30 KHz 3D Imaging Sensor for Pavement Surface Survey

Kelvin CP Wang

and the Team

Oklahoma State University & WayLink

kelvin.wang@okstate.edu

Presentation at the 2012 SURF Conference, Norfolk Marriott, Sept 20 2012

Acknowledgement

- Federal Highway Administration
  - Mike Moravec, Gary Crawford
  - Mark Swanlund
  - Tom Van
  - LTPP Staff, Others
- UA, OSU, AR DOT, OK DOT

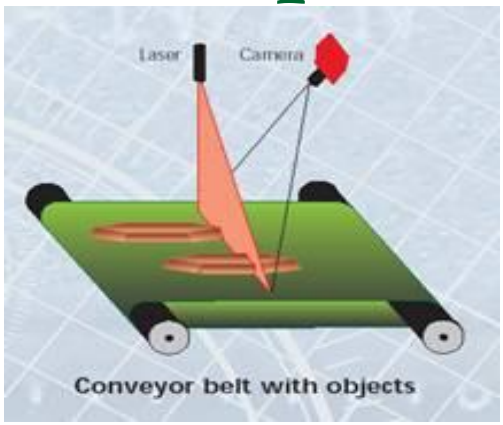
Acknowledgement

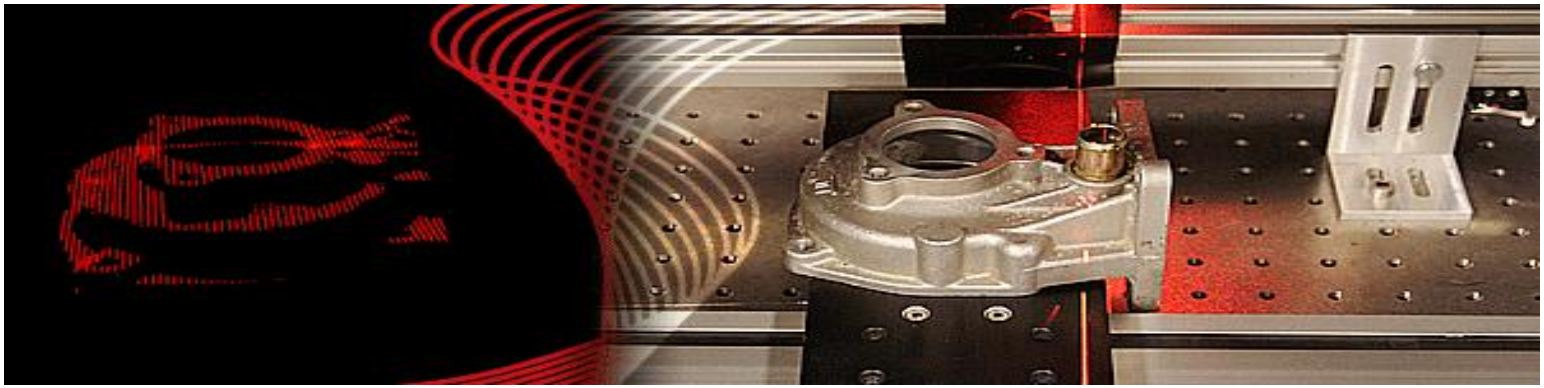
- The TEAM

3D Laser Imaging for Pavements

- Mature Technology in Other Industries
  - Indoor and Controlled Environment
- Paradigm Shift for Pavement Engineering
  - Potential to Cover Most if Not All Data Collection on Pavement Surface
- How to Obtain True 1mm 3D Visual Data at Highway Speed?
- How to Provide Multiple Solutions in One Pass that Meet Expectations?

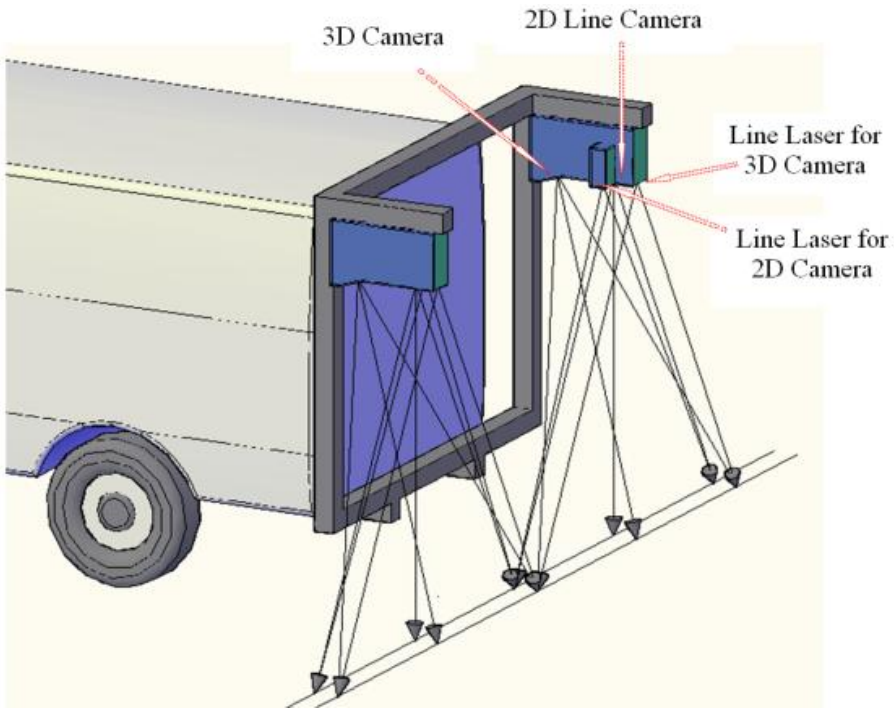
Laser Line based 3D Triagulation Imaging Technique





