



TEXAS DEPARTMENT OF TRANSPORTATION

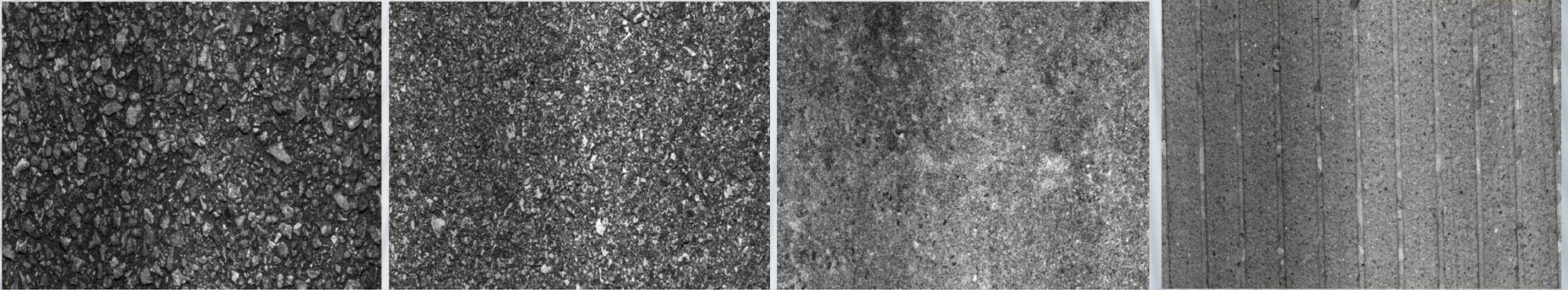
3D TEXTURE MEASUREMENT

Development and Field Evaluation of a Texture Measurement System Based on Continuous Profiles from a 3D Scanning Instrument

PAVEMENT TEXTURE FEATURE AND DATA COLLECTION

Texture: Irregularities or smoothness on a pavement surface

Skid Resistance, Noise, and Structural Integrity



Static Measurement:

- Sand Patch Test
- Circular Track Meter
- Outflow Meter

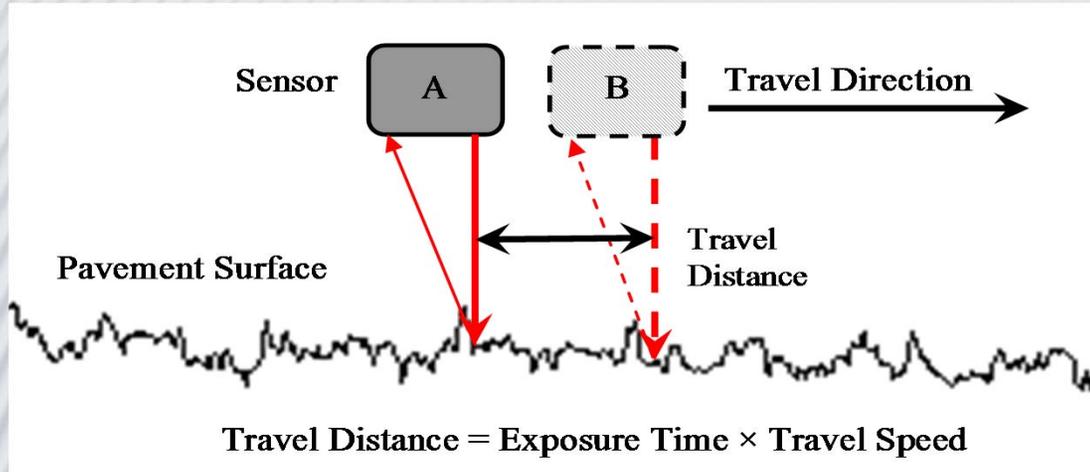
Slow, limited samples, not for all pavement surfaces.

Dynamic Measurement:

- High Speed Laser
- 2D Laser Line Sensor

Vehicle speed dependent or vehicle vibration errors.

