Certifying a 3D Pavement System as an Inertial Profiler

By

Michael Richardson, PE – Senior Product Engineer

Mandli Communications, Inc.

Overview

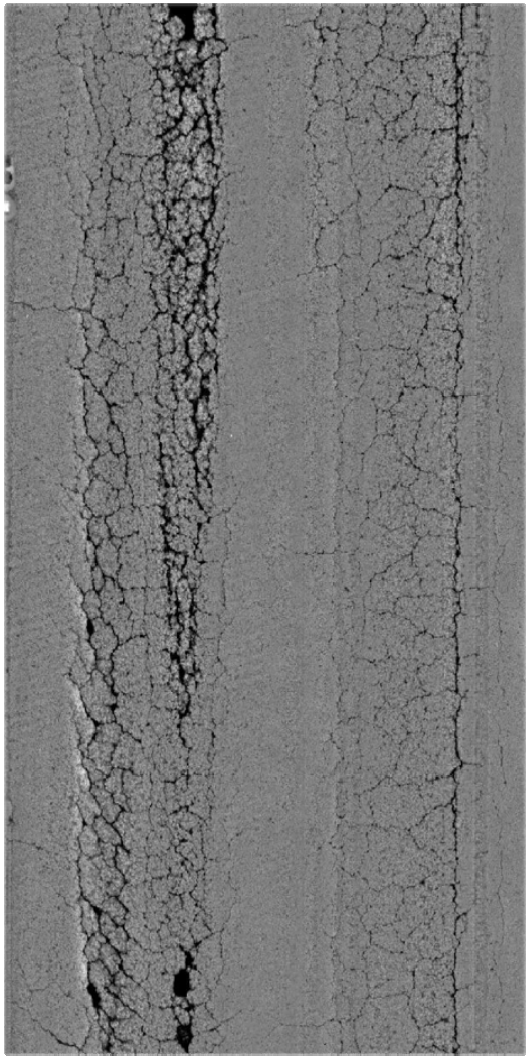
- Background in Pavement Data Collection
- Background in Certification
- Why Upgrade to 3D System for Profiling?
- Standard Review (AASHTO R56)
- Certification Site Details
- Certification Results
- Future Improvements

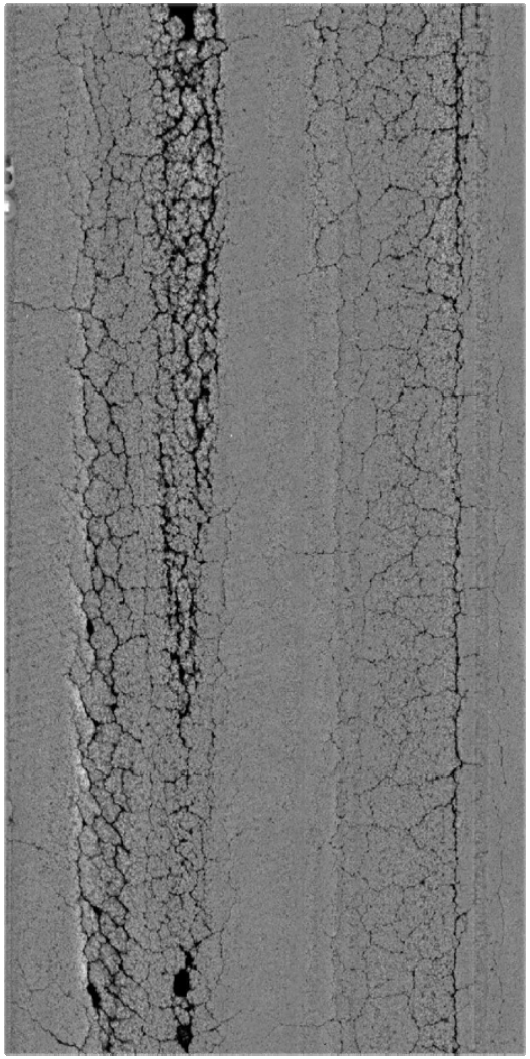
Background in Pavement Data Collection

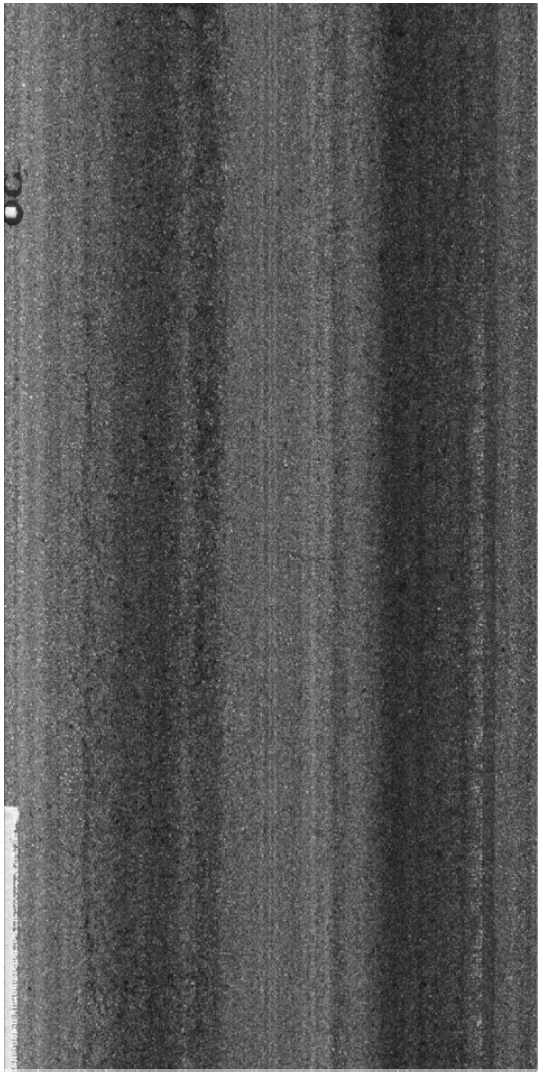
- 2001
  - Began network-level profiling
  - Distress analysis from ROW imaging
- 2005
  - Started experimenting with line-scan pavement imaging
- 2006
  - Purchased LRIS and LRMS to begin network-level collection of pavement images and transverse profiles