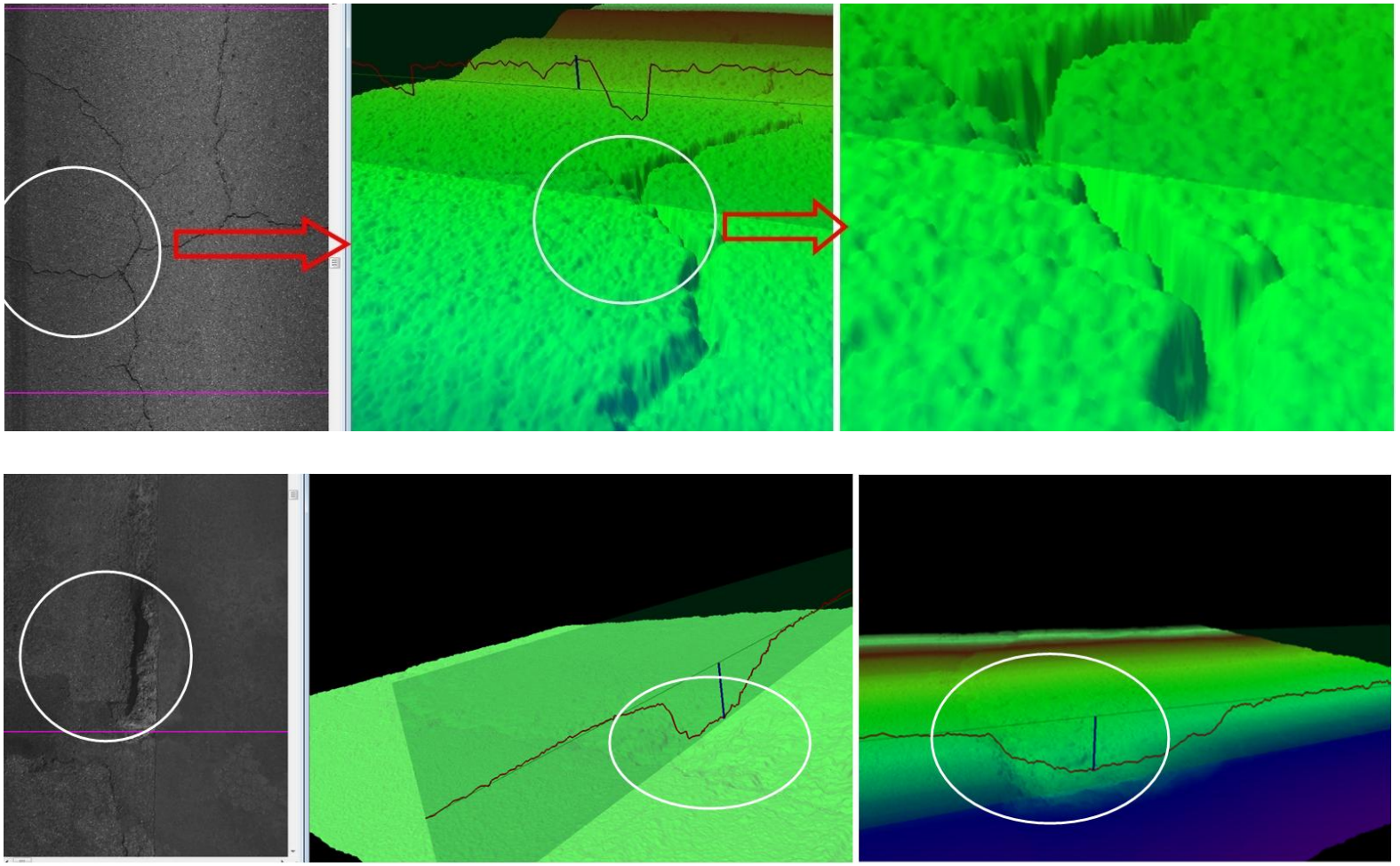
http://www.adept.net.au/news/newsletter/200810-oct/3D_Camera.shtml

Sensor Design & Prototyping 2009-2010



Sensor Illustrations

Collected 3D Sample Images with the Prototyping System



A Major Limitation

- Operating 3D Profile Line Rate
  - From 4000, 6000, to 8000/second
  - About 4mm to 6mm Resolution in the Longitudinal Direction at 60MPH (100KM/H)
    - Or ¼-inch Resolution in Long
  - Good Enough for Some Purposes; Not Sufficient

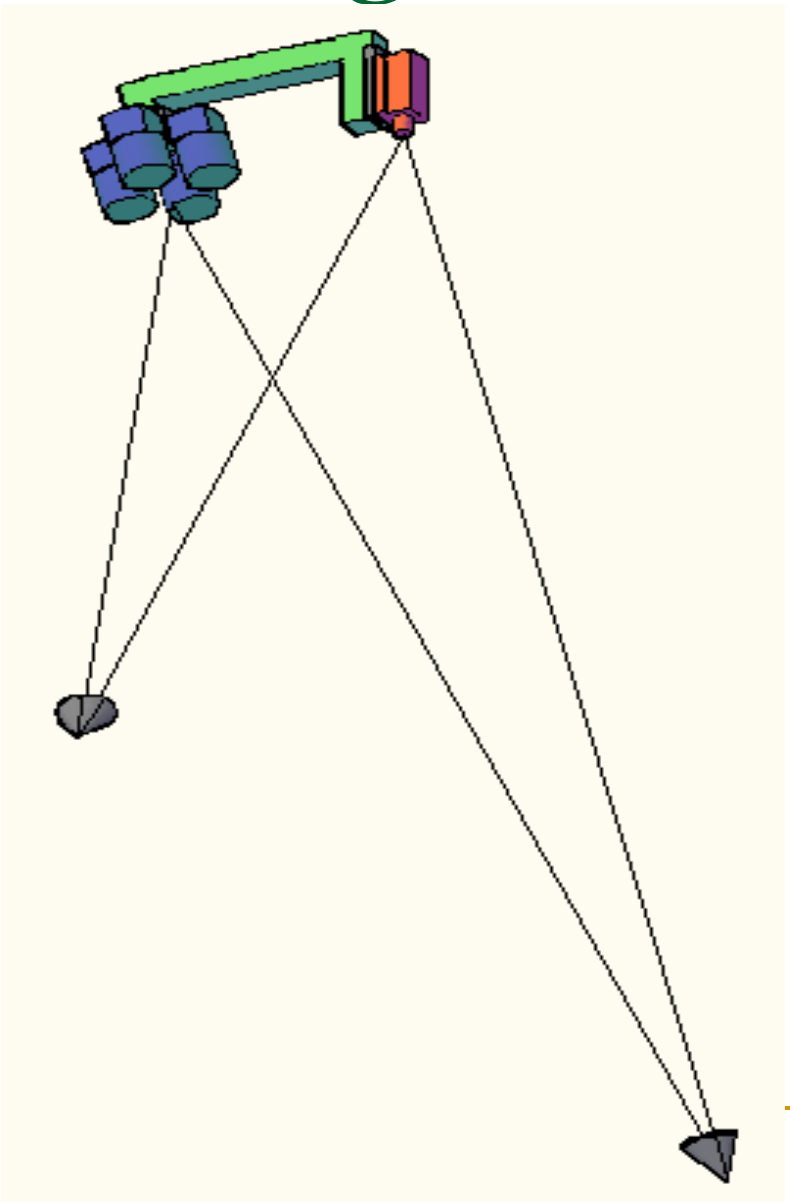
Research Approach

- Use Multiple Sensors
- Increase 3D Profile Line Rate to 30,000/second
- Complete Coverage of Pavement Lane
  - True 1mm at Any Data Collection Speed up to 60MPH (100KM/H)