SPEED DEPENDENT ISSUE IN TEXTURE DATA



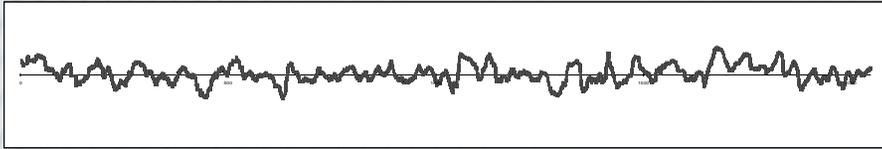
Macro-Texture wavelength: 0.5 ~ 50 mm

High speed texture measurement is equipped with laser distance sensor(s). During high speed texture data collection, sensors travel with vehicle.

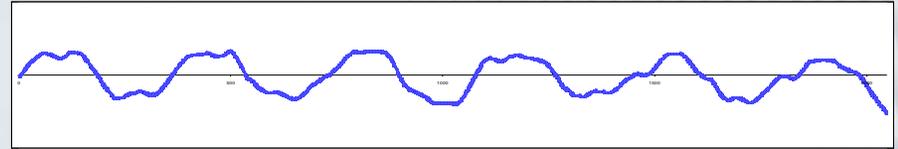
Optical receiver in the laser sensor collects return laser light in a given period of time, called Exposure Time. Surface features in a distance traveled during exposure will be averaged, which has a filtering effect on the measurement data.

In a given vehicle speed, the averaging error is in proportion to the exposure time !

Sensor travel distance at given speed for different exposure time									
Travel Distance (mm)		Exposure Time (μs)							
		20	30	40	50	100	150	200	250
Travel Speed (mph)	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	0.09	0.13	0.18	0.22	0.45	0.67	0.89	1.12
	20	0.18	0.27	0.36	0.45	0.89	1.34	1.79	2.23
	30	0.27	0.40	0.54	0.67	1.34	2.01	2.68	3.35
	40	0.36	0.54	0.72	0.89	1.79	2.68	3.58	4.47
	50	0.45	0.67	0.89	1.12	2.23	3.35	4.47	5.59
	60	0.54	0.80	1.07	1.34	2.68	4.02	5.36	6.70
	70	0.63	0.94	1.25	1.56	3.13	4.69	6.26	7.82



