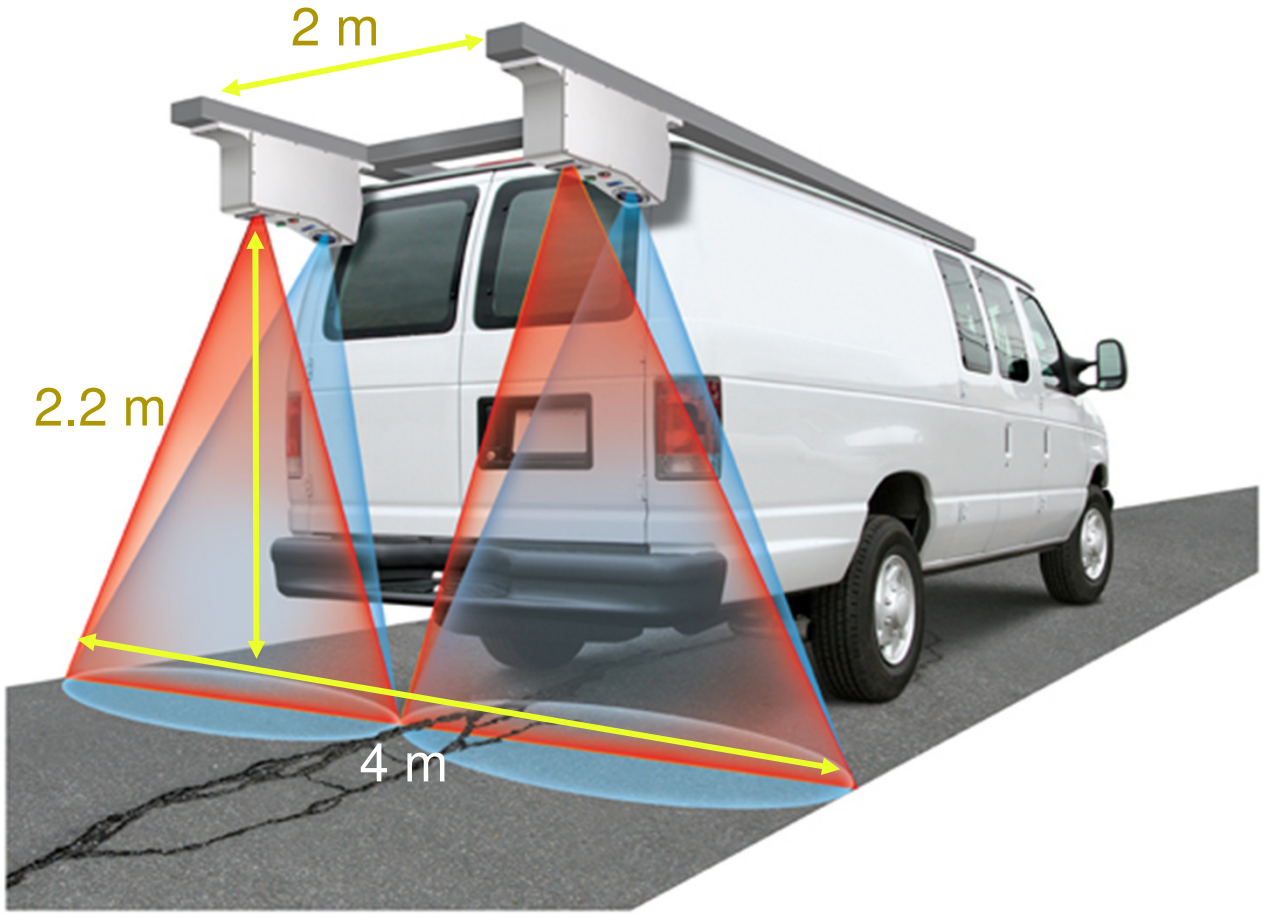
LRMS is now faster : High Speed version now captures 3D profiles at150Hz

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

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

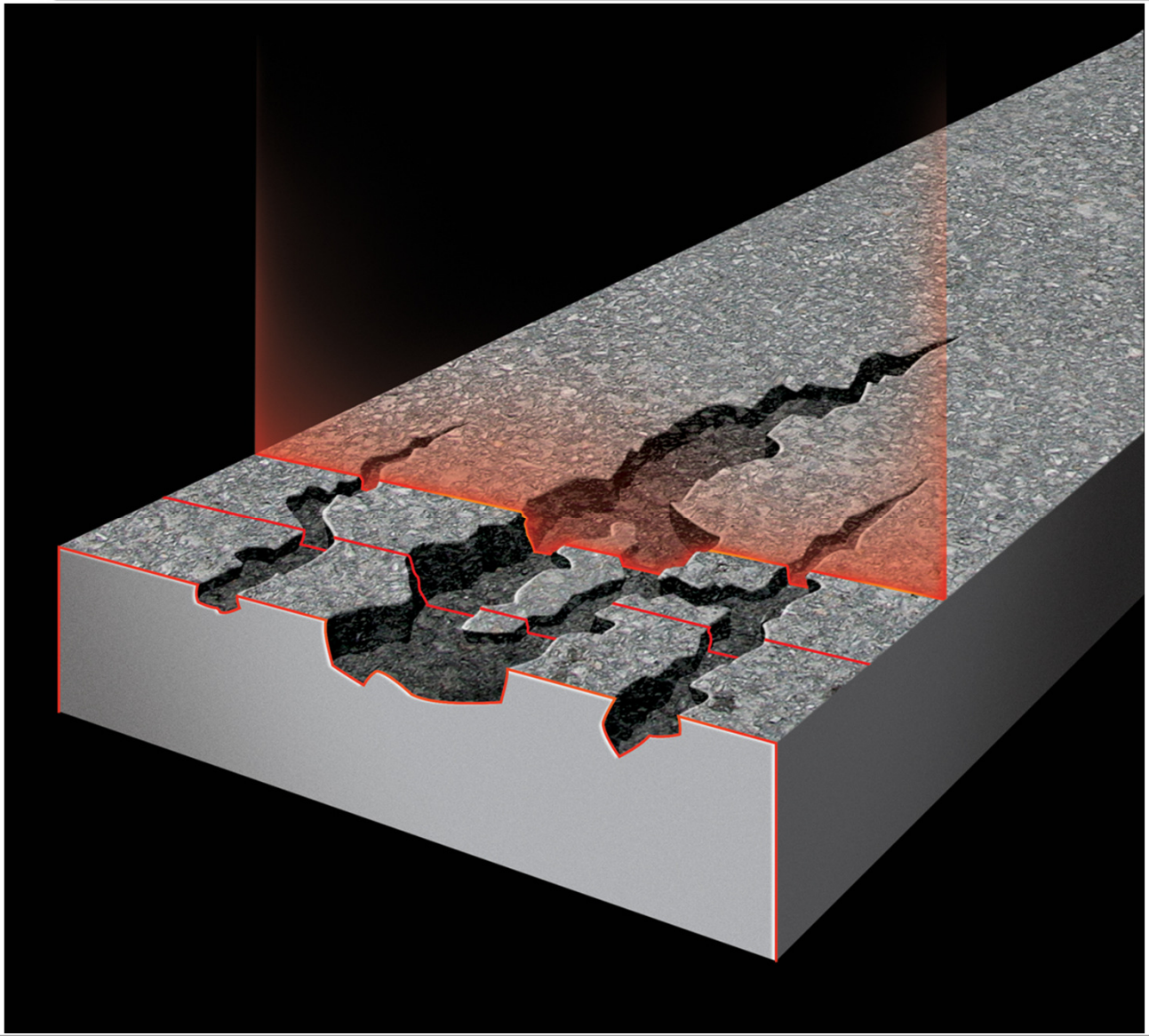
Pavemetrics

LCMS - System configuration



Pavemetrics

Laser profiling (principle)

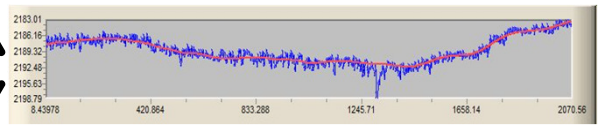


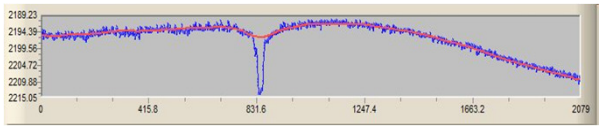
Pavemetrics

Specifications

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

Excellent 3D Accuracy



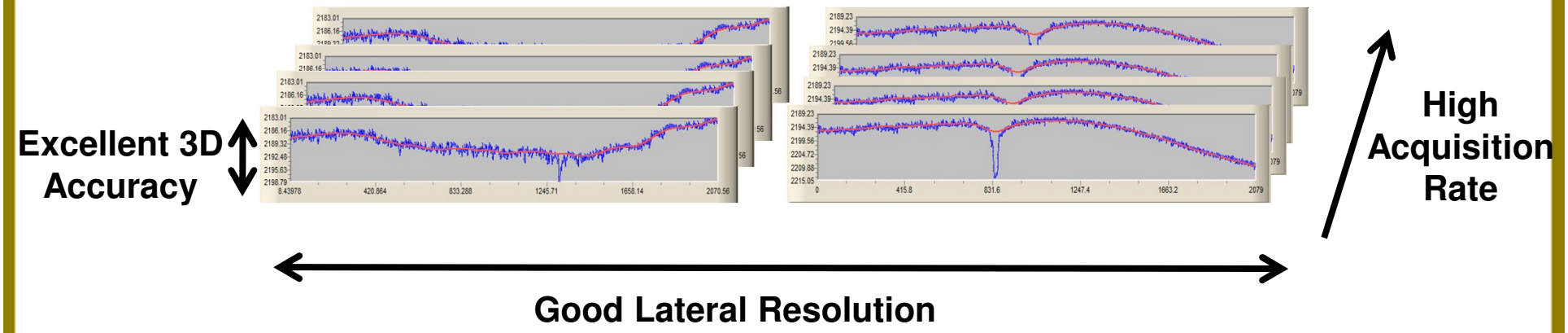


Good Lateral Resolution

Pavemetrics

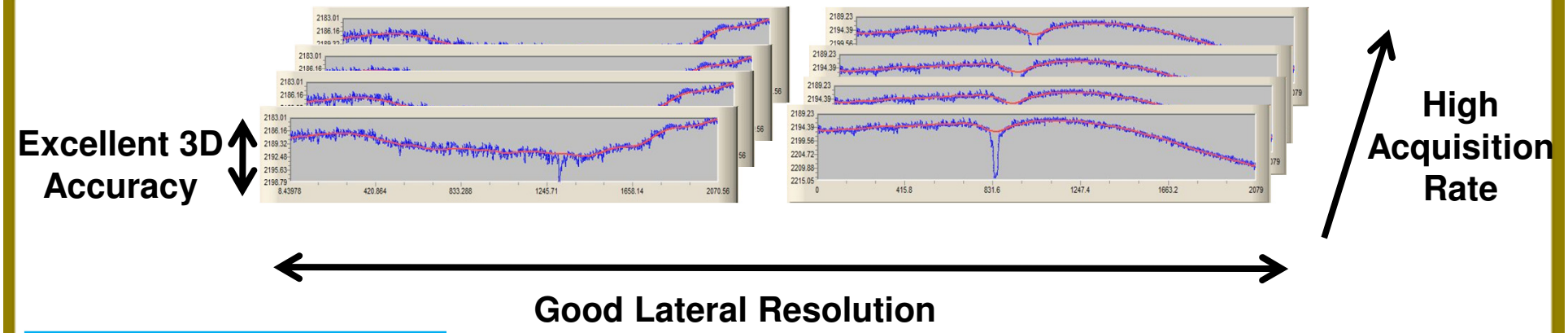
Specifications

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



Specifications

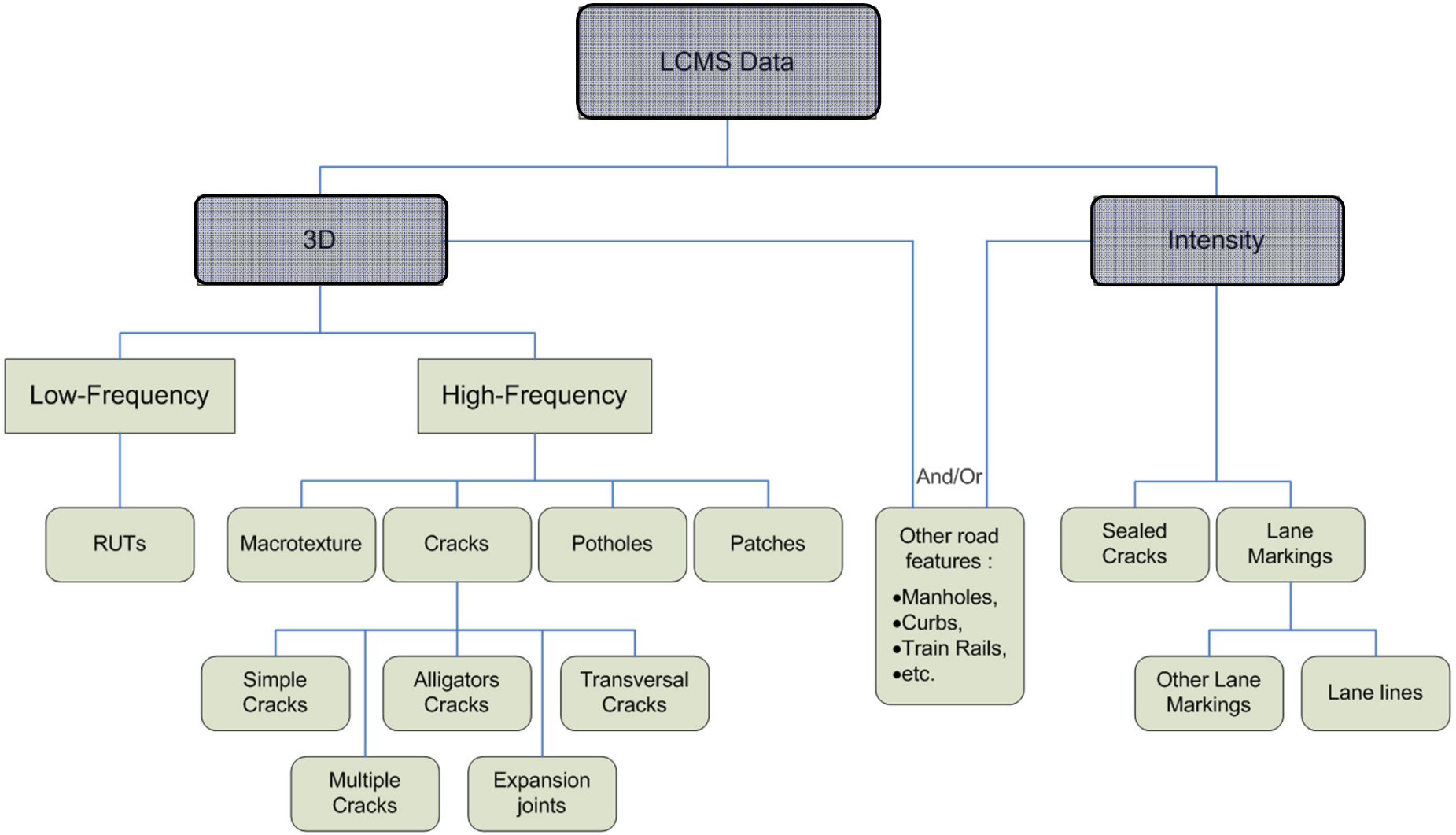
What makes a 3D sensor very good for crack measurement?