Data Rate & Power at 60MPH

- Single Computer
- Data Rate for 3D Only
  - 4000x2x28000=224,000,000 bytes, 224 MB/sec before compression
  - Continuous for a few hours non-stop
- Advantage
  - Low Power < 1000 watts in all
  - Complete Coverage at True 1mm

Design



First Deployment

First Deployment

First Deployment

Data Compression & Management

- Raw Data from All Sensors
  - Over 10GB per Mile at 60MPH (100KM/H)
- 2D Compression: JPG/JPG2000
- 3D Compression
  - Proprietary Compression: over 10:1
- Production Data to Computer Storage: 1GB per Mile
- Relational Database Driven

Virtual Pavement

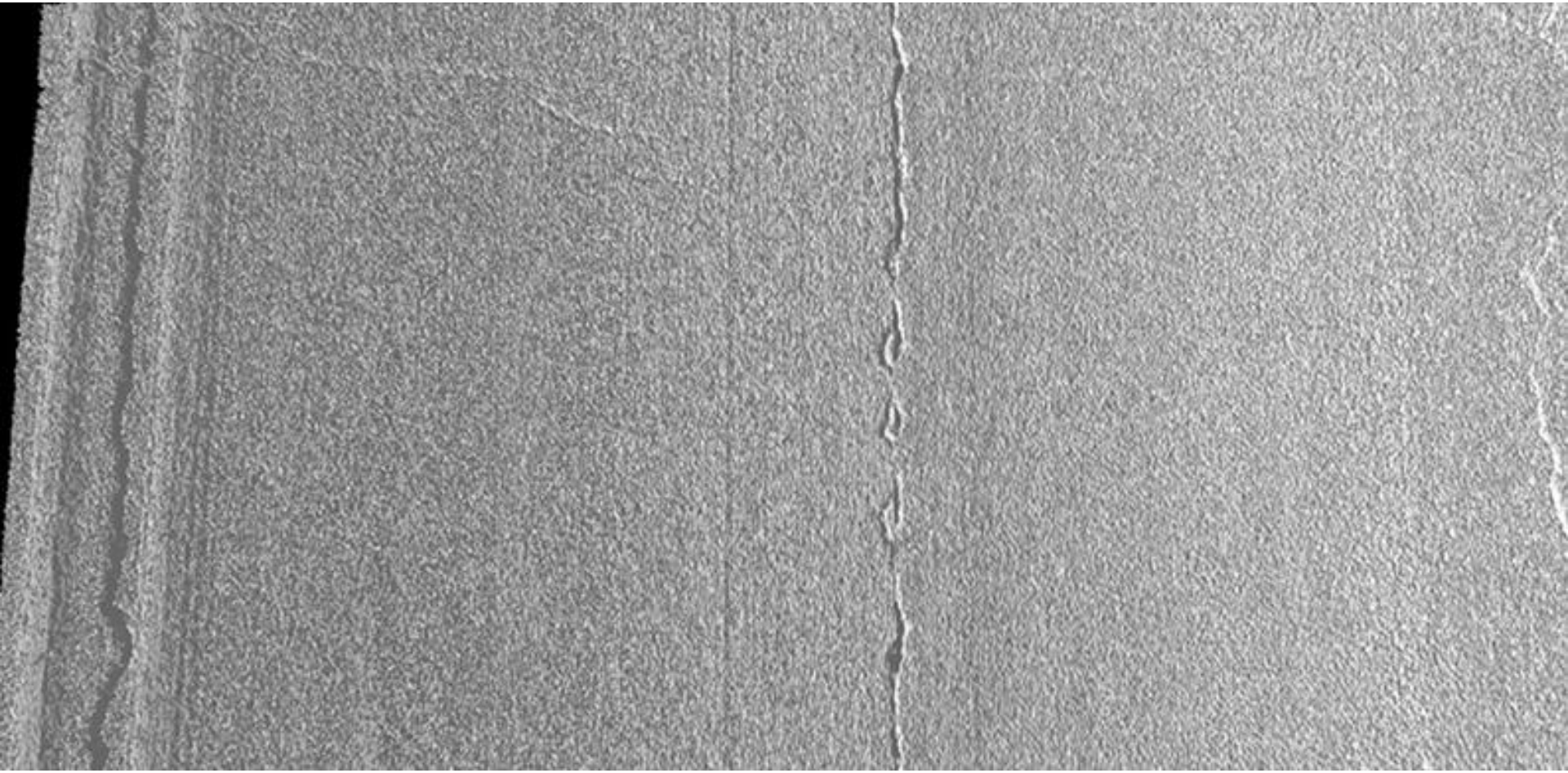
- 1mm Pavement Surface in All Three Dimensions
- High-Precision IMU
- Result
  - Grades
  - Horizontal Curves
  - Cross-Slope

Applications

- Now
  - Cracking, Rutting, Macro-Texture (MPD, MTD)
  - Safety Analysis: High-Friction, Rumble Strips, Hydroplaning/Grooving
  - Virtual Surface for Visualization
- Future
  - Longitudinal Profiling
  - Comprehensive Evaluation of All Surface Distresses
  - Comprehensive Performance Metrics