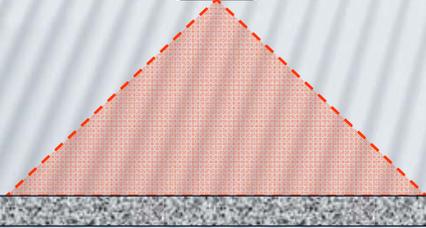
Pavement macro-profile



Vehicle vibration

Dynamic Texture Measurement

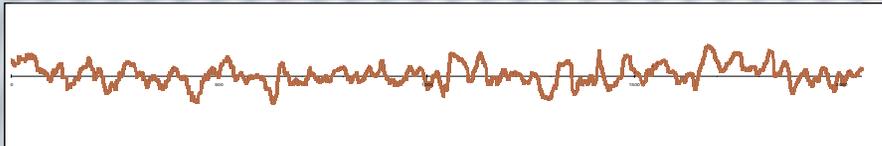
2D Line sensor



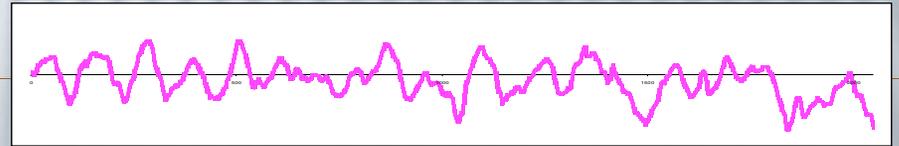
Travel Direction



1D point sensor

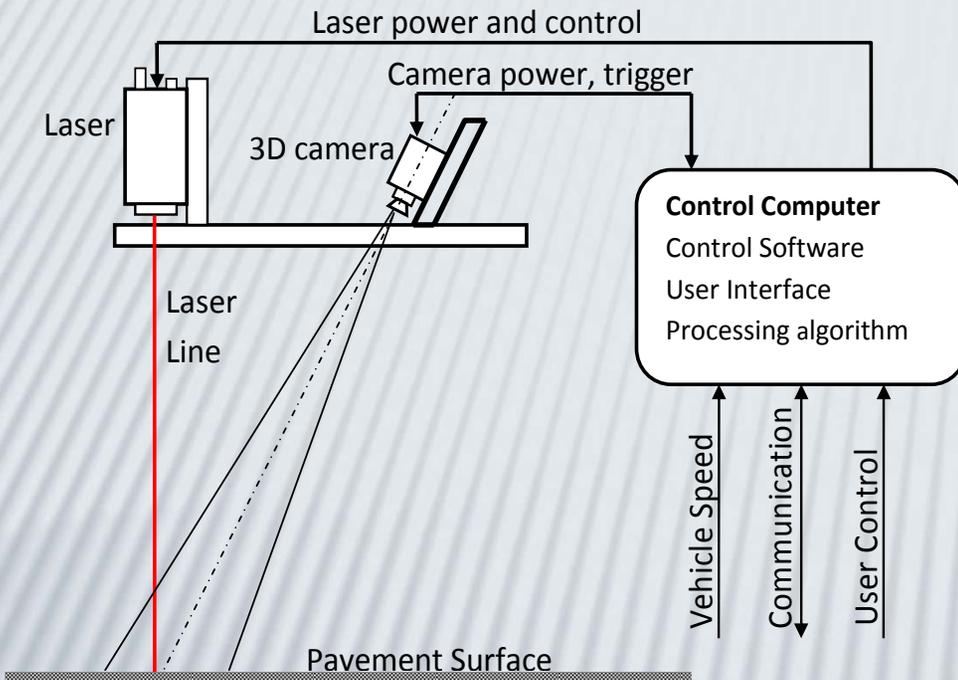


Captured true profile



Captured profile and vehicle motion

TXDOT HIGH SPEED 3D TEXTURE SYSTEM- - -VTEXTURE



- Based on high speed laser 3D Technology
- 2048 data point in each profile line
- Up to 7,500 profile line per second
- 10 um texture (z) resolution