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

Pavemetrics

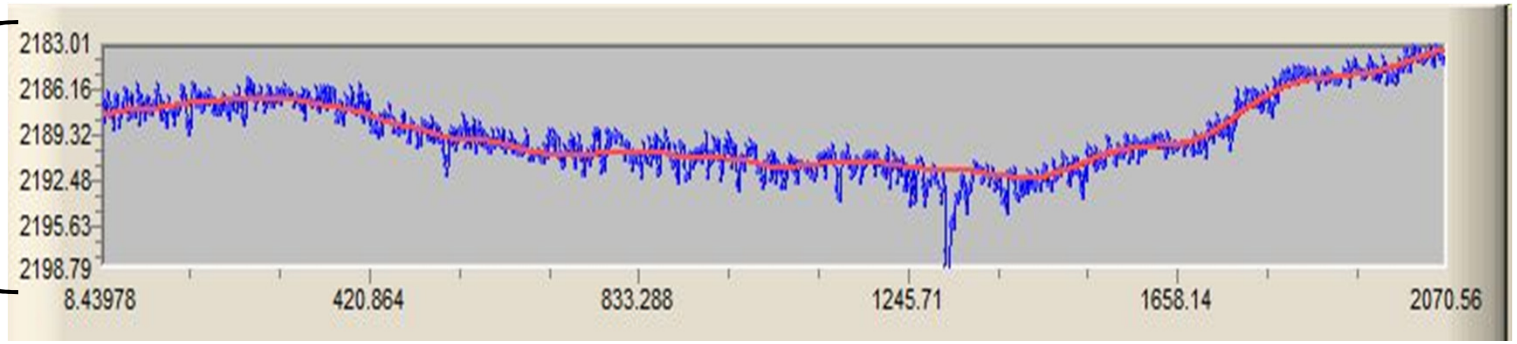
LCMS Data Processing Tree



Pavemetrics

Single Road Profile (2 meter)

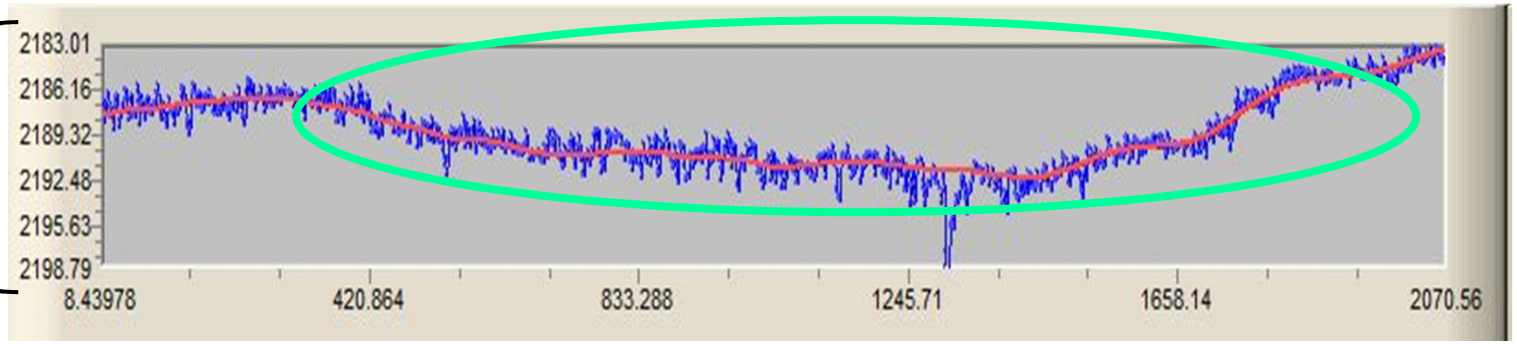
Distance between Sensor and ground (in mm)



Single Road Profile (2 meter)

Rut

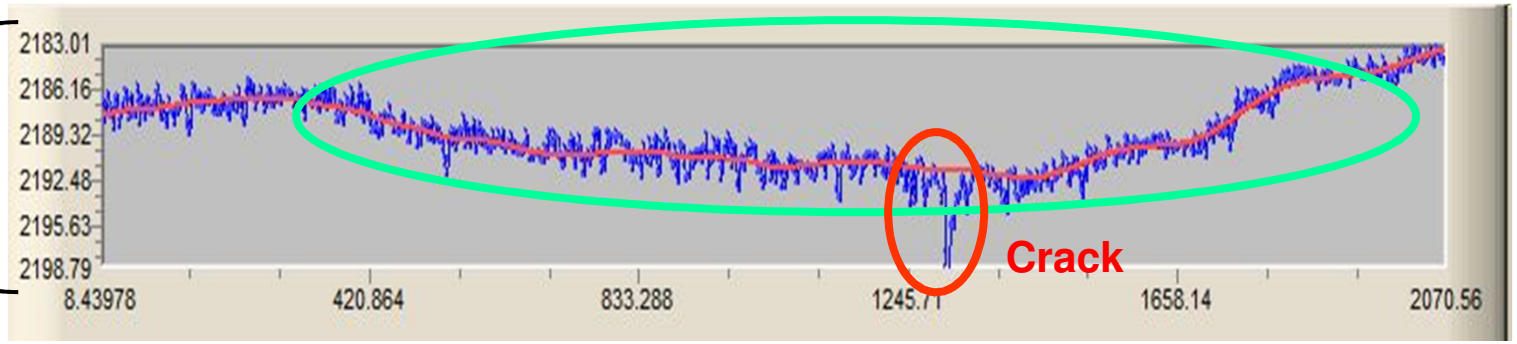
Distance between Sensor and ground (in mm)



Single Road Profile (2 meter)

Rut

Distance between Sensor and ground (in mm)

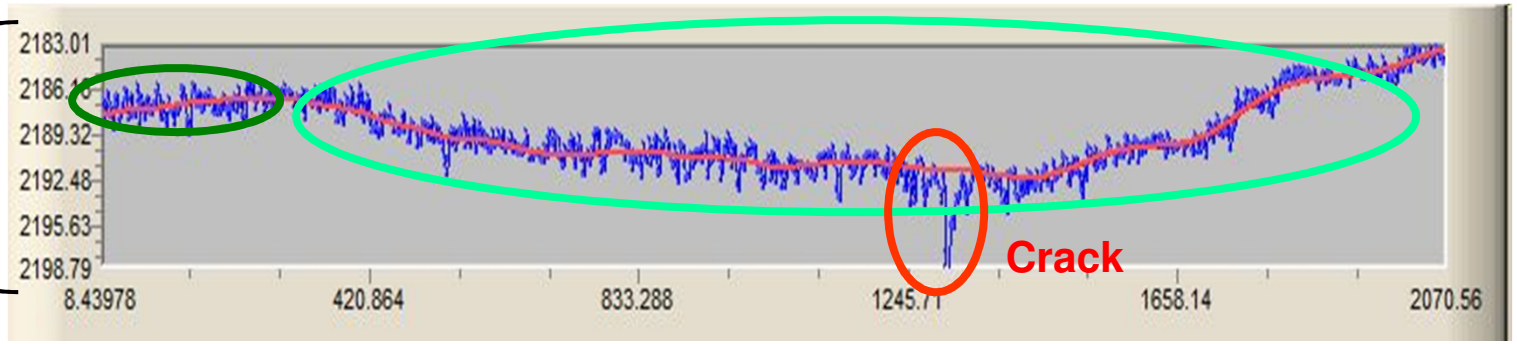


Single Road Profile (2 meter)

Macro-texture

Rut

Distance between Sensor and ground (in mm)

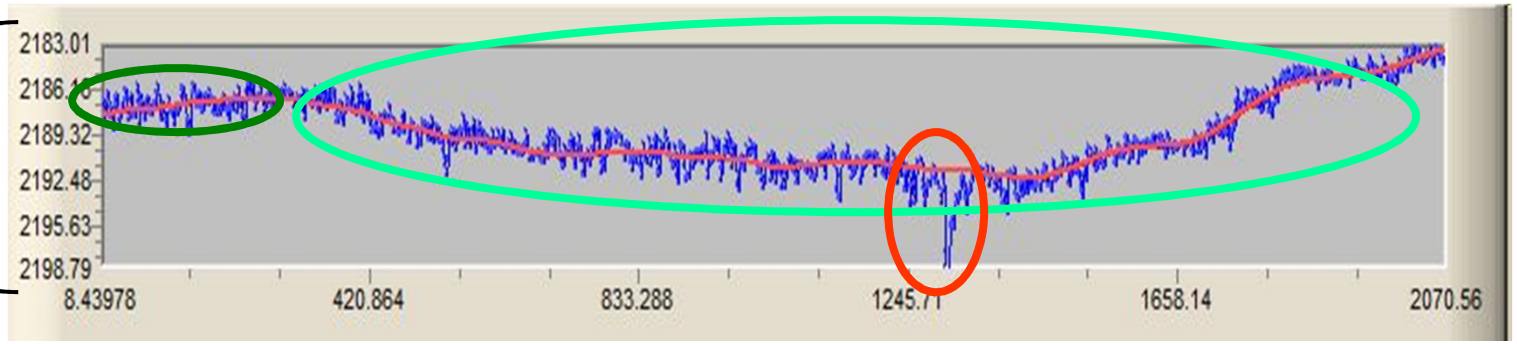


Single Road Profile (2 meter)

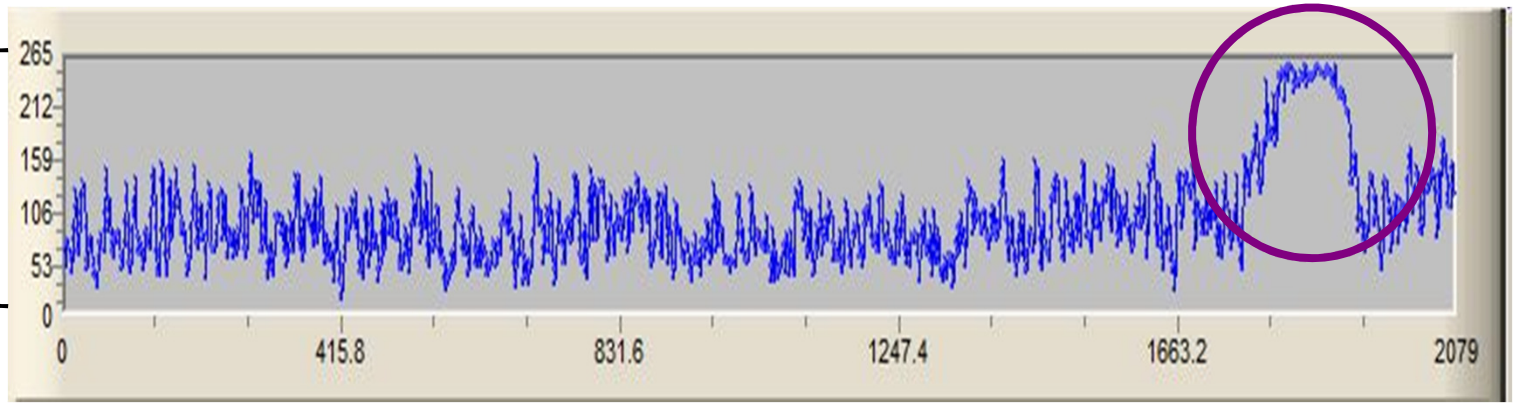
Macro-texture

Rut

Distance between Sensor and ground (in mm)



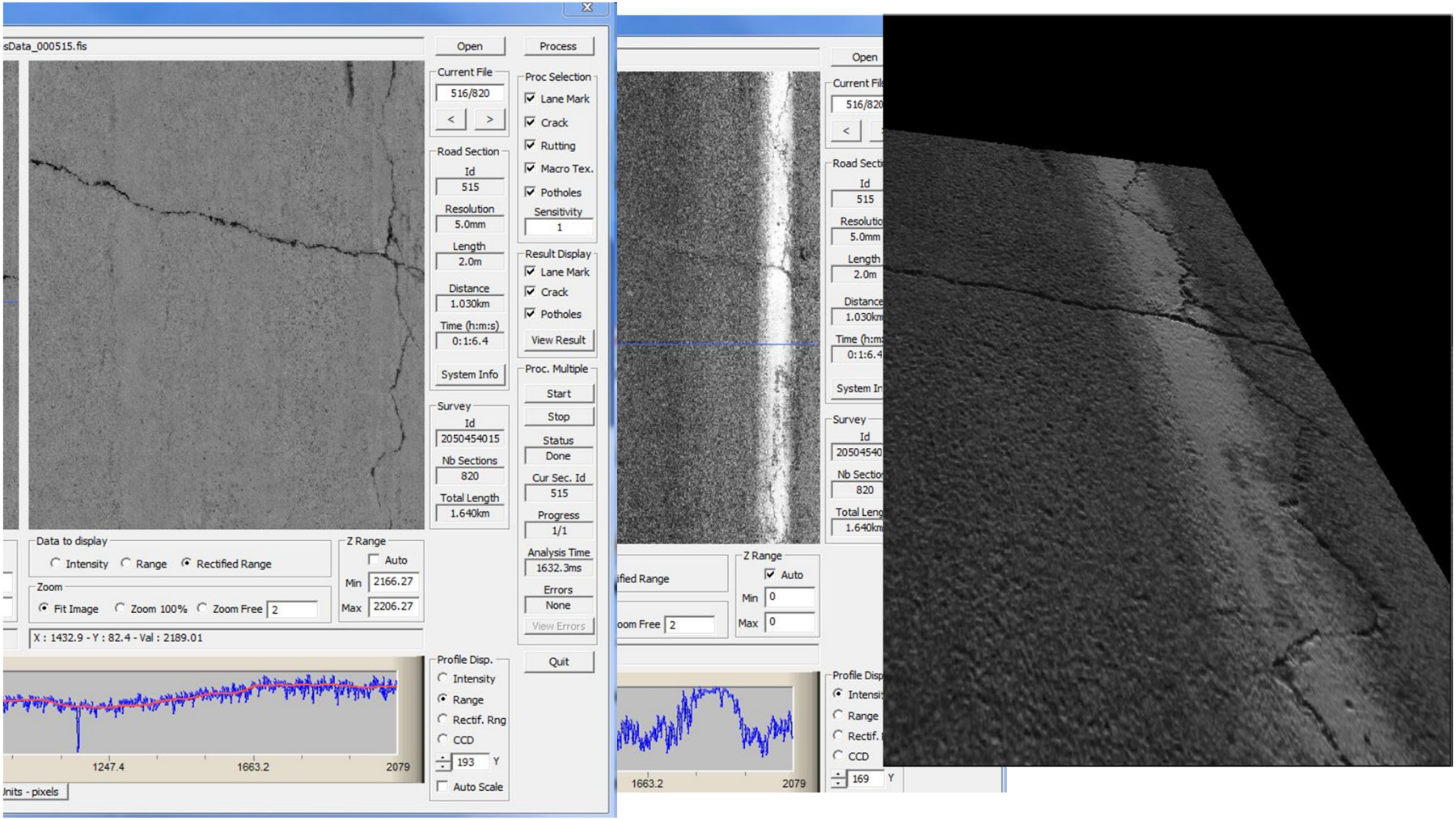
Laser intensity (black = 0, white = 255)