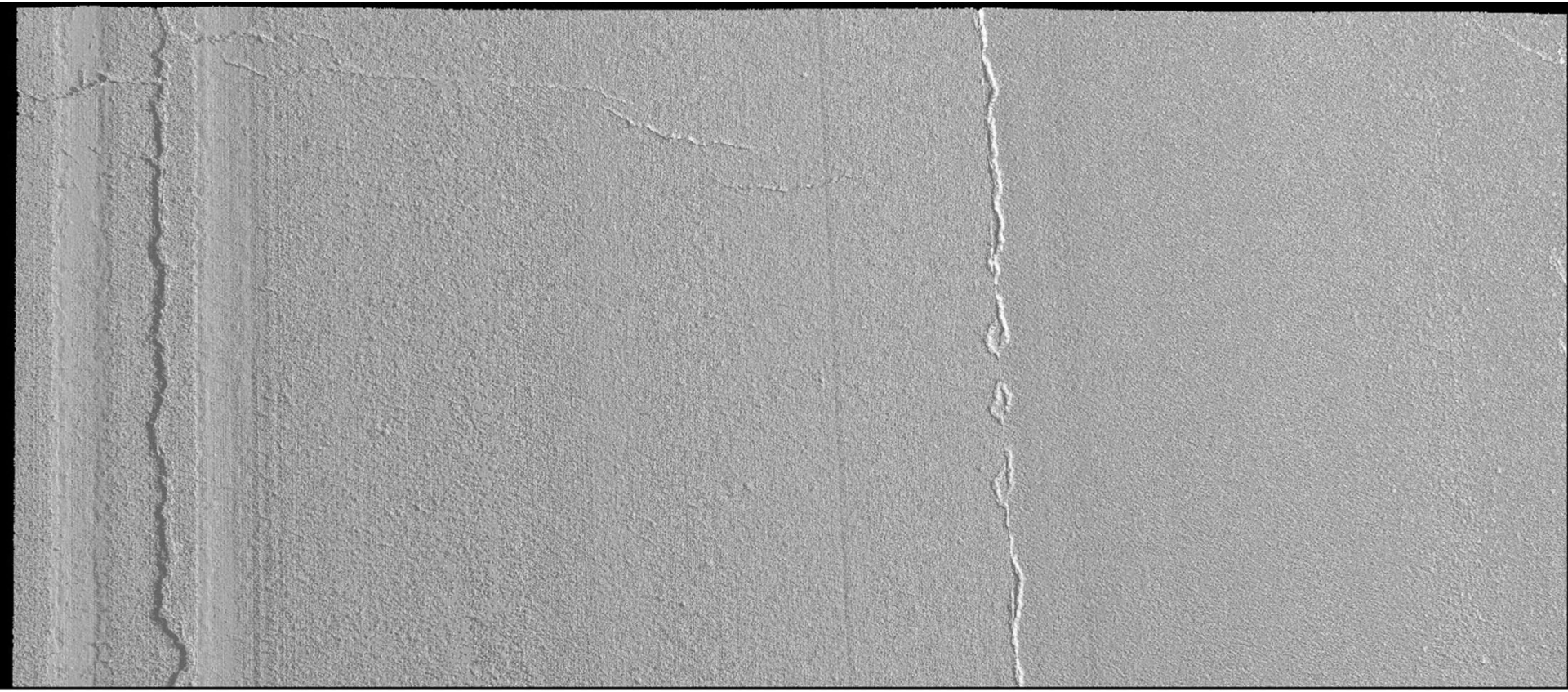
Comparison on the Same Pavement

- 7000 3D Profiles/Sec

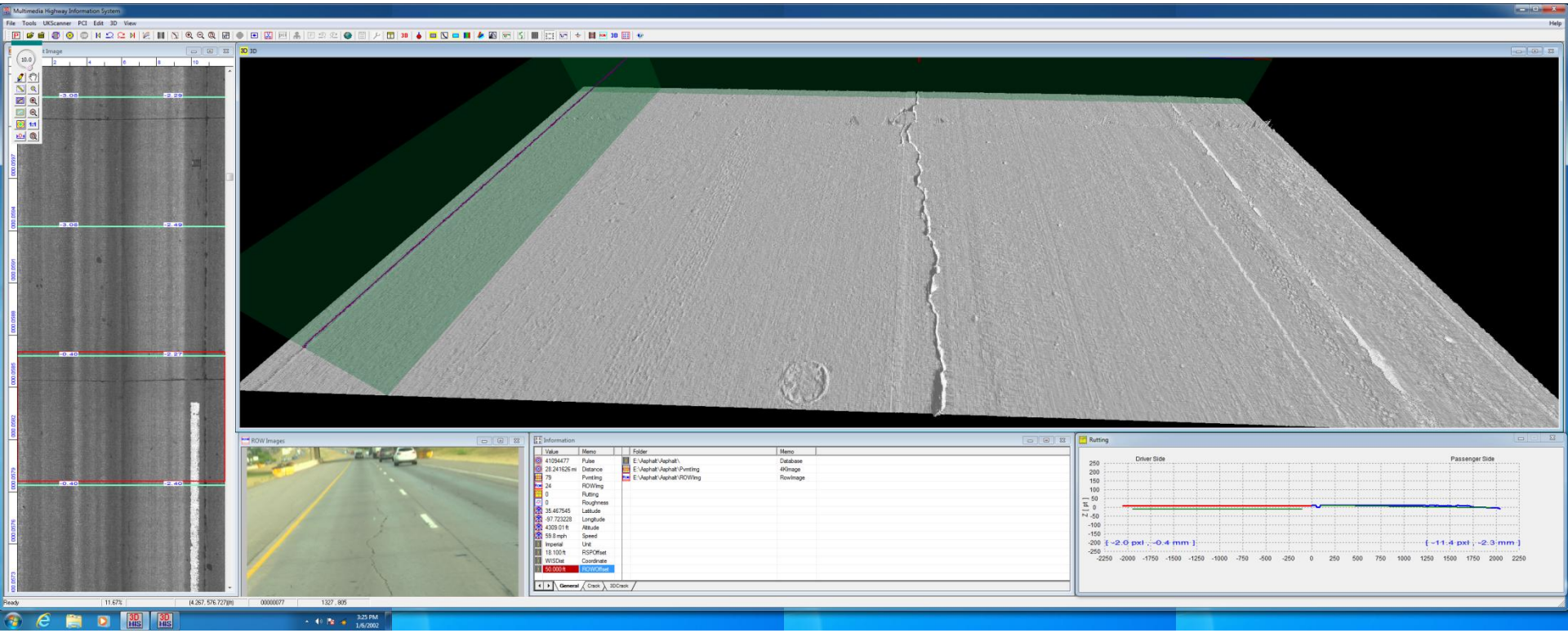