- 0.2 mm spatial (x,y) resolution

Wheel path mount, transverse scan



Center mount, longitudinal scan

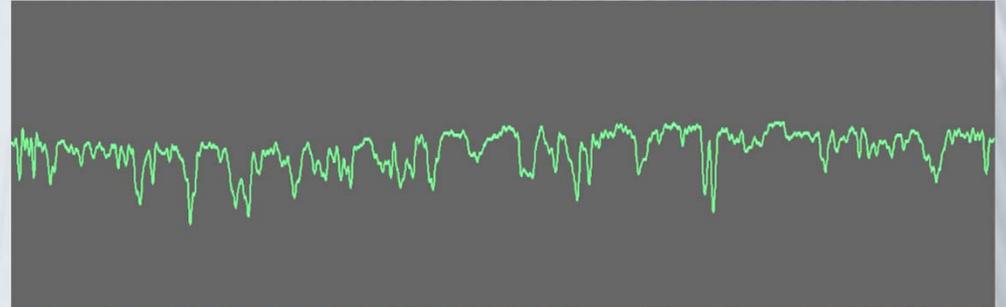


VTEXTURE OPERATION

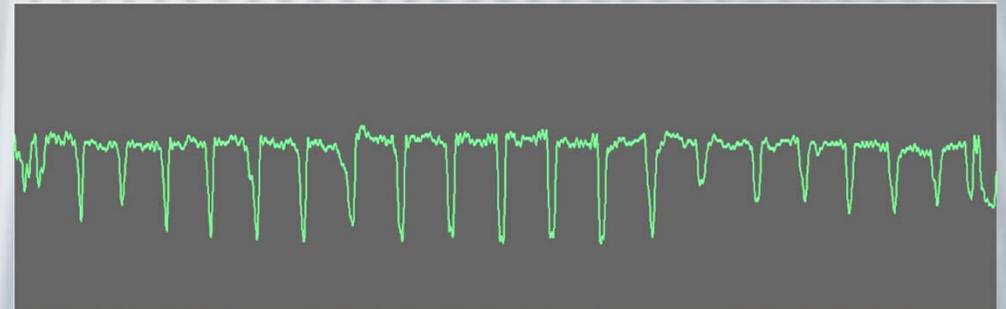
VTexture sensor captures a 12" long, 2048 data points, surface profile in a single measurement. It uses two 100 mm segment to calculate two texture MPD values.

As the VTexture takes the entire profile at the same time, Vehicle vibration does add noise into the data

If texture MPD is calculated with in a single profile, the vehicle motion does not effect results.