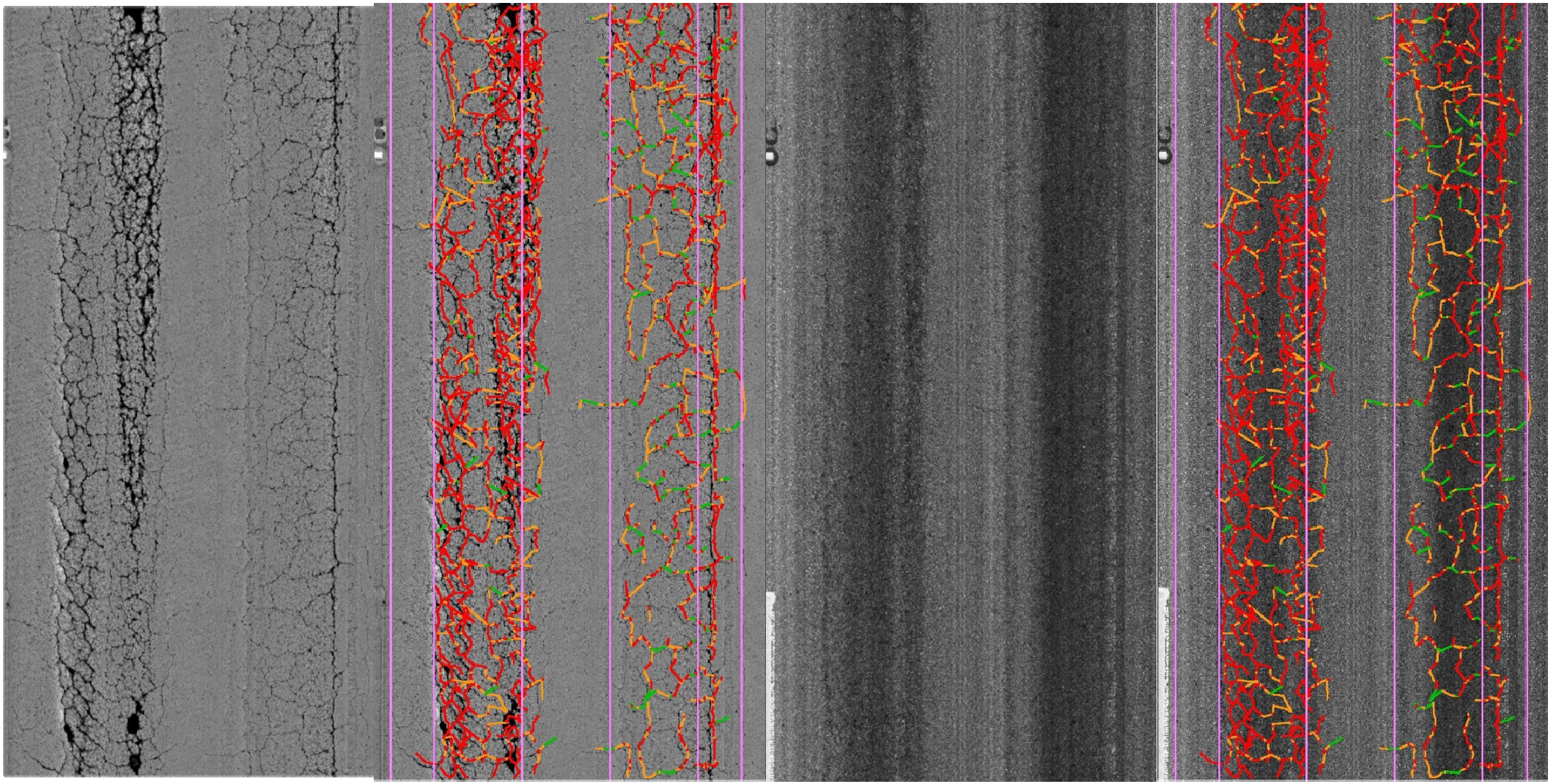
Background in Pavement Data Collection, Cont'd.

- 2009
  - Purchased LCMS and started network-level collection of 3D pavement data
- 2015
  - Purchased IMUs for LCMS and began extracting longitudinal profiles from 3D pavement data









Background in Certification

- 2010
  - Began working with walking profilers
- 2011
  - Set up our first SurPRO site near Stoughton, WI with rented equipment
  - Had number of issues passing on this site due to rutting and other distresses
  - Valuable learning experience
  - Created internal certification process

Background in Certification, Cont'd.

- 2013
  - Purchased SurPRO 3500
  - Set up new site in Fitchburg, WI
  - New road with two lanes in each direction
- 2015
  - Certified RSP at NCAT
  - Certified LCMS at Fitchburg, WI site
- 2012 – 2016:
  - Set up SurPRO sites in AK, DE, KS, KY, OK, and UT

Why Upgrade to 3D System for Profiling?

- Streamline pavement collection vehicle
- Single source of pavement data
- System has proven to be repeatable
- Accounts for most driver-wander
- Ability to extract longitudinal profile from anywhere across the detected lane
- Offers option to use a bridging filter transversely and longitudinally