Comparison on the Same Pavement

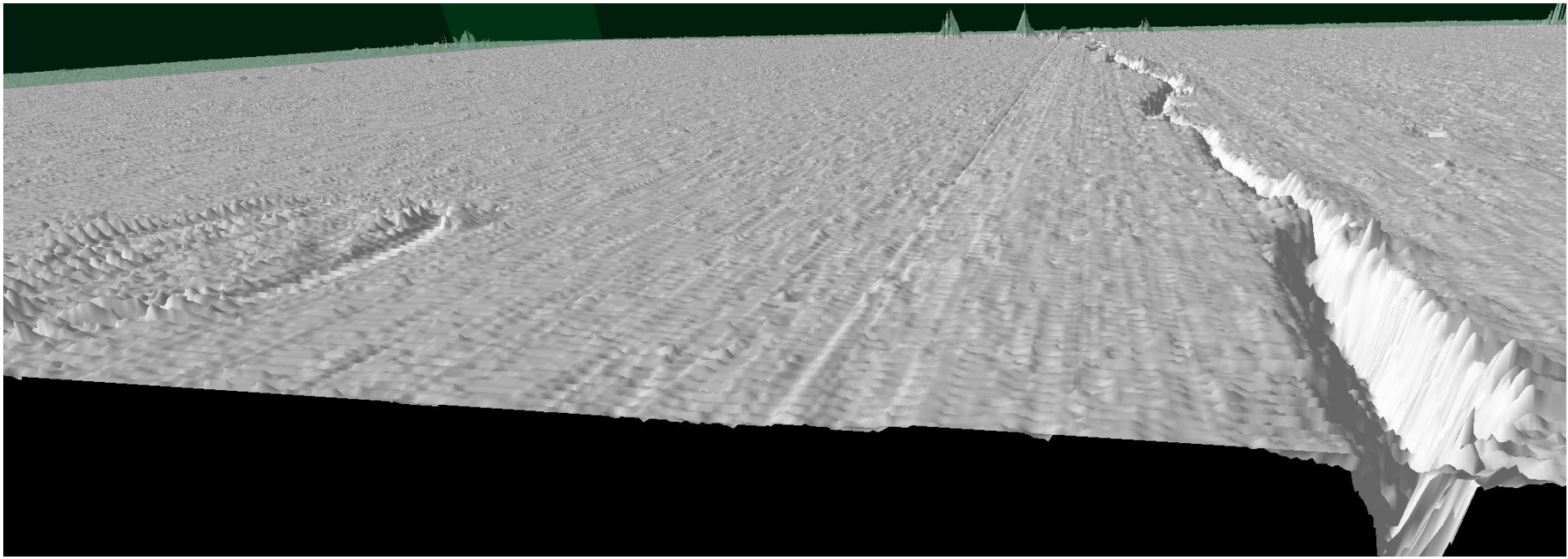
- 28,000 3D Profiles/Sec



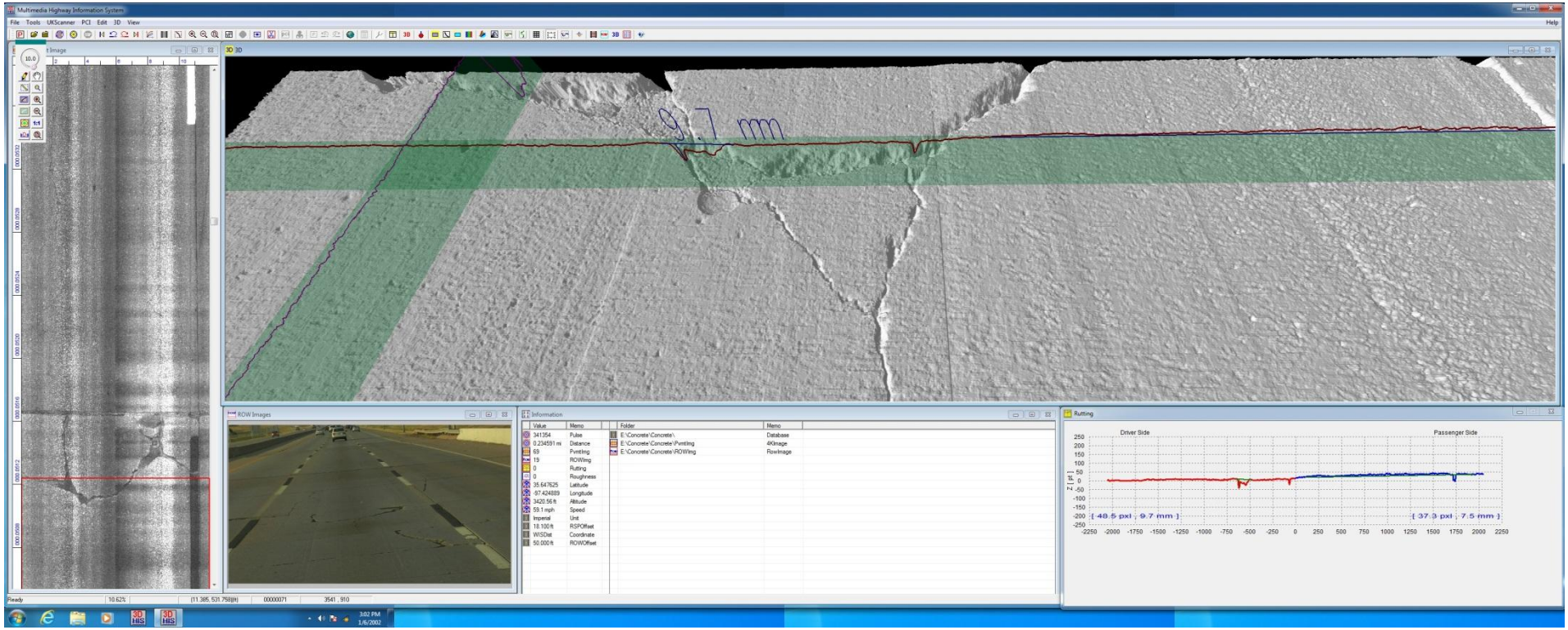
3D Data at 60MPH (100KM/h)