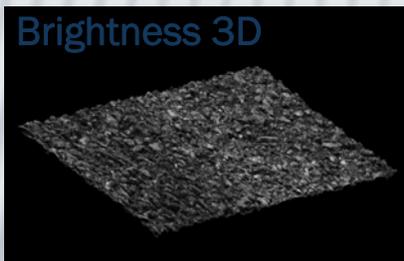
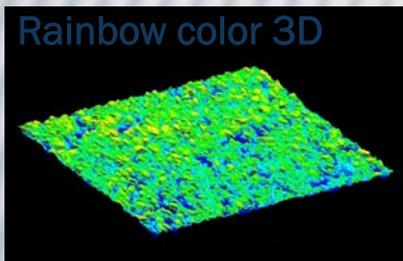
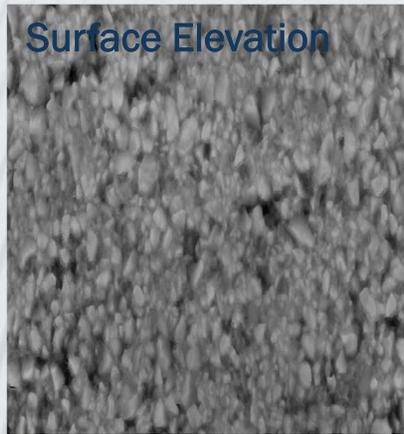
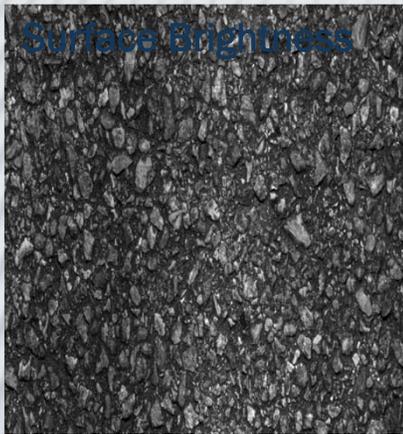
ACP pavement



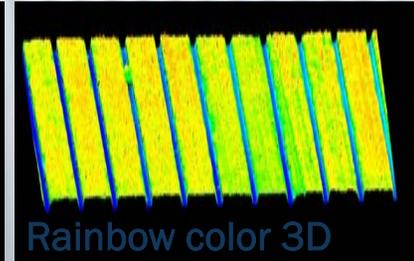
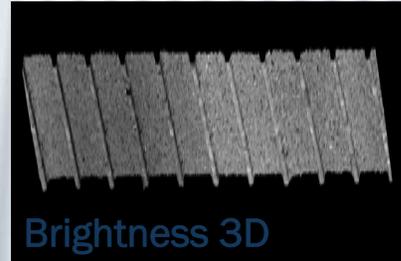
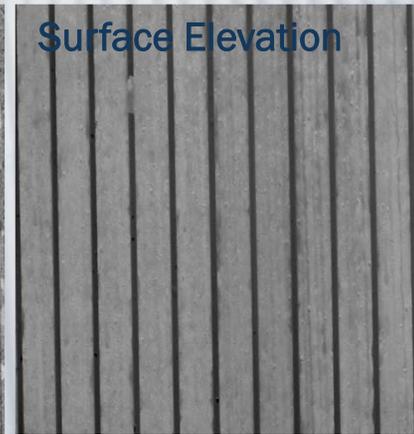
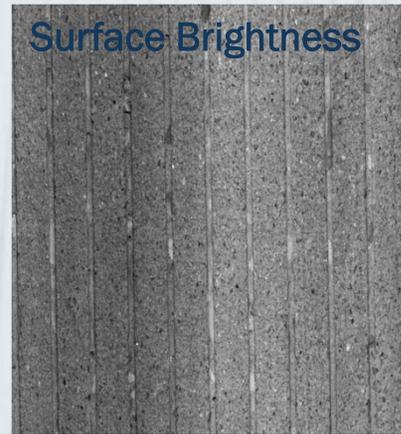
Concrete pavement with tinning

HIGH RESOLUTION 3D SURFACE SCAN

VTexture captures surface height and brightness images, displays in 2D or 3D modes