Right Lane Marking

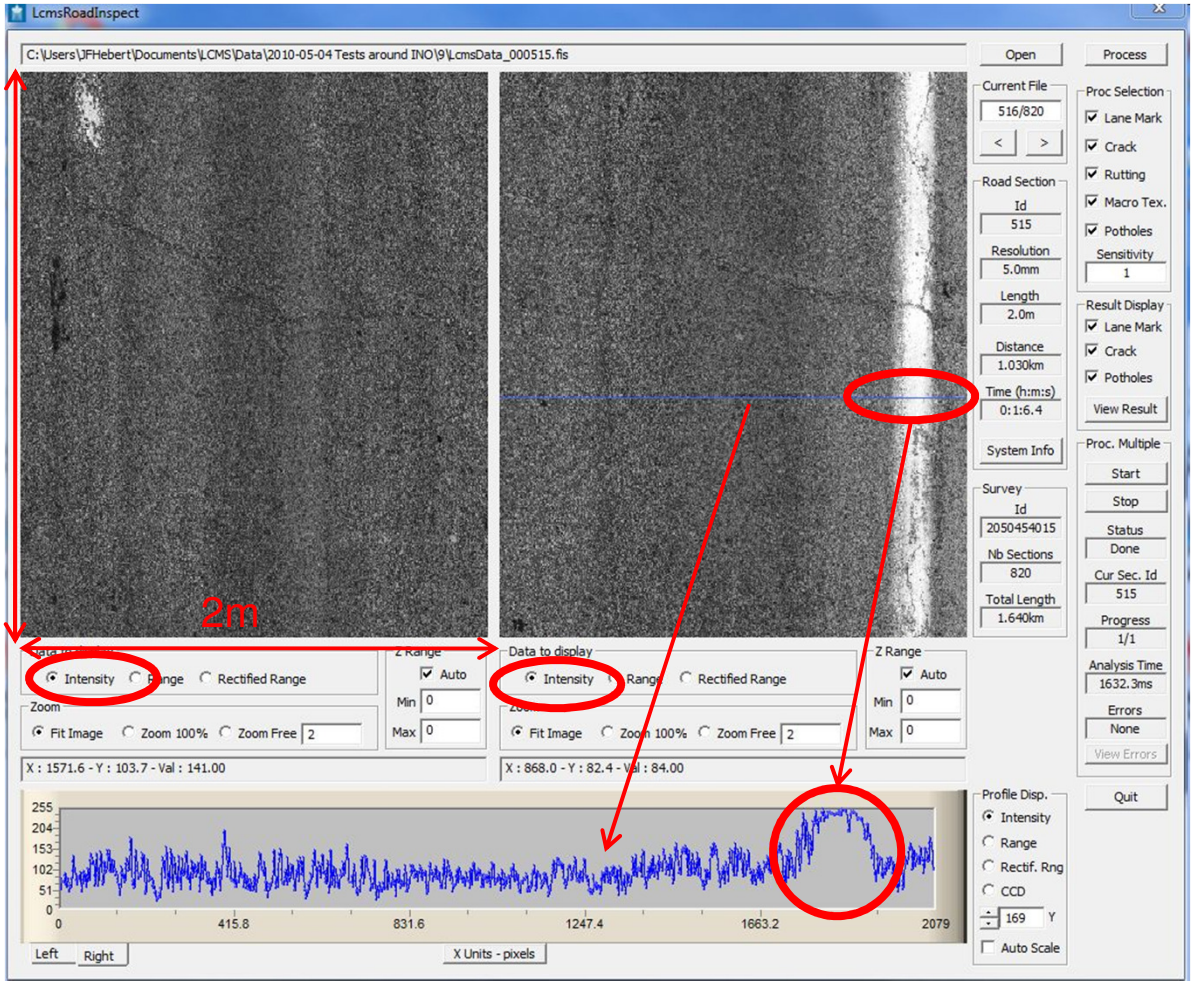
Pavemetrics

Range + Intensity = 3D !



Road Section: Intensity Data

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



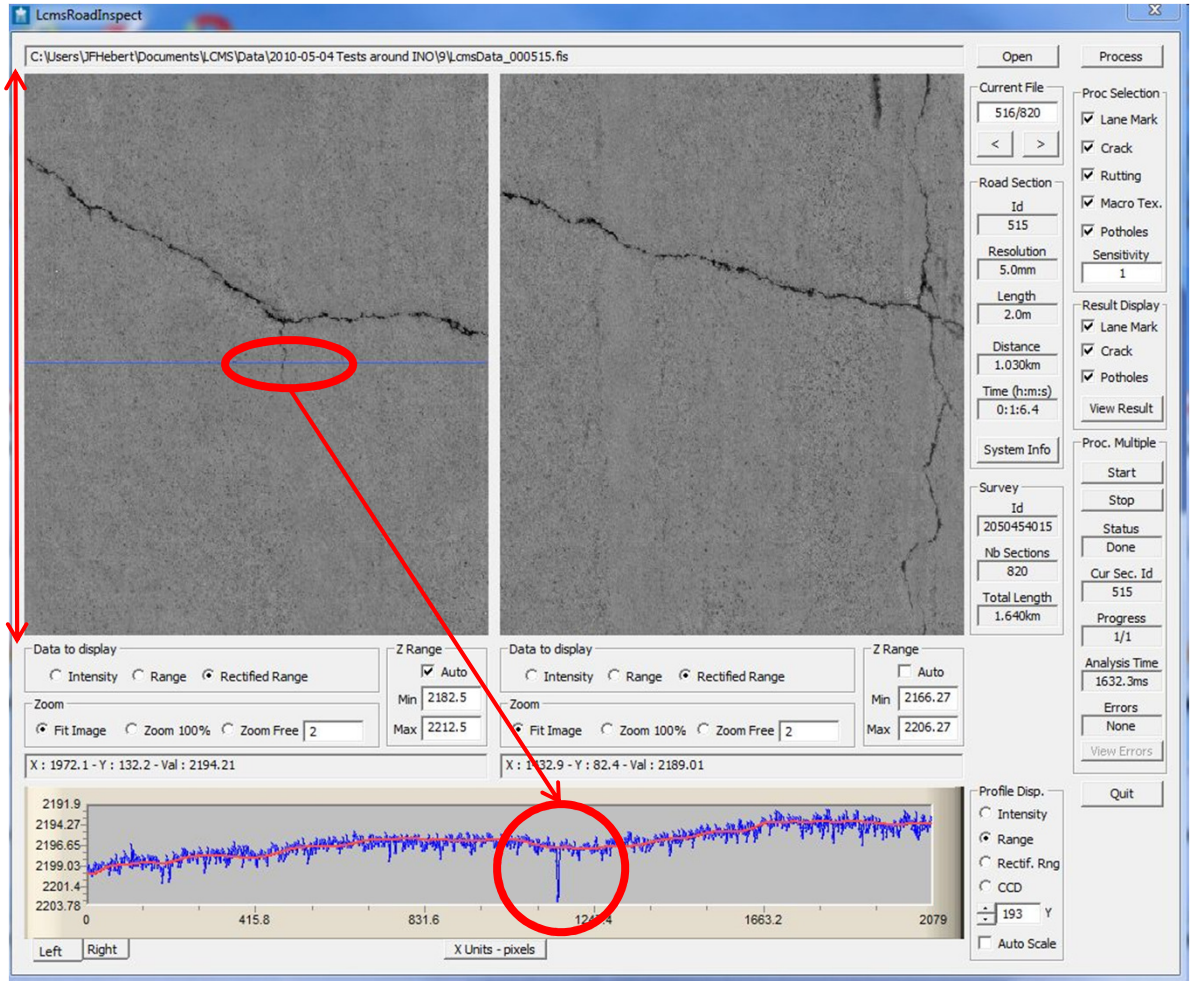
Definition:
A Road Section is a set of profiles merged together.

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.

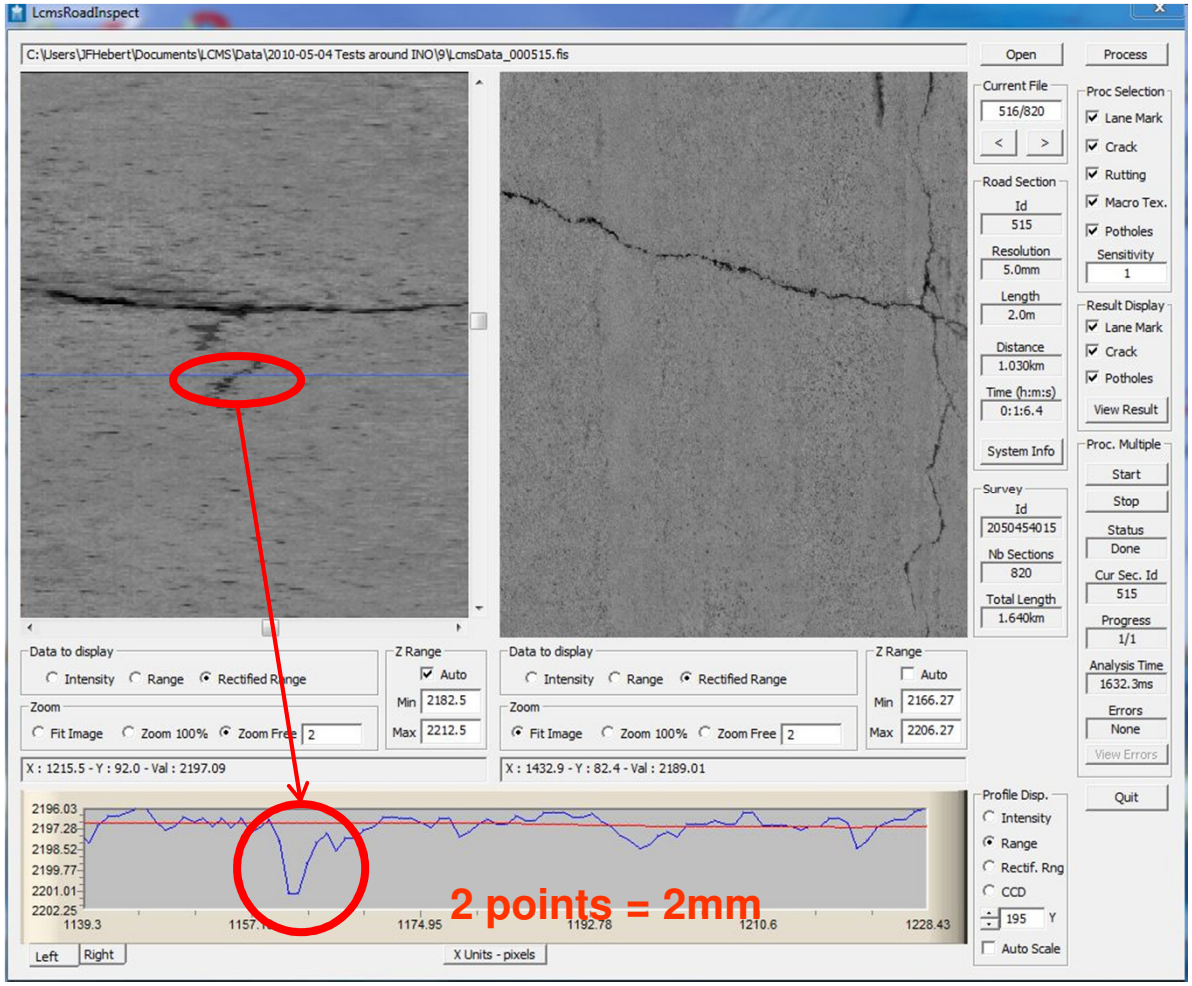
Mapping to 2D Viewer:

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

Cracks:

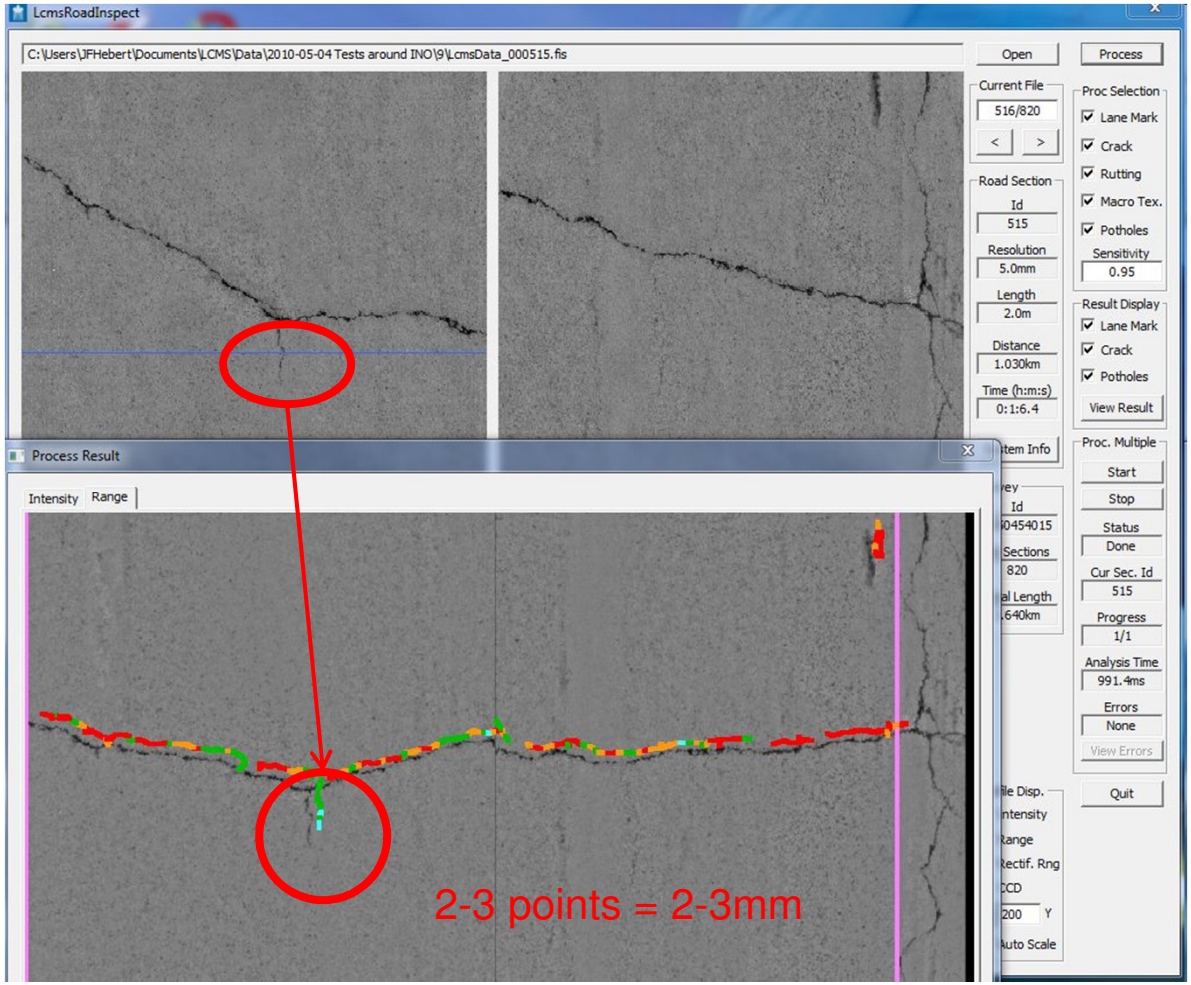
- Notch in the profile
- Appear darker in range image

Road Section: Range Data (zoomed)



Zoom on a 2 to 3 mm crack

Crack detection example



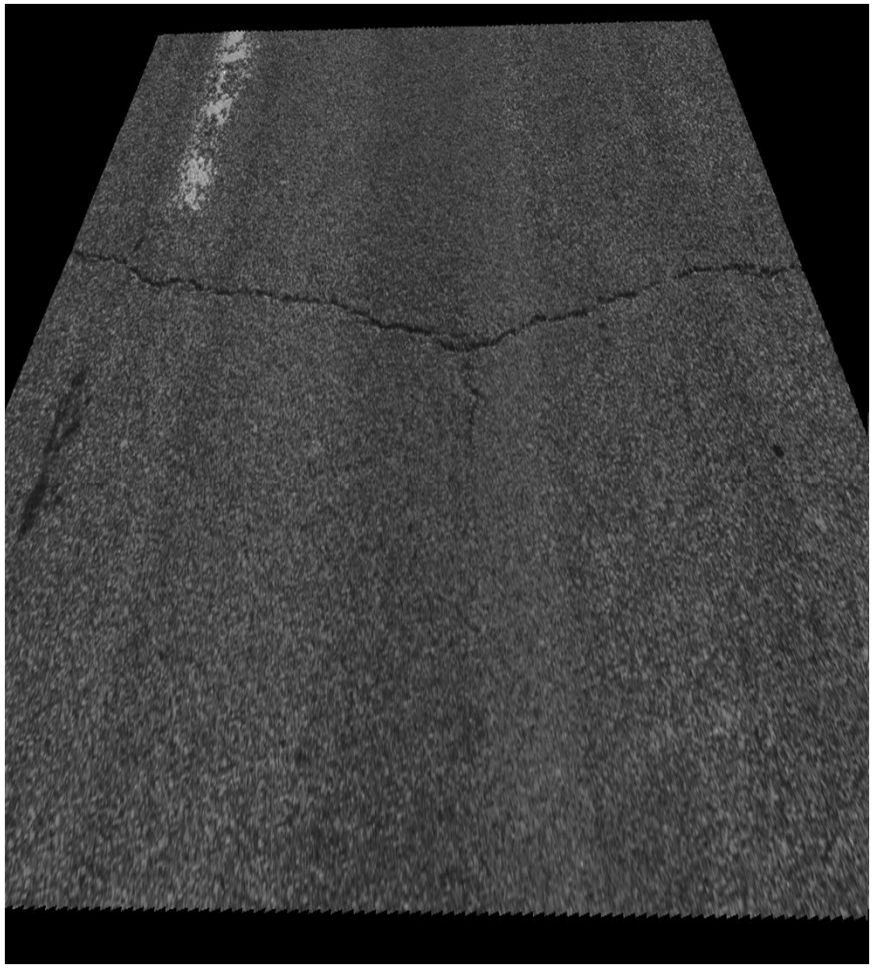
LCMSLib:

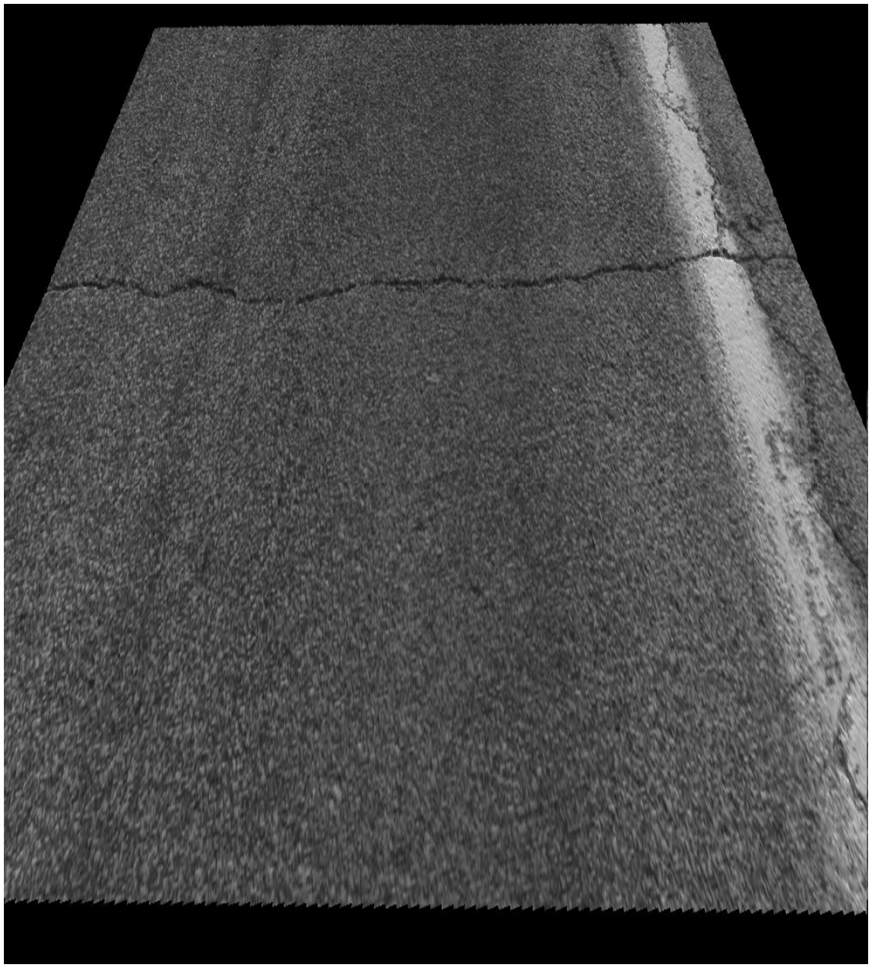
- C/C++ Win32 DLL library
- Easy to interface (Open, Process, GetResults)
- Outputs crackmap as a XML string.

```
- <CrackInformation>
    <DataFormat>1.0</DataFormat>
  - <Unit>
      <X>millimeter</X>
      <Y>millimeter</Y>
      <Width>millimeter</Width>
    </Unit>
  - <CrackList>
    - <Crack>
      - <Node>
          <X>2093.0</X>
          <Y>9445.0</Y>
          <Width>11.8</Width>
        </Node>
      - <Node>
          <X>2098.0</X>
          <Y>9465.0</Y>
          <Width>11.2</Width>
        </Node>
      - <Node>
          <X>2104.0</X>
          <Y>9485.0</Y>
```

Pavemetrics

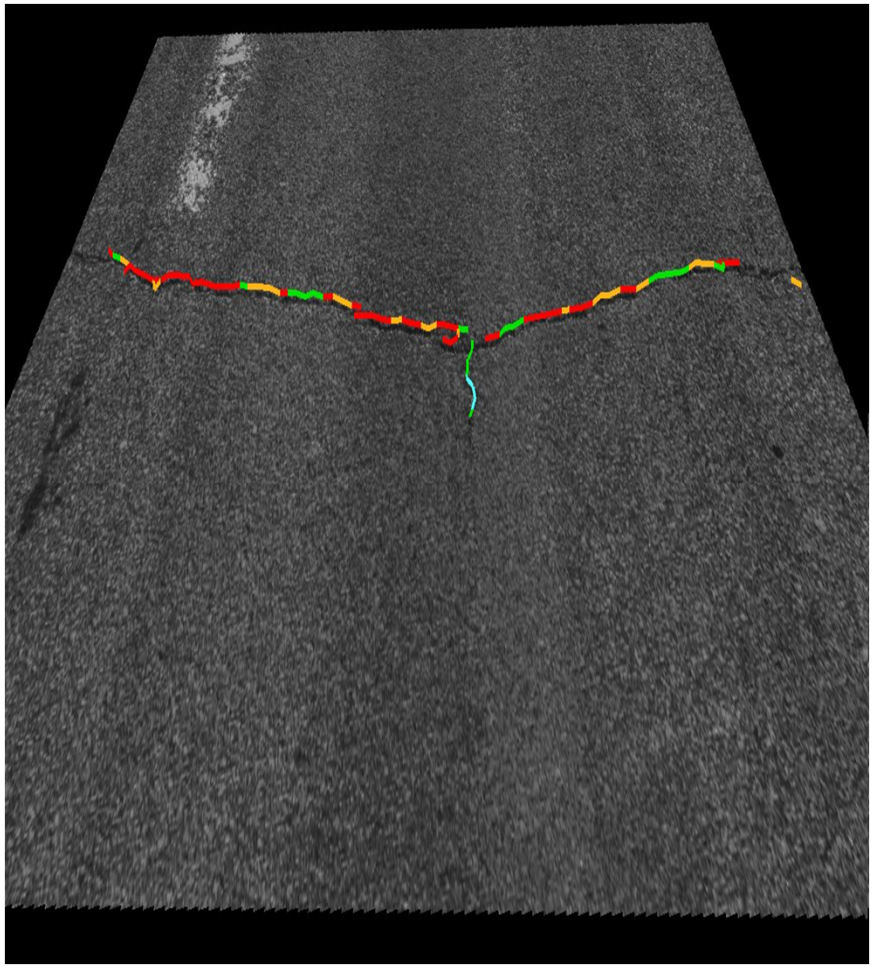
Range + Intensity = 3D !