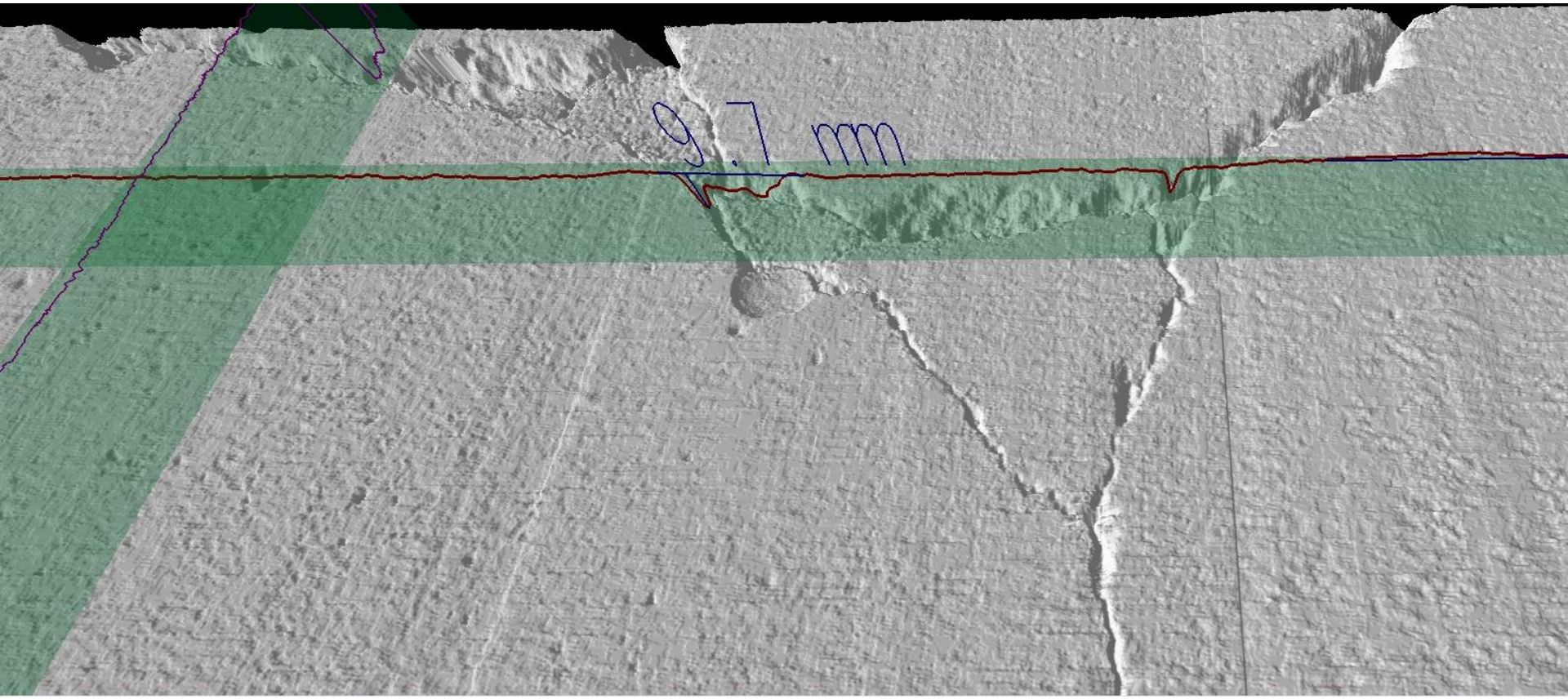
3D Data at 60MPH (100KM/h)



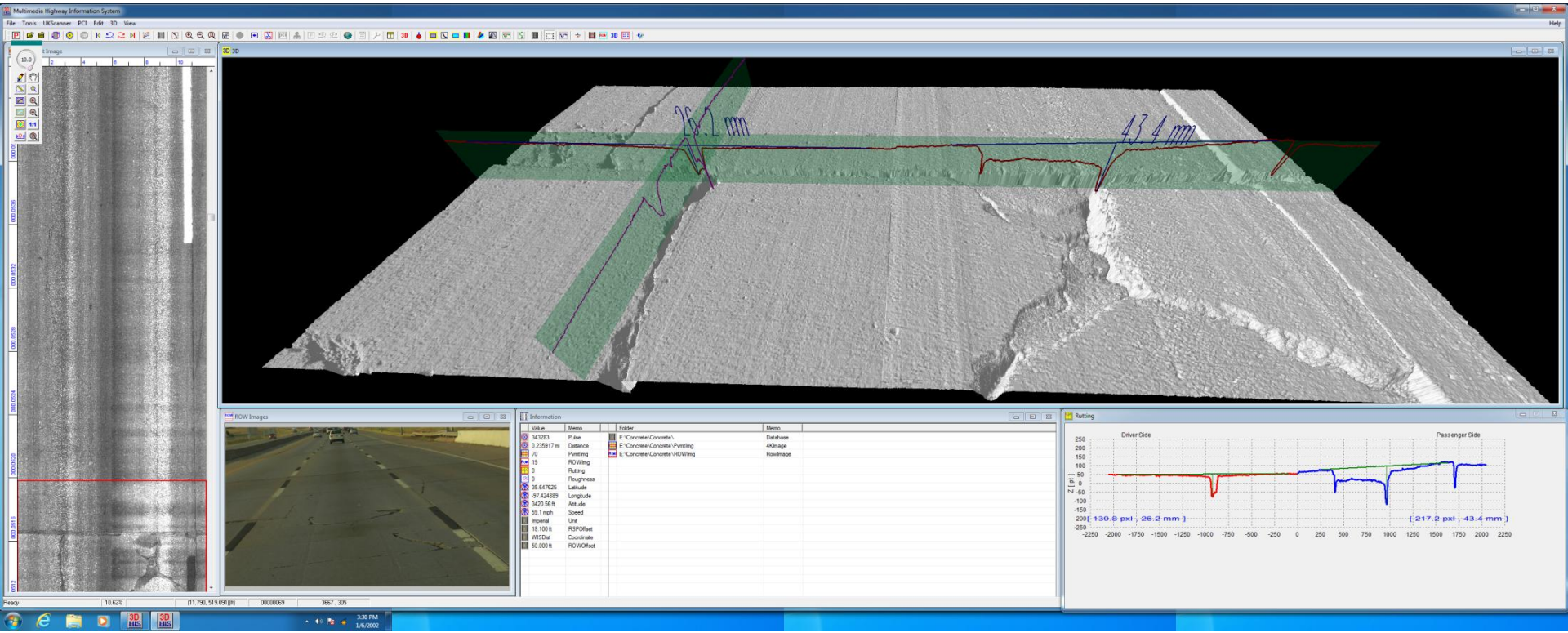
3D Data at 60MPH (100KM/h)