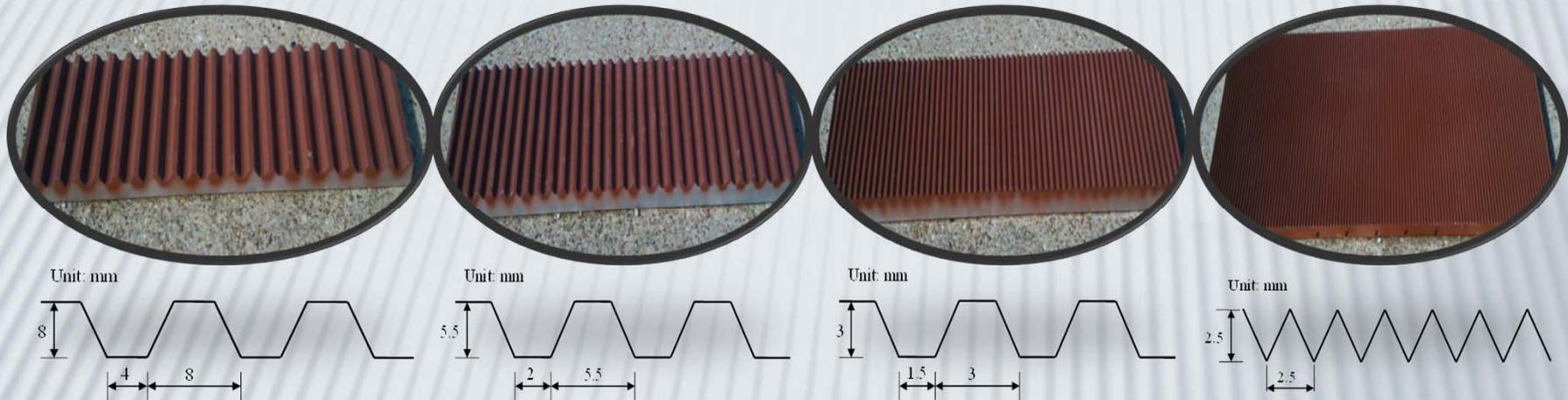
Asphalt Pavement



Concrete Pavement

Scanned at 512 profiles per foot, 2048 profiles per measurement

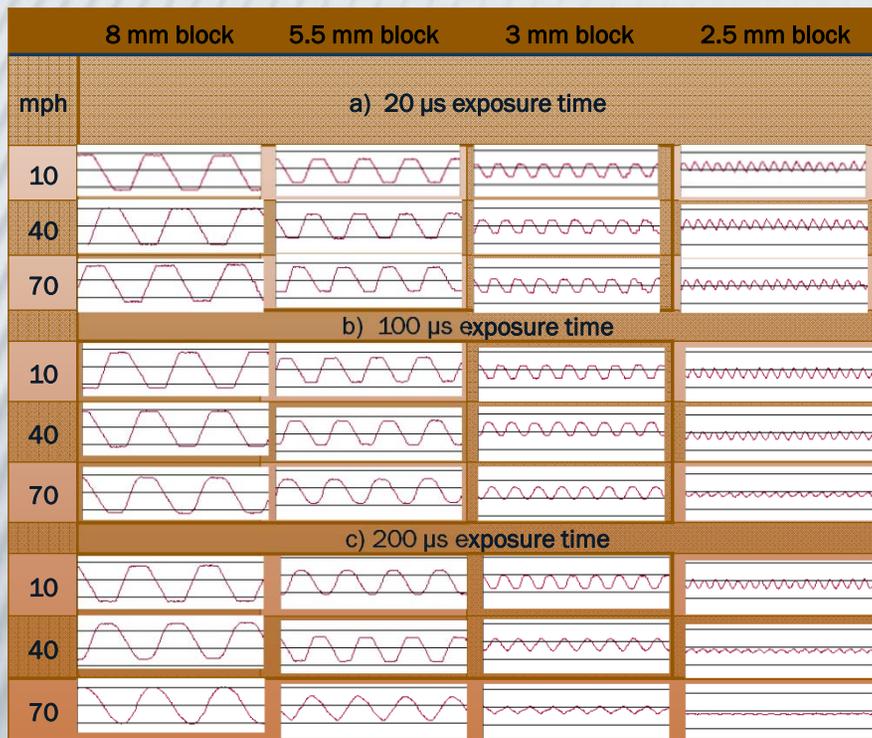
SPEED DEPENDENCY STUDY



- Different type of test pads were precisely machined and put in a line.
- **VTexture** scanned each test pad at different travel speed
- **VTexture** sensor exposure times set from 10 us to 250 us
- Surface profile of each test pad were examined under different test conditions.