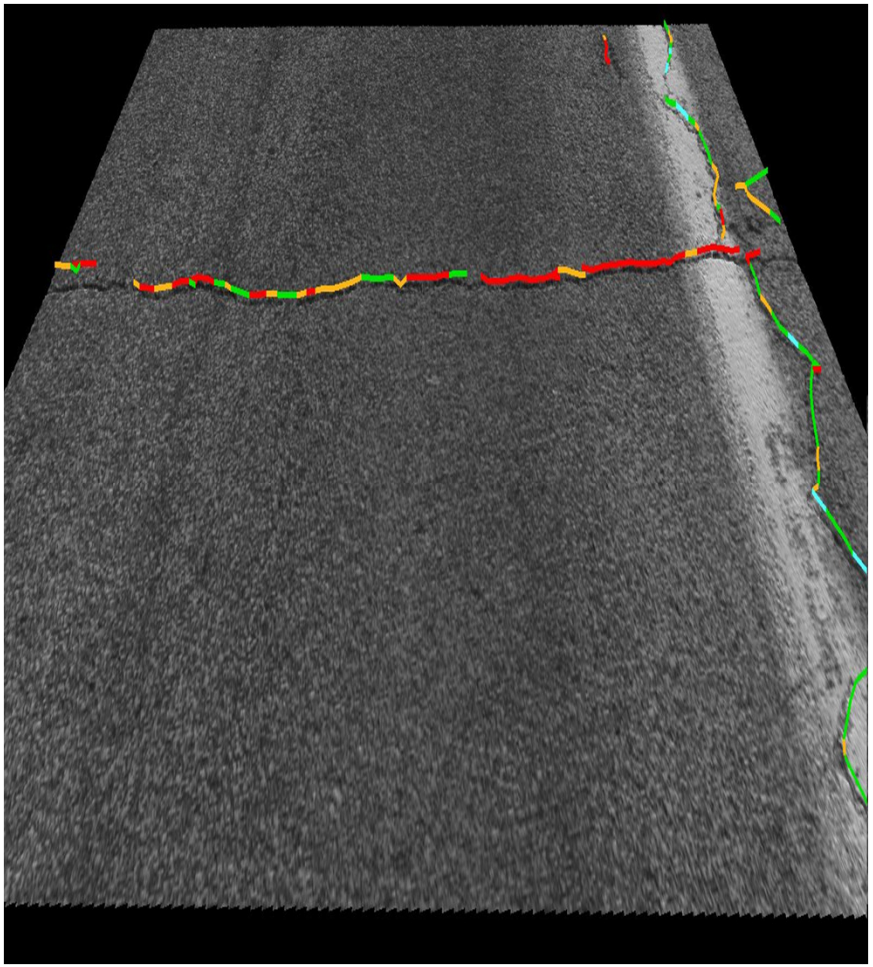




Pavemetrics

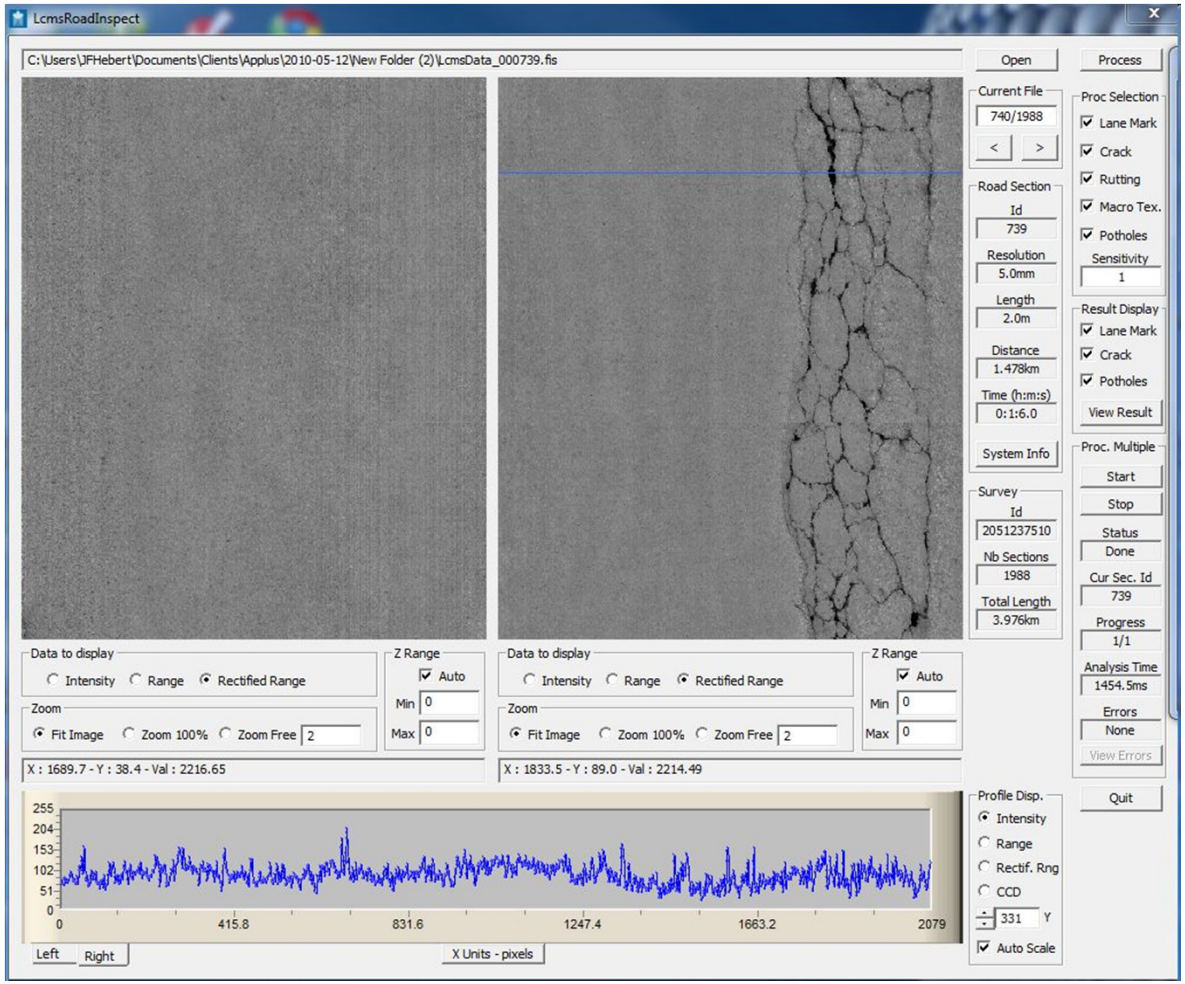
Automatic Crack Detection
Length, Type, Severity