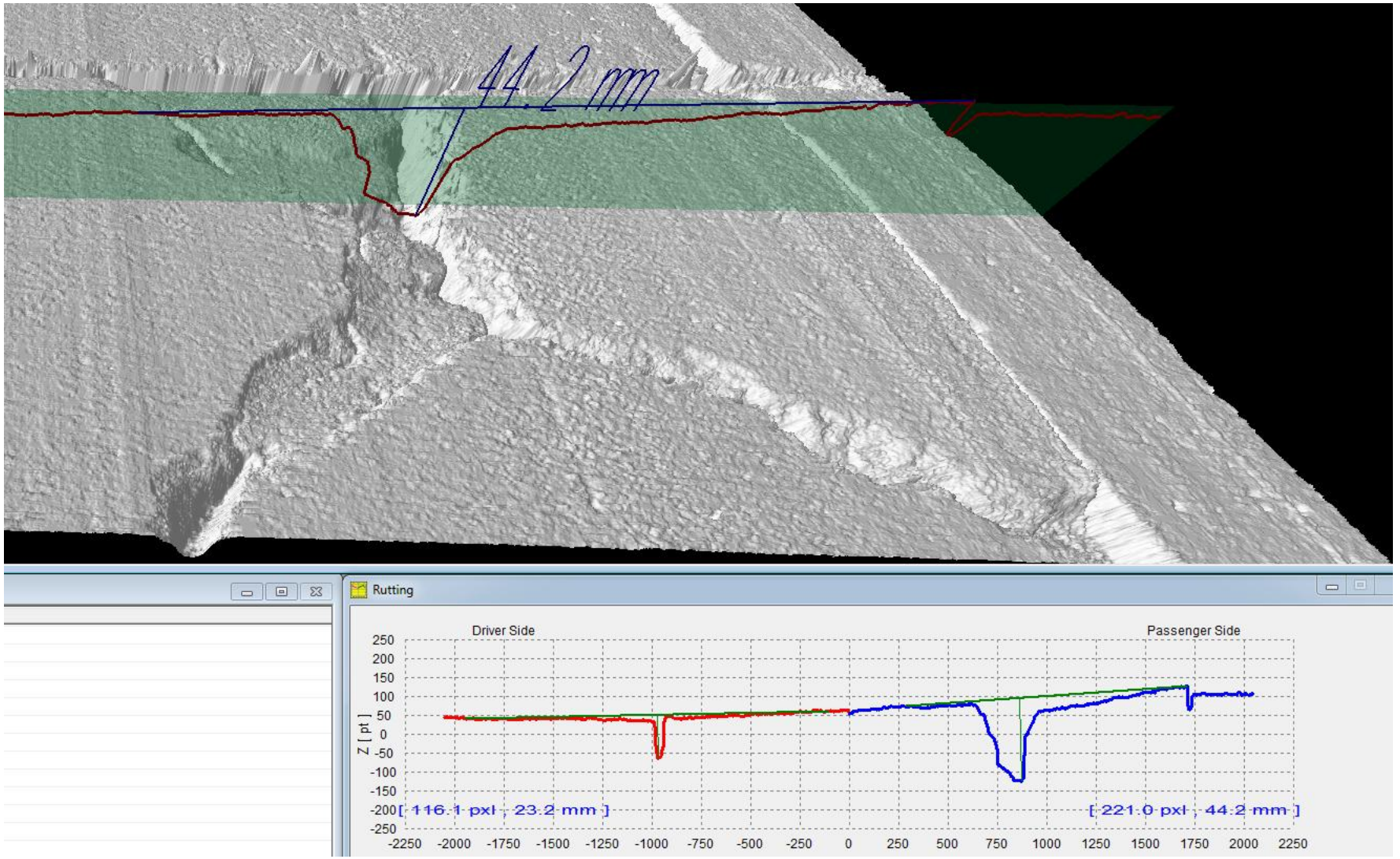
3D Data at 60MPH (100KM/h)



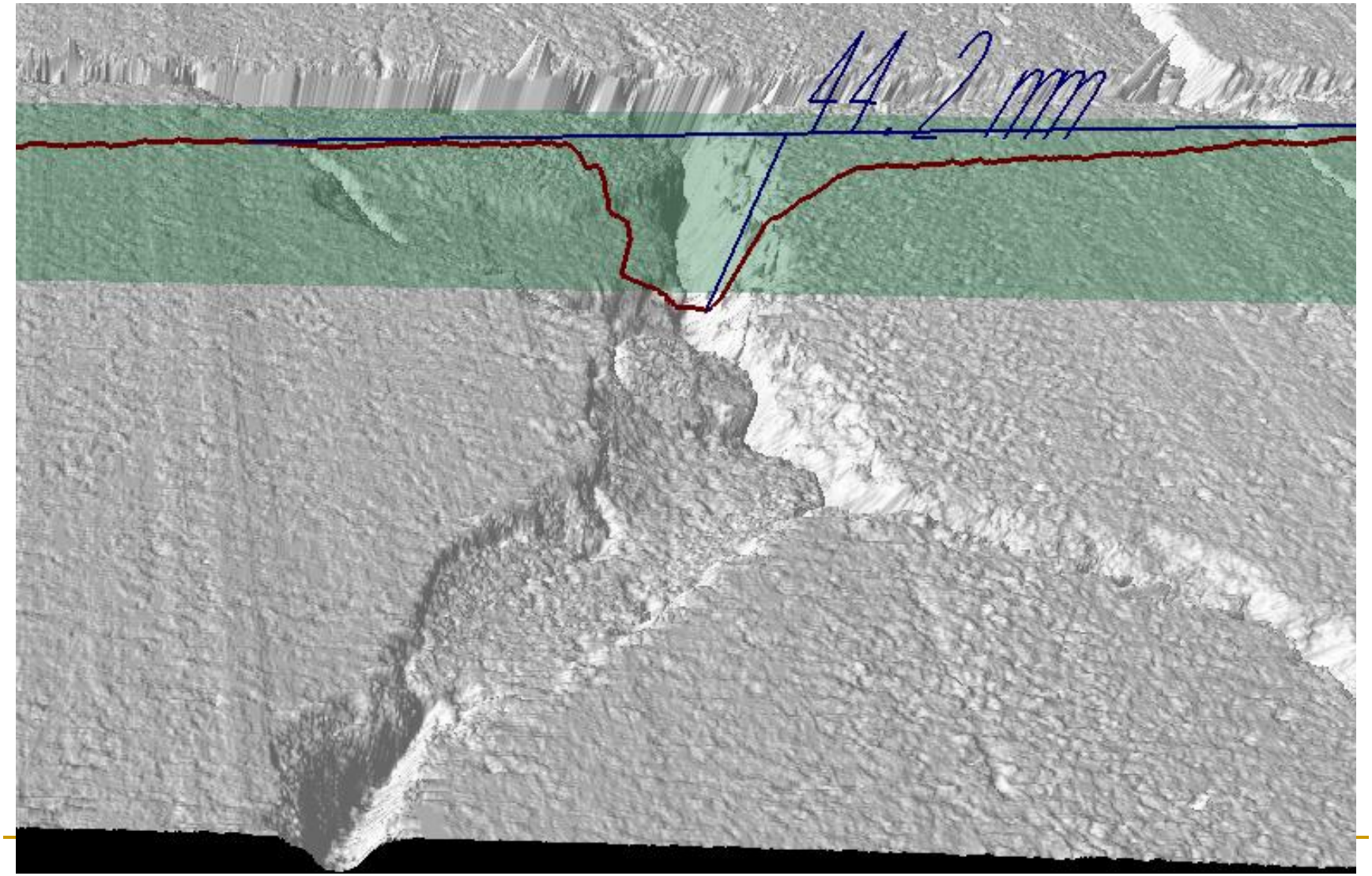
3D Data at 60MPH (100KM/h)