IMPACT OF DIFFERENT EXPOSURE TIME

Profile distortion with different exposure time at different travel speed

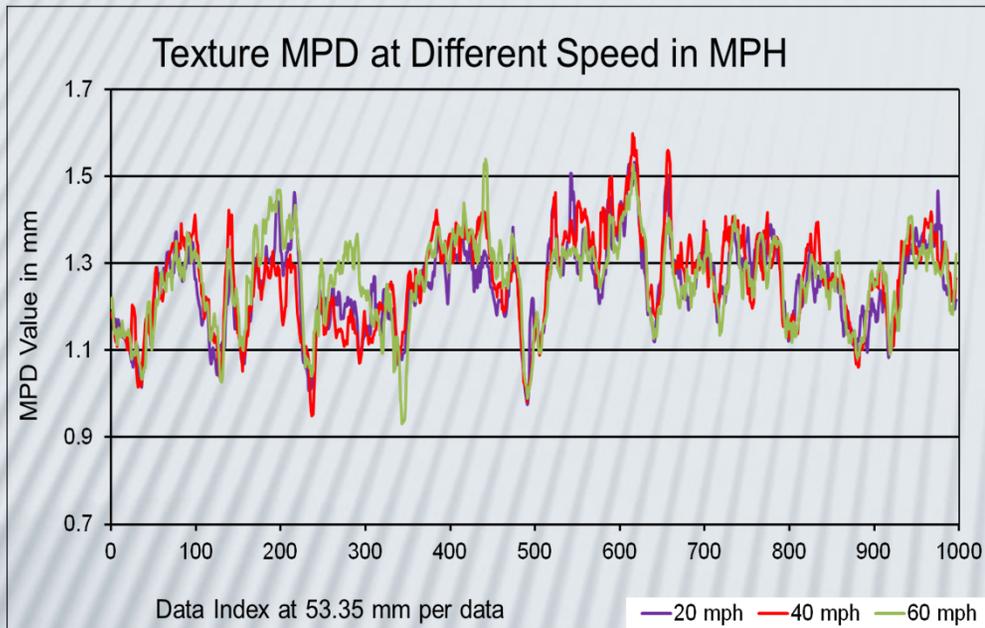


MPD percentage errors with different exposure time at different travel speed

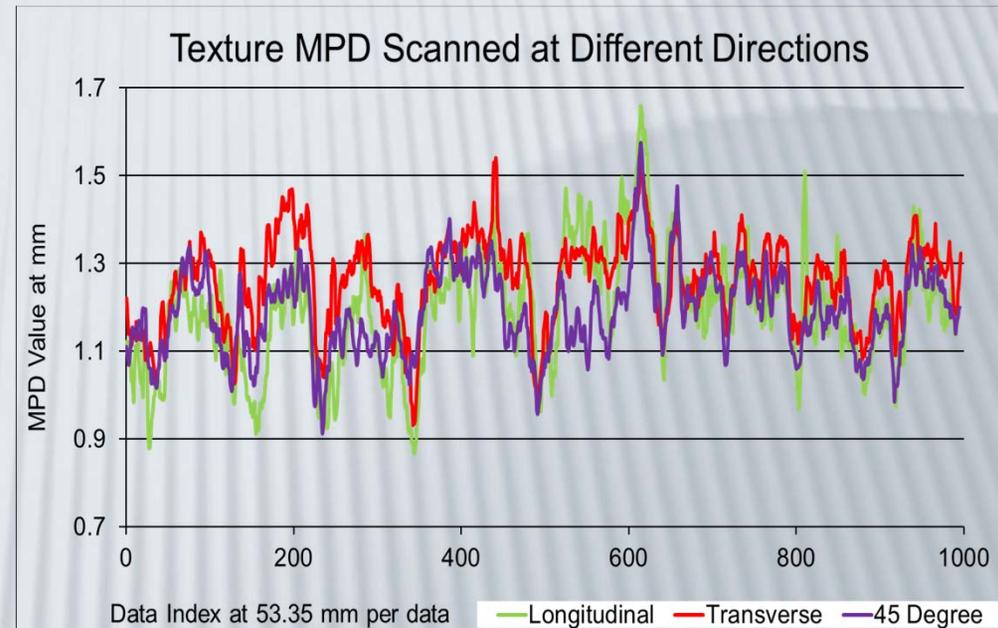
Travel Speed	Exposure time in μs								
	20	30	40	50	100	150	200	250	
2.5 mm block	0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
	10	3.0	2.4	4.0	4.8	5.9	11.2	11.2	
	20	4.3	4.0	6.6	6.7	9.1	21.0	28.8	34.7
	30	6.6	4.2	5.0	8.8	19.5	33.1	43.5	55.2
	40	6.6	7.1	9.2	11.9	28.6	43.5	63.1	82.1
	50	9.6	11.4	10.8	15.1	36.4	57.5	82.8	87.0
	60	9.8	10.2	13.6	19.1	43.4	69.9	85.6	82.4
5.5 mm block	0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	10	2.0	2.6	2.2	3.9	4.4	3.3	4.1	2.4
	20	2.1	2.5	3.1	2.9	4.0	4.7	4.3	3.7
	30	1.5	2.4	2.3	2.5	3.8	4.9	5.2	4.9
	40	2.4	2.8	3.6	3.8	3.8	4.4	5.9	6.1
	50	2.3	3.0	3.6	2.9	4.1	5.1	6.8	7.1
	60	2.5	2.5	4.5	3.3	4.2	5.8	7.5	9.0
8 mm block	0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	10	0.1	0.3	1.5	1.1	1.9	2.0	2.0	0.6
	20	1.1	1.4	1.3	1.3	2.0	2.1	2.1	2.4
	30	1.0	1.6	1.8	1.5	2.1	2.7	2.4	2.6
	40	1.4	1.8	1.5	1.0	2.3	2.9	2.7	3.6
	50	1.2	1.6	2.1	1.6	2.4	3.6	3.9	3.7
	60	1.8	1.8	2.6	2.4	2.5	4.2	4.4	4.2
70	-2.1	2.0	1.7	2.5	2.8	4.2	3.9	5.0	

Long sensor exposure time is the main reason causing texture data error with vehicle speed, especially on small surface features. The maximum exposure time of 20 μs is recommended to maintain MPD errors under 10% over the full speed range.