Pavemetrics

Alligator Cracks

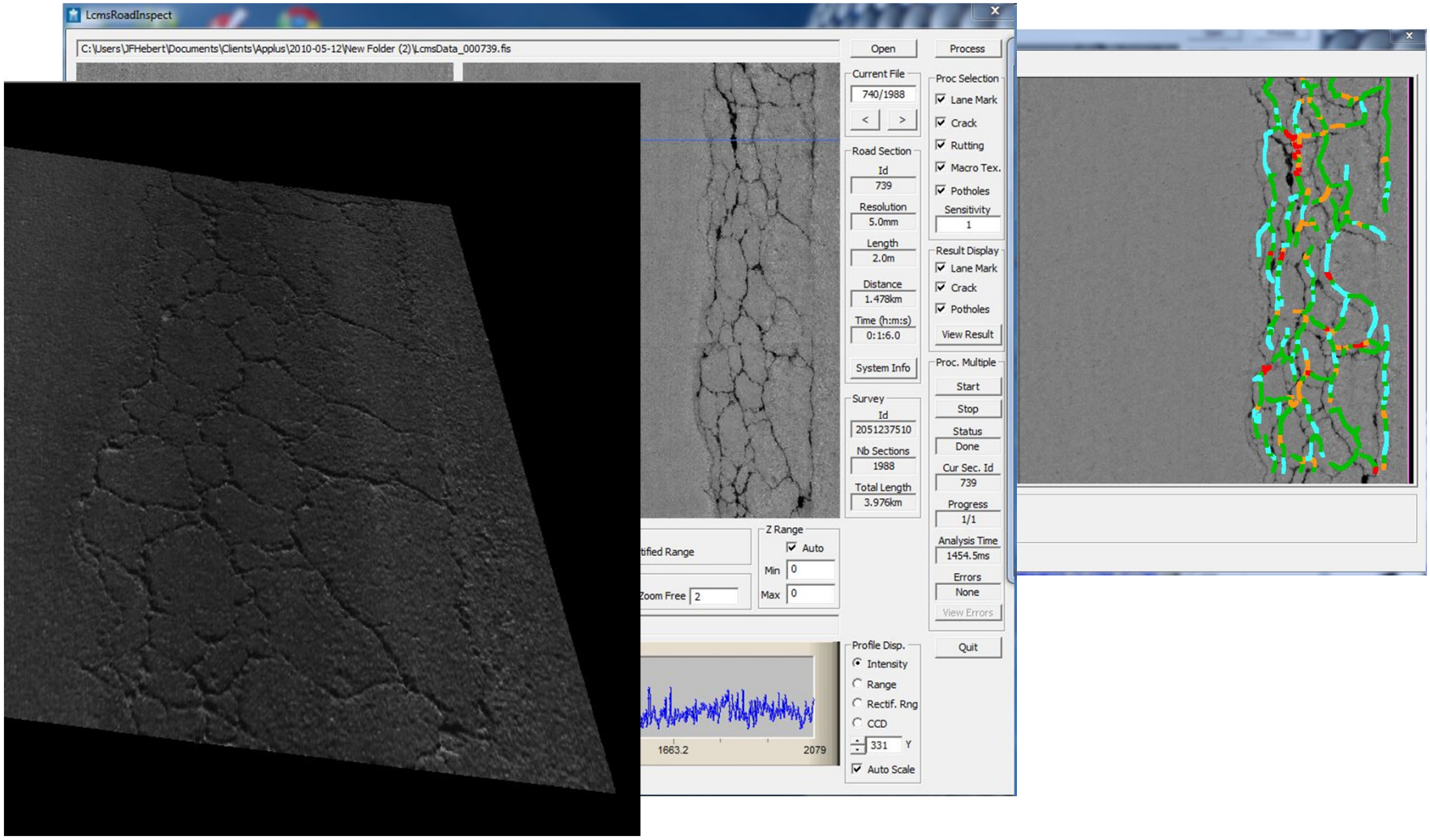


Definition

Alligator cracking

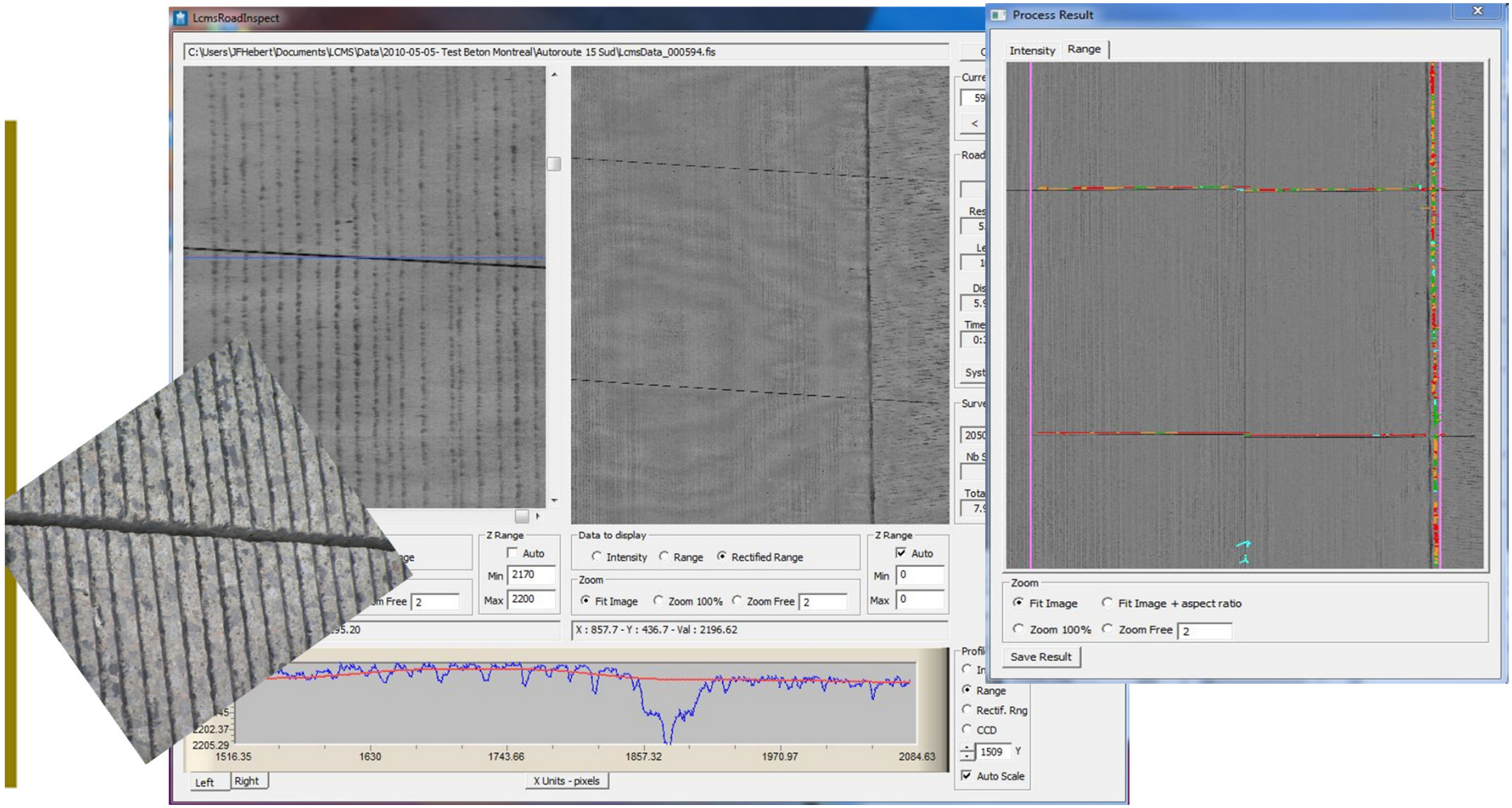
Pavemetrics

Alligator Cracks



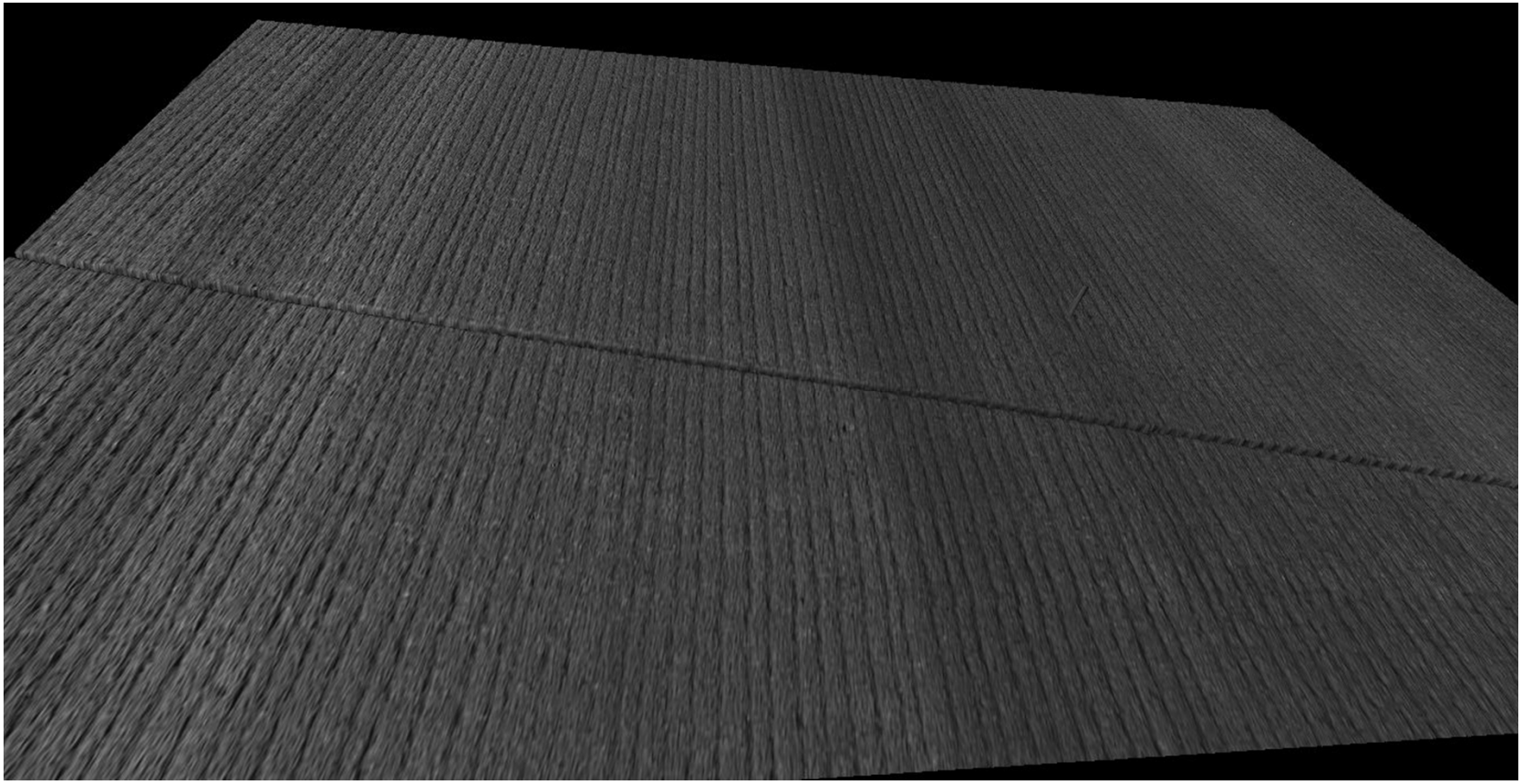
Pavemetrics

Concrete Roads



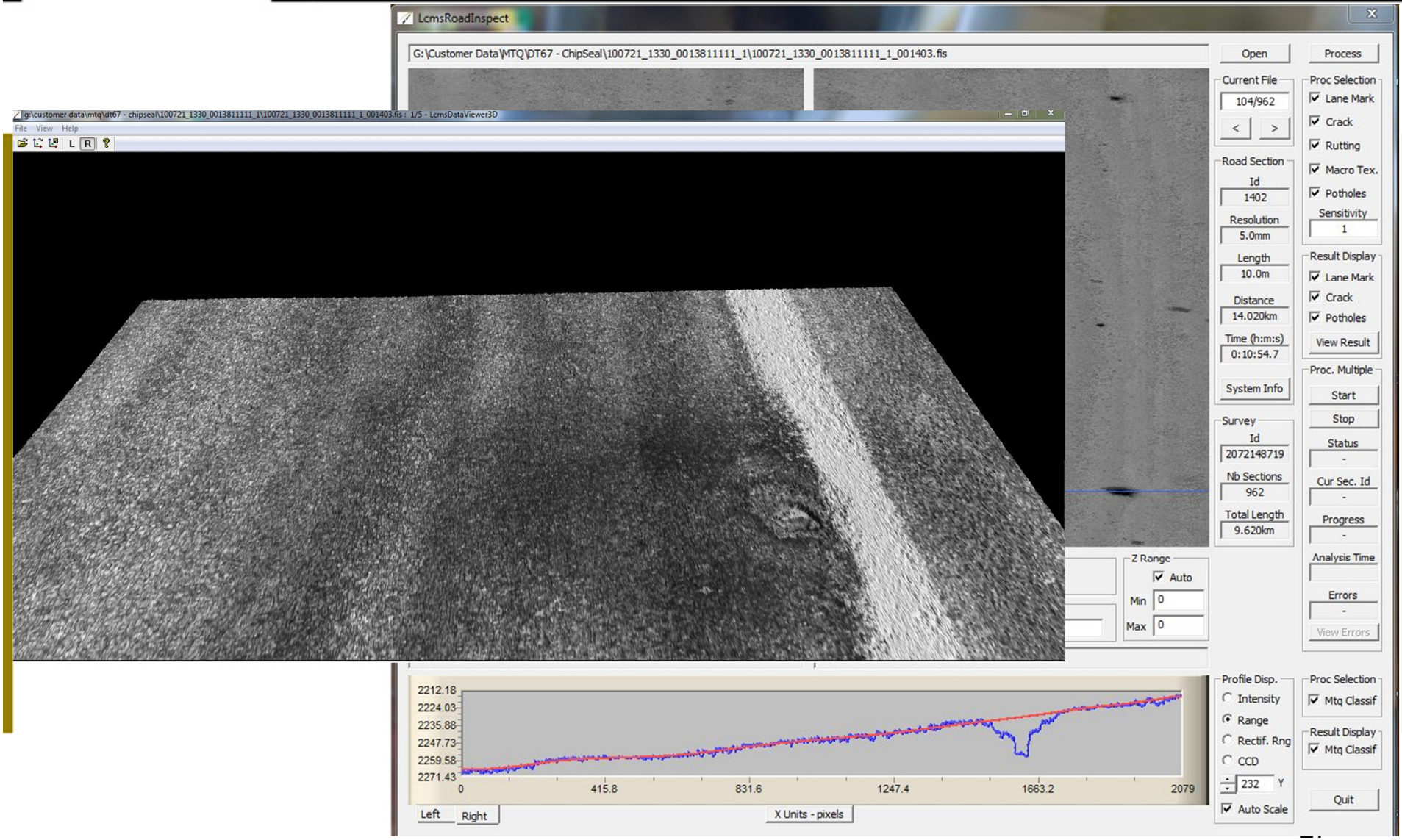
Pavemetrics

Concrete Roads

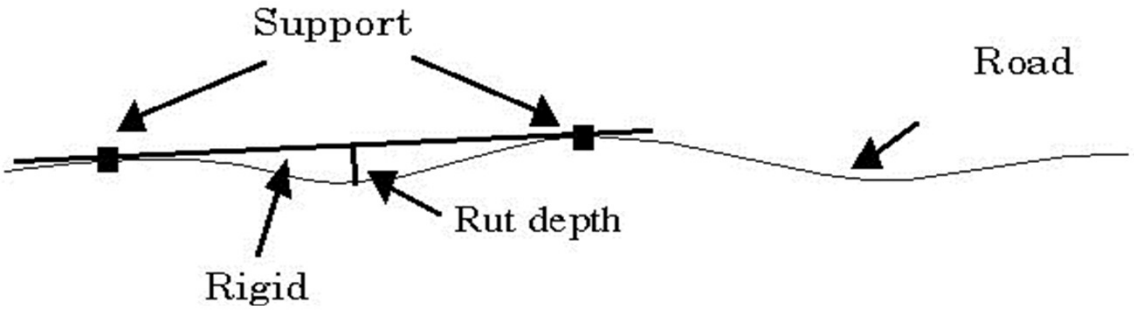


Pavemetrics

Chip seal surfaces

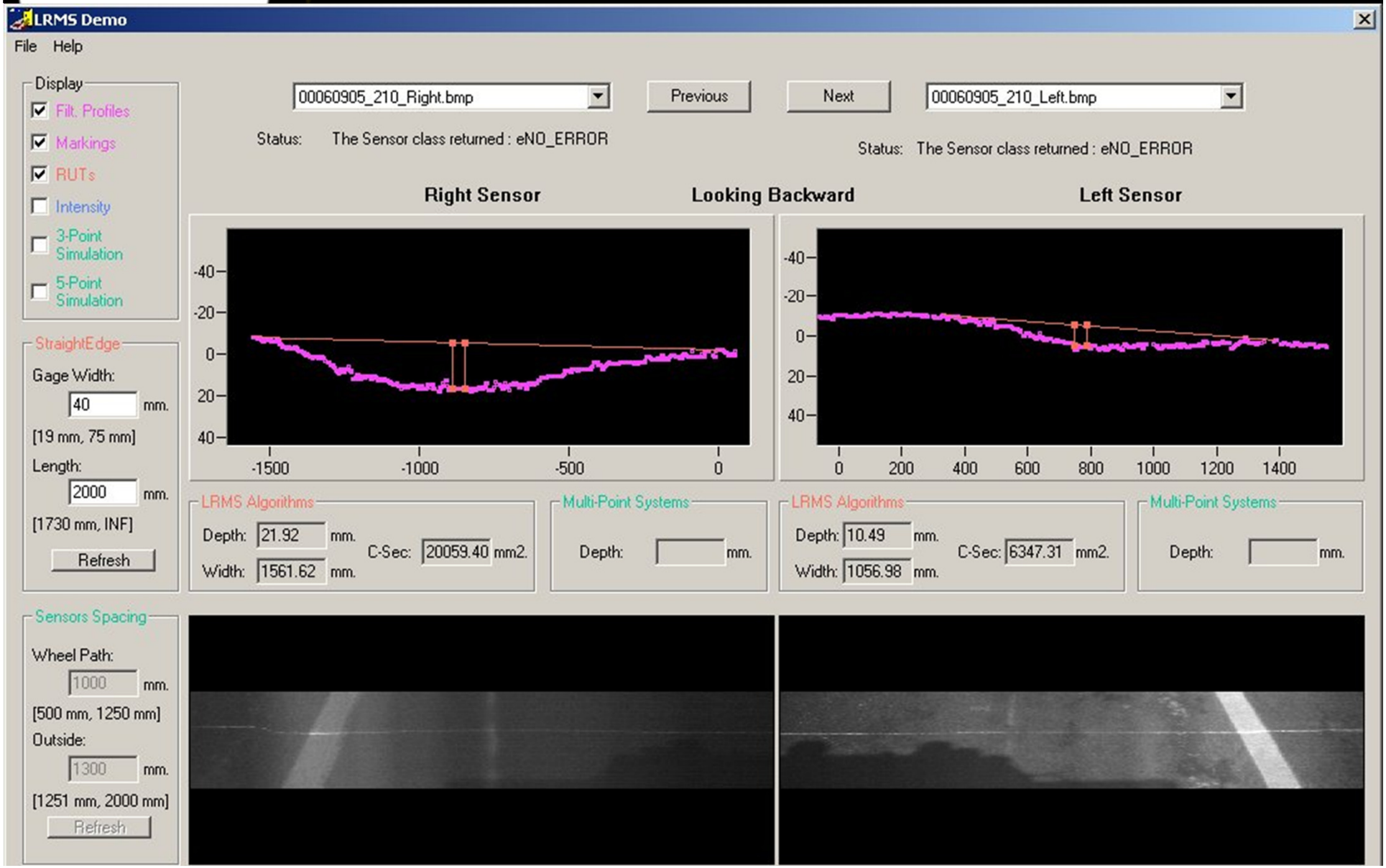


Manual rut depth measurements



Pavemetrics

Example



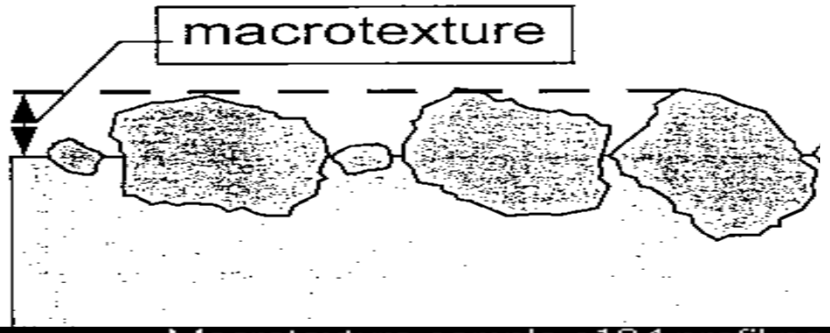
Pavemetrics

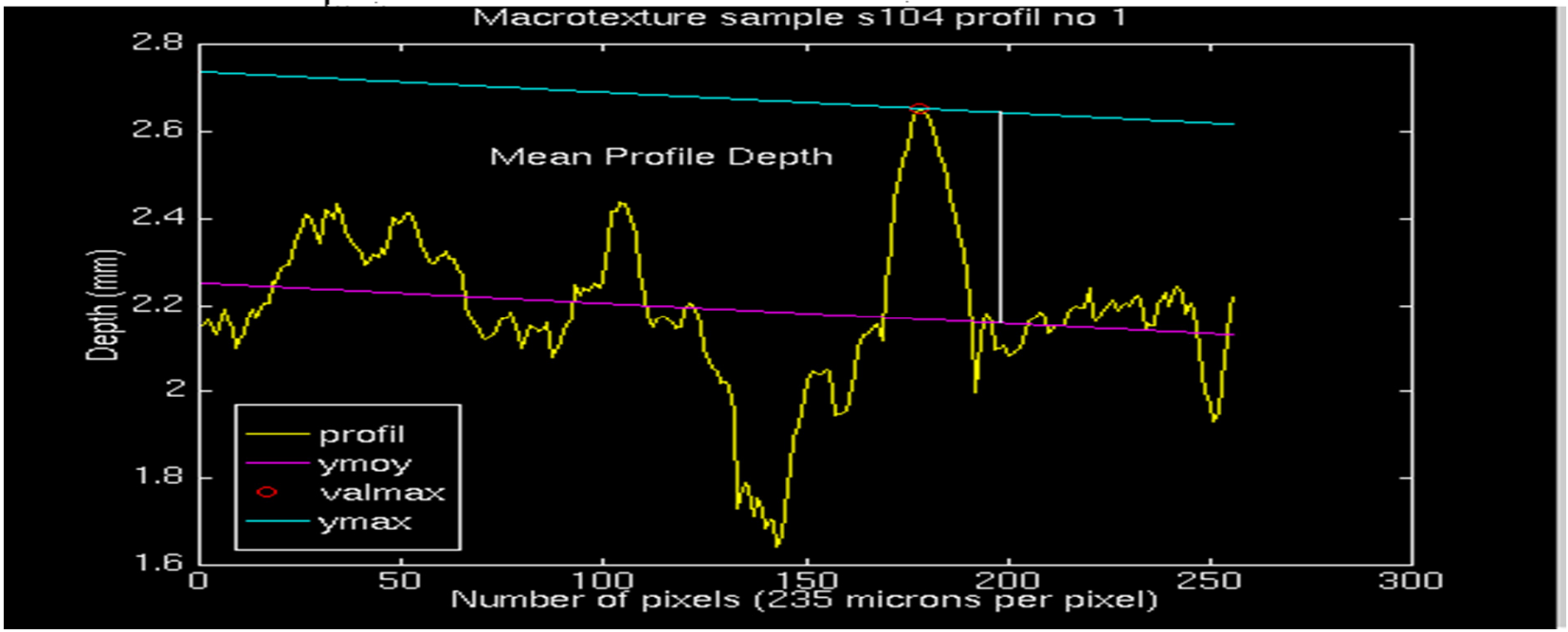
Validation – 10 m intervals

RUT DEPTH (mm)	Right rut			Left rut		
	INO		MTQ	INO		MTQ
Segment	Avg.	Std. Dev.	Rut Bar	Avg.	Std. Dev.	Rut Bar
10	5.2	0.4	6.0	6.4	0.9	4.0
50	9.2	0.3	10.0	6.2	0.6	6.0
100	14.7	1.1	13.0	9.2	0.8	10.0
150	14.8	0.7	14.0	4.3	0.3	3.0
200	22.6	0.4	22.0	1.4	0.4	2.0
250	19.6	0.7	19.0	6.2	0.6	5.0
300	19.7	0.7	23.0	7.3	3.2	8.0
350	37.6	2.2	42.0	10.4	1.2	7.0
Average (of 40 segments)	**20.3**	**1.0**	**21.7**	**8.8**	**1.1**	**7.1**