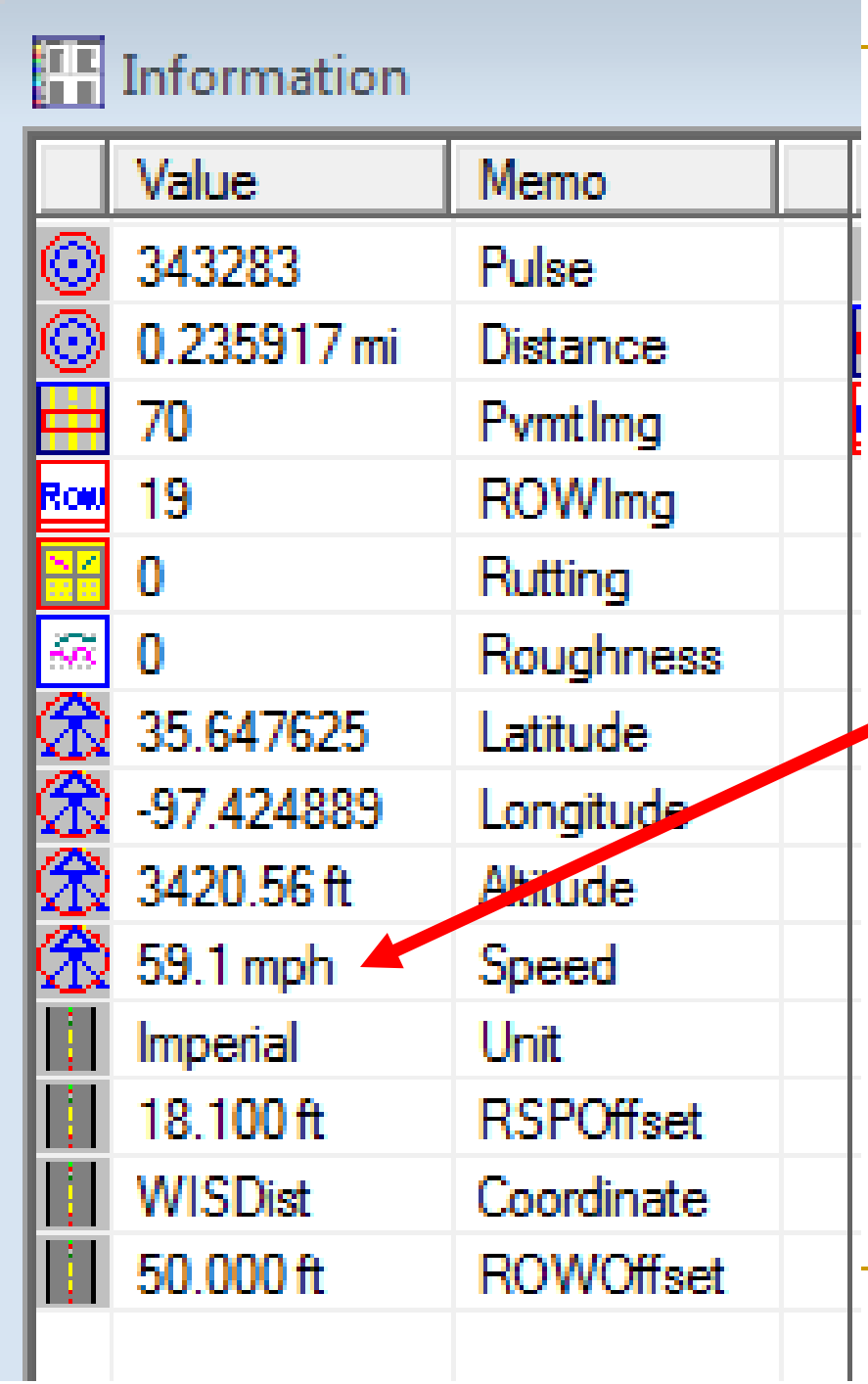


3D Data at 60MPH (100KM/h)



3D Data at 60MPH (100KM/h)




Information
Value
Memo
343283
Pulse
0.235917 mi
Distance
70
PvmtImg
19
ROWImg
0
Rutting
0
Roughness
35.647625
Latitude
-97.424889
Longitude
3420.56 ft
Altitude
59.1 mph
Speed
Imperial
Unit
18.100 ft
RSPOffset
WISDist
Coordinate
50.000 ft
ROWOffset

60MPH

Conclusions

- Sensor Technology: Completed
- Biggest Challenges to the Team & Industry: Software Solutions
  - To make something beautiful, & also usable to pavement engineers
  - Confidence in quality of delivered final data