SYSTEM VERIFICATION



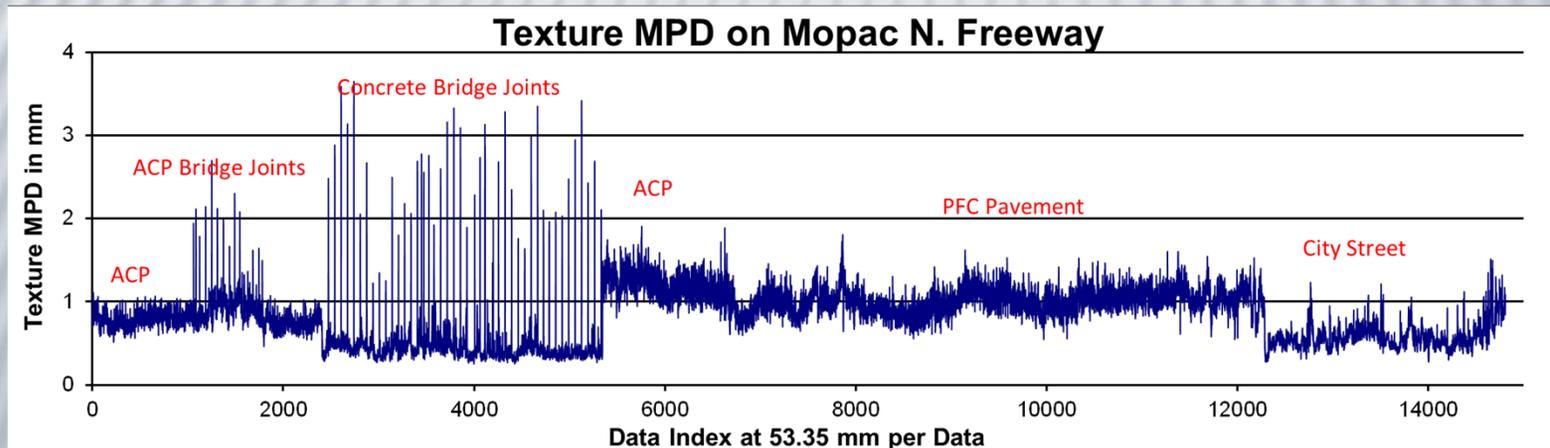
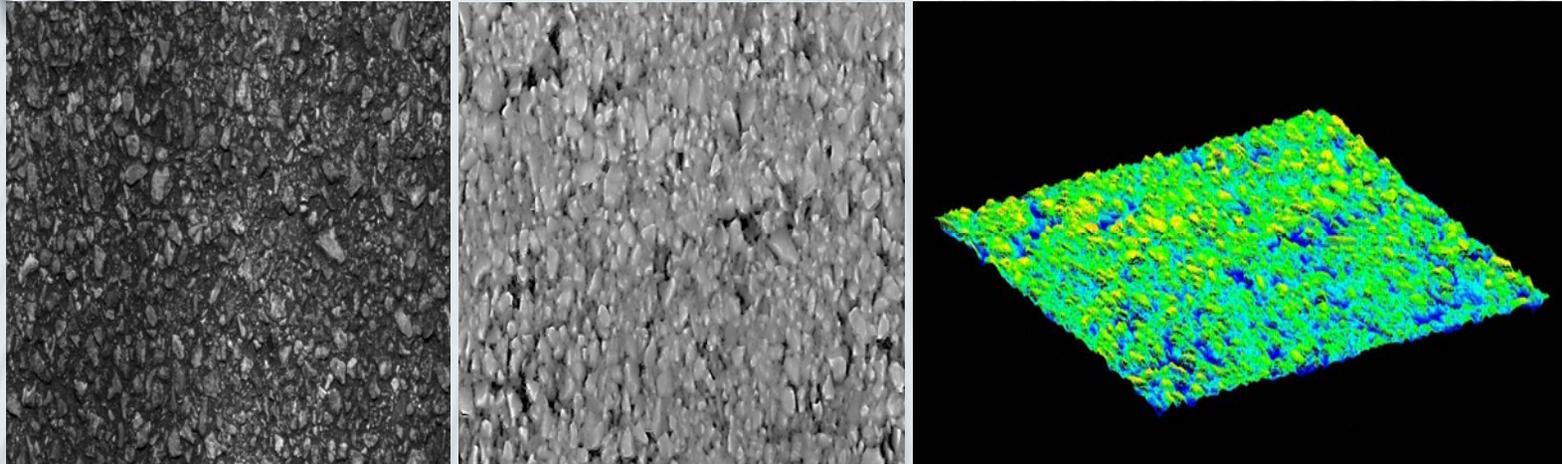
VTexture was tested at different vehicle speeds on selected pavement section. In this sample test on a PFC surface, the average correlation between different runs is $R^2=0.756$



VTexture was mounted longitudinally, transversely, and 45 degree to the travel directions. At network level data collection, scanning at different directions does not show significant difference.

APPLICATIONS

Project level data collection provides high resolution 3D surface and detailed surface feature measurement.



Network level data collection provides texture MPD at every 2.1 in (53.35 mm) of travel. And summaries data at every 0.1 mile.

SUMMARY

A high speed 3D technology based pavement texture device called **VTexture** was developed by a team in the Material & Pavement Branch, Maintenance Division, Texas Department of Transportation (TxDOT). **VTexture** is a part of TxDOT pavement data collection system and provides high speed network level survey or high resolution project level 3D pavement inspection.

As the **VTexture** is implemented with a very small sensor exposure time, data errors related to travel speed is minimized. Over the past years, VTexture has been used in different TxDOT projects. It provides accurate and stable results on a variety of different pavement surfaces.

Thank you !

Texas Department of Transportation, Maintenance Division.

Yaxiong (Robin) Huang, Ph.D. Robin.Huang@txdot.gov, 512-465-3675

Todd Copenhaver, Todd.Copenhaver@txdot.gov, 512-465-3065

Phillip Hempel, P.E. Philip.Hempel@txdot.gov, 512-465-3650

Magdy Mikhail, Ph.D, P.E. Magdy.Mikhail@txdot.gov, 512-465-3686