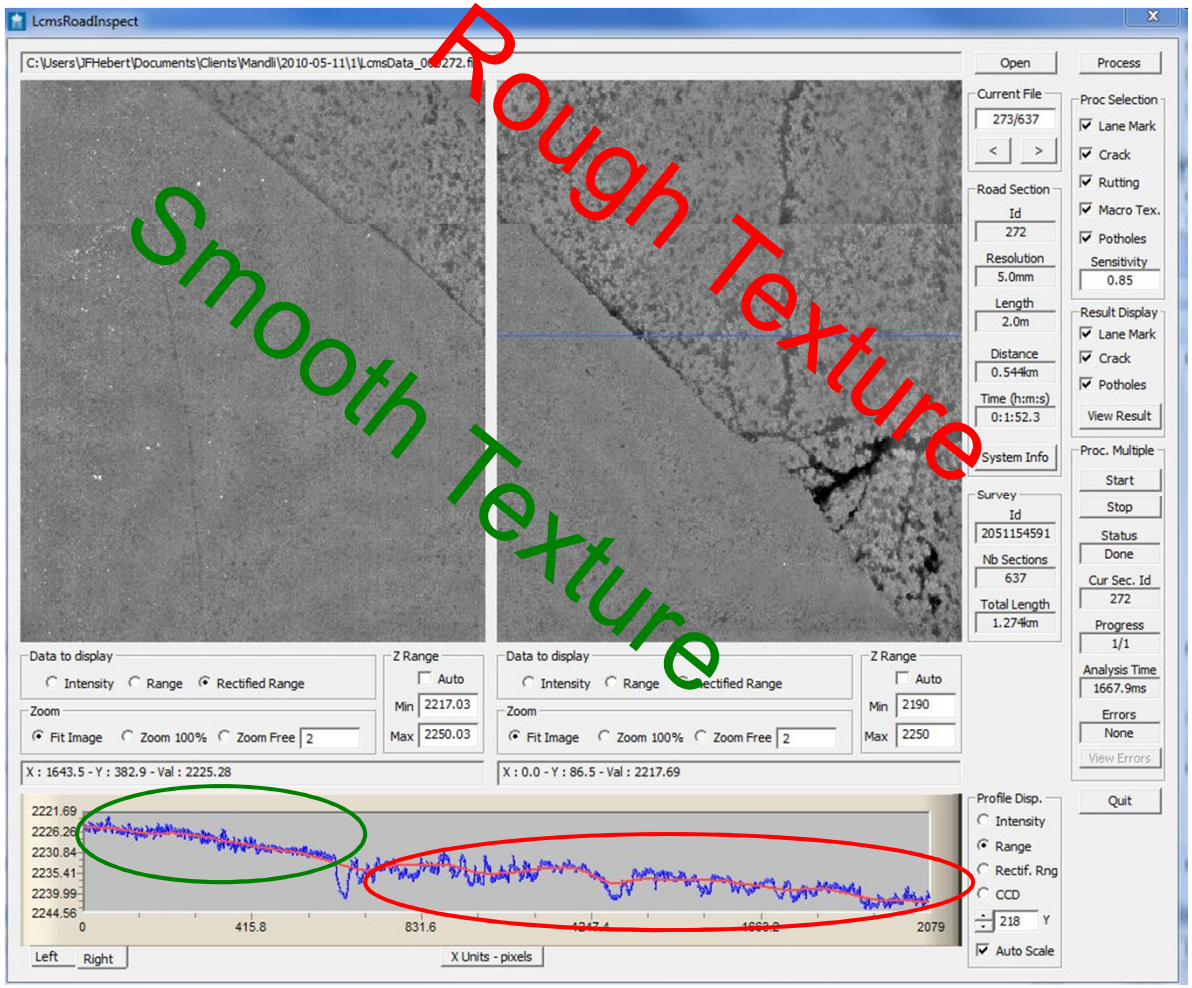
Pavemetrics

Macrotexture (MPD - ASTM E1845-01)



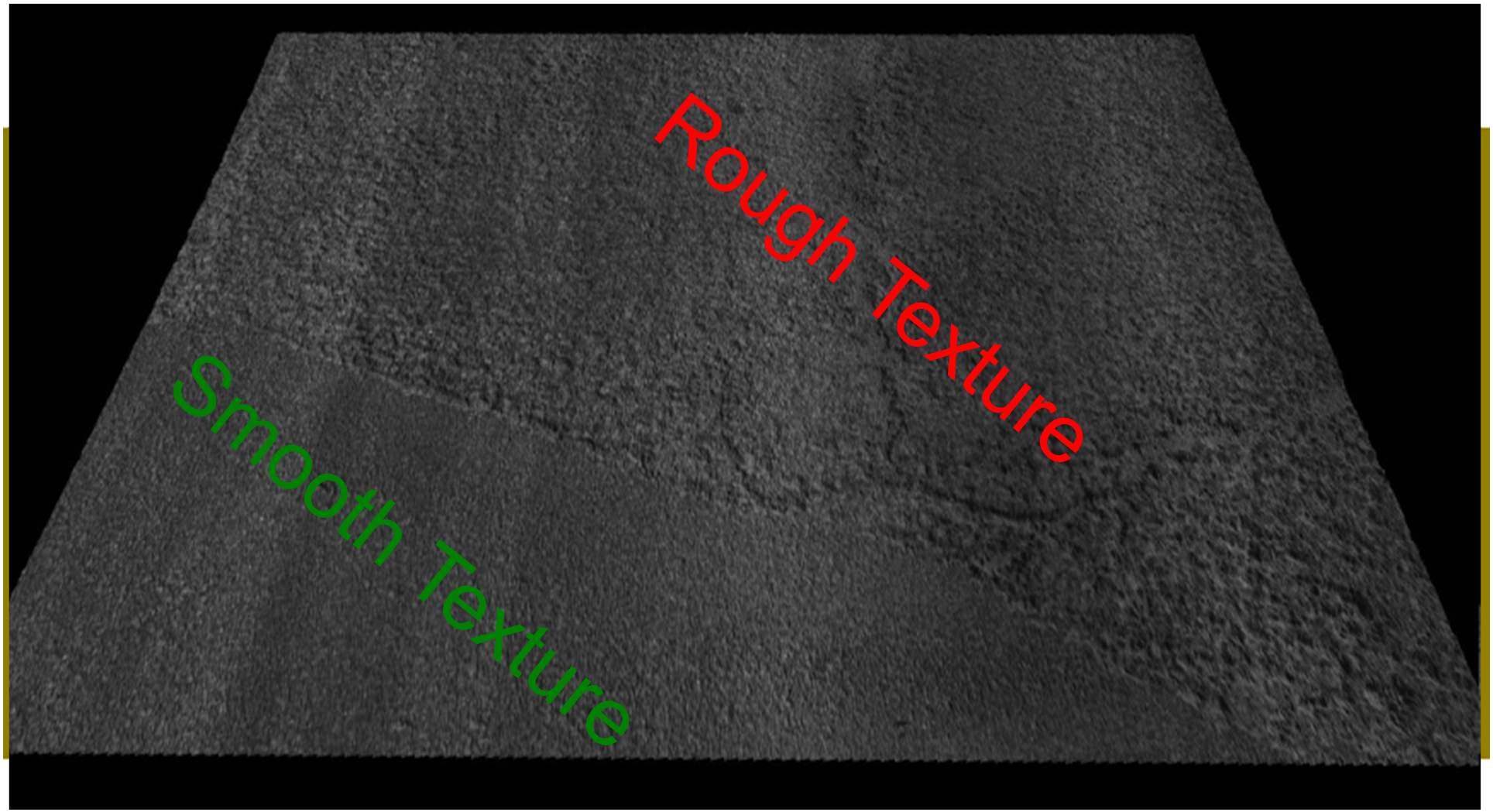


Macrotexture (MPD - ASTM E1845-01)



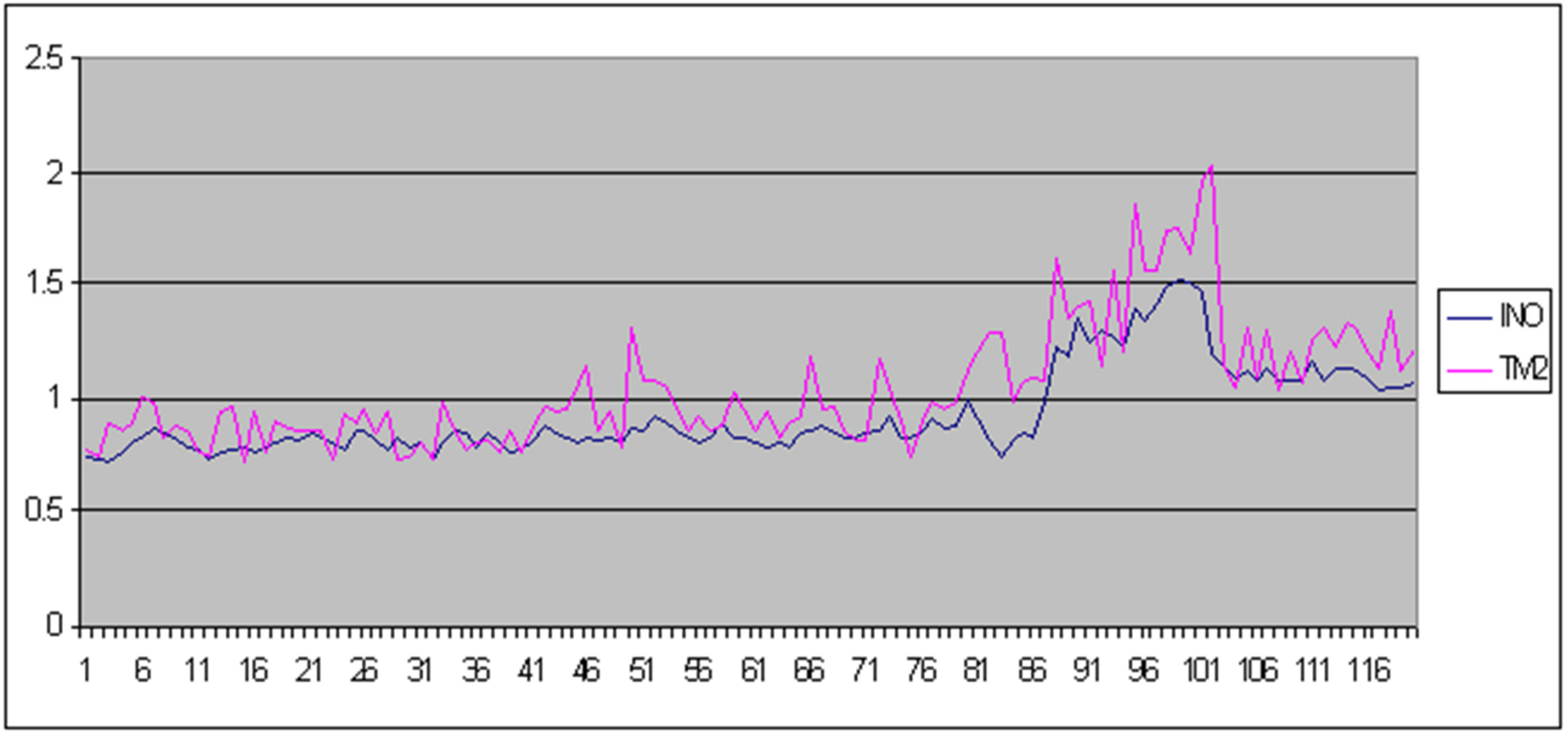
- Preliminary results are promising
- Studies are underway to compare with other devices

Macrotexture (MPD - ASTM E1845-01)



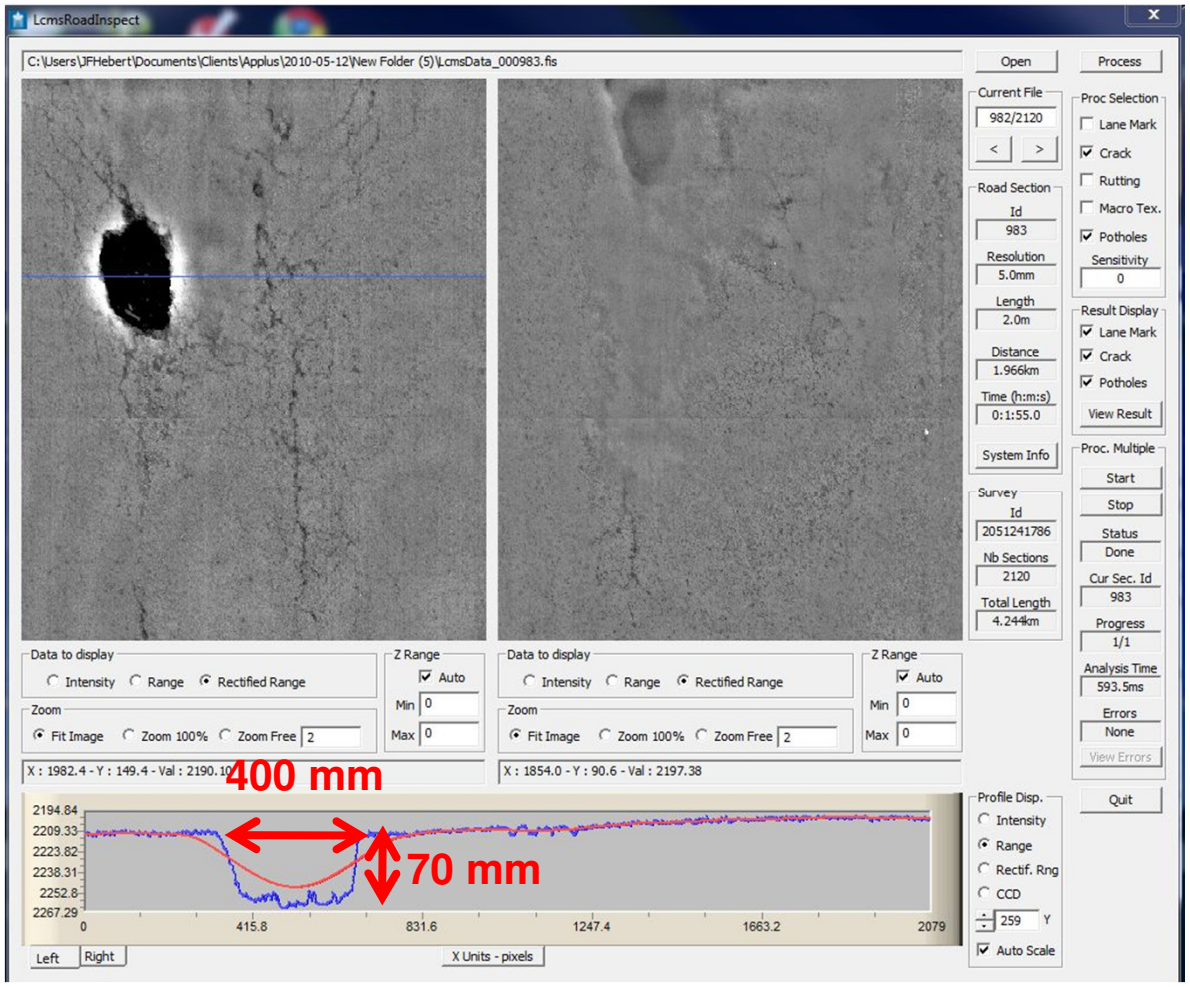
Pavemetrics

Macro-texture results (LCMS vs WDM – TM2)

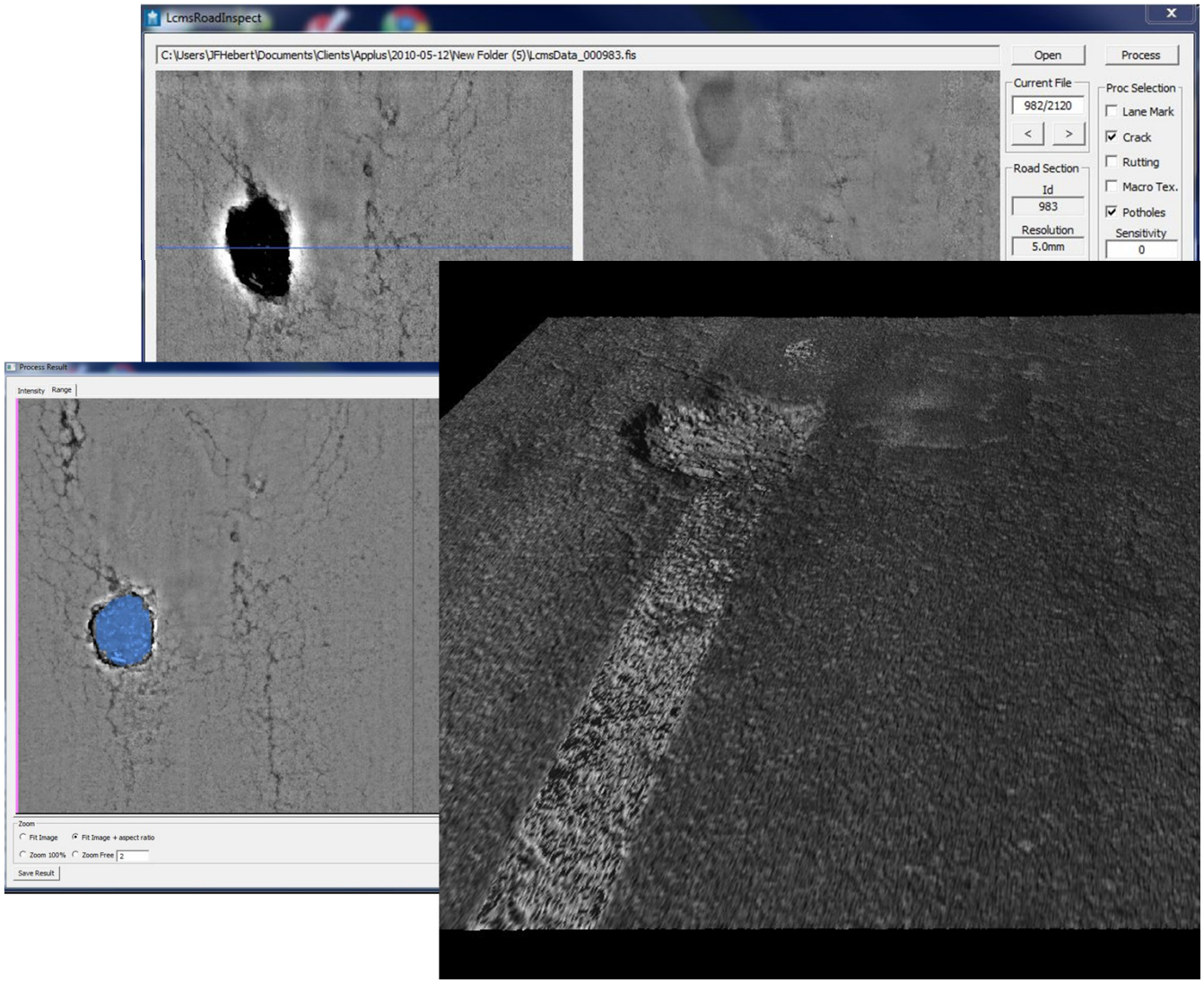


Pavemetrics

Pothole Detection



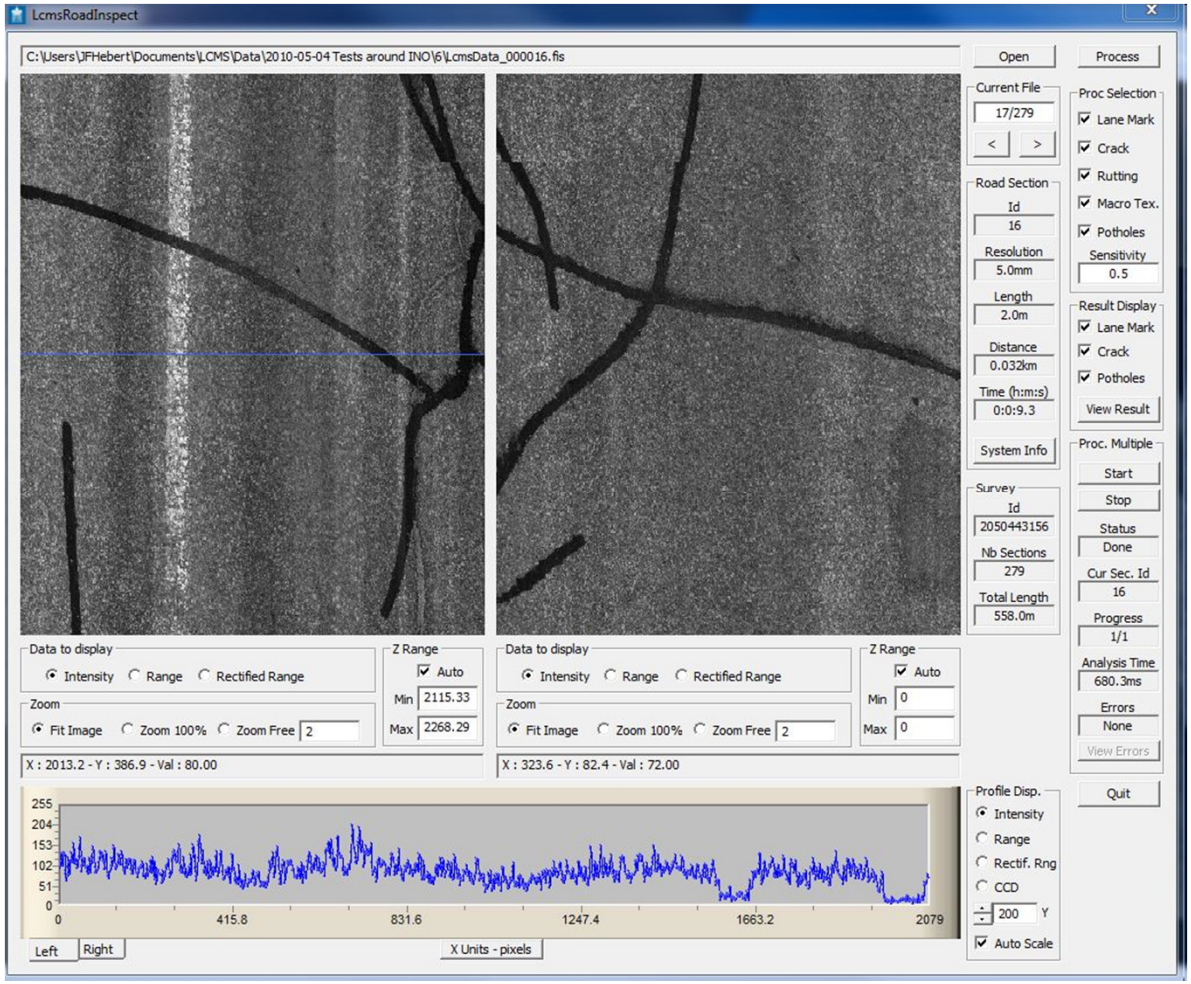
Pothole Detection



- Our library detects and characterize the potholes

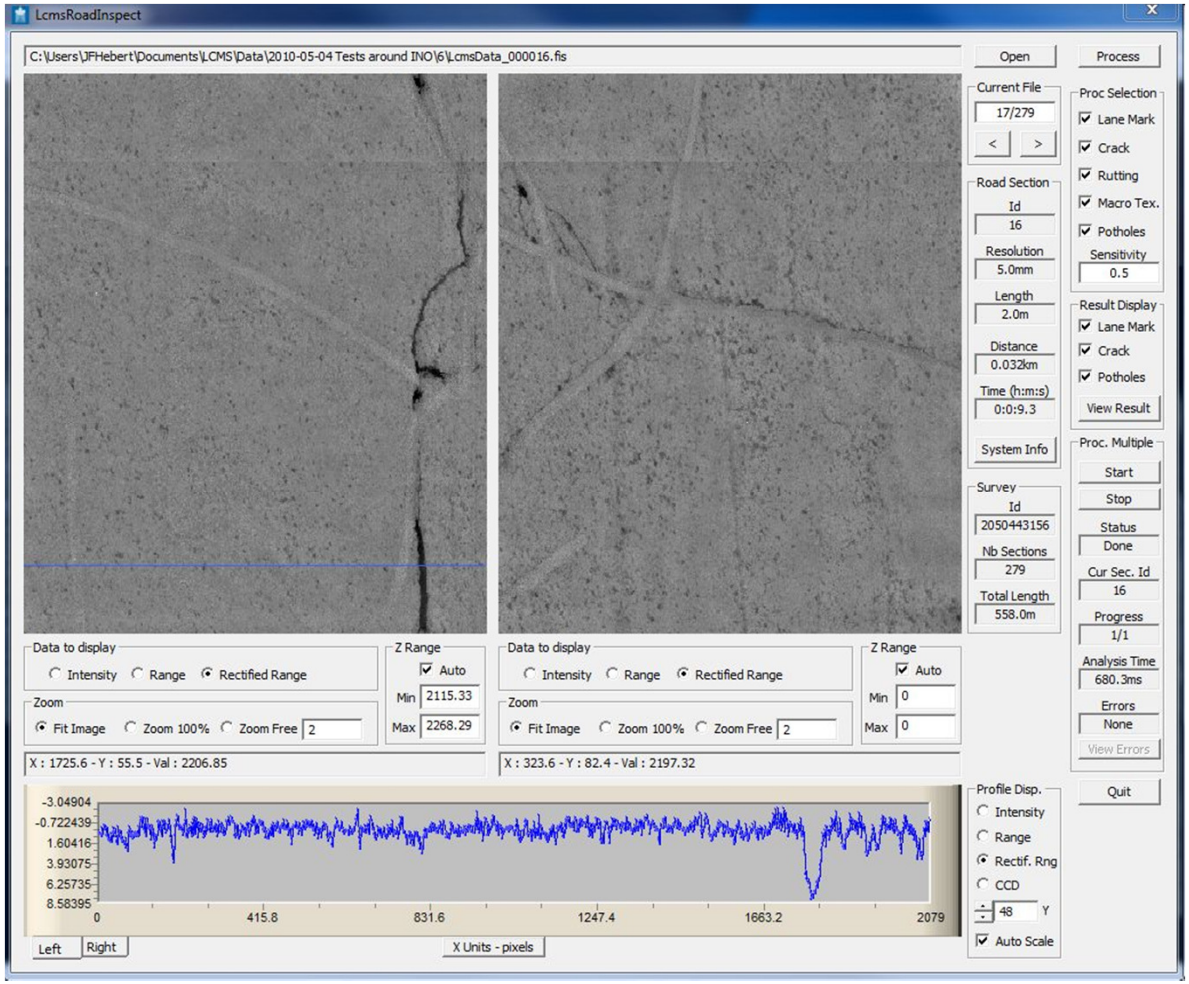
Characterization:
- Bounding box
- Area
- Perimeter (list of points)
- Volume

Sealed cracks: Work in progress…



- Sealed cracks are visible in the intensity images …

Sealed cracks: Work in progress…



- But they aren't visible in 3D…

Pavemetrics

Pavemetrics

Network level testing

Pavemetrics

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 seperated into 4 classes:

Good
OK
Bad
NA = other

Pavemetrics

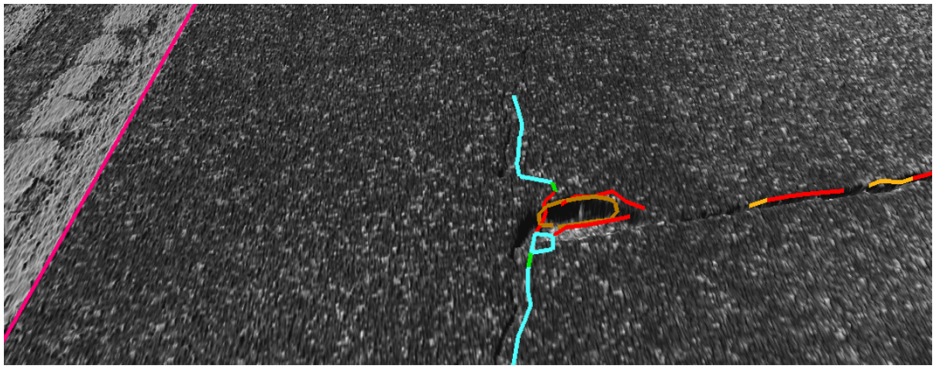
Results – network level visual evaluation

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

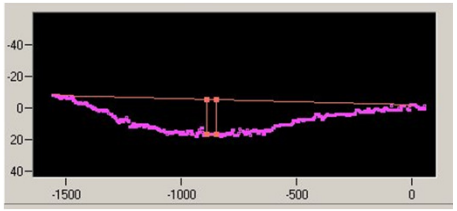
Conclusions

- Lane Marking cracks and Pothole Detection



- Tining Concrete

- Rut Measurement
  - Type
  - Depth
  - Width



- Sealed Cracks Detection

- Macro-Texture Measurement using MPD - ASTM E1845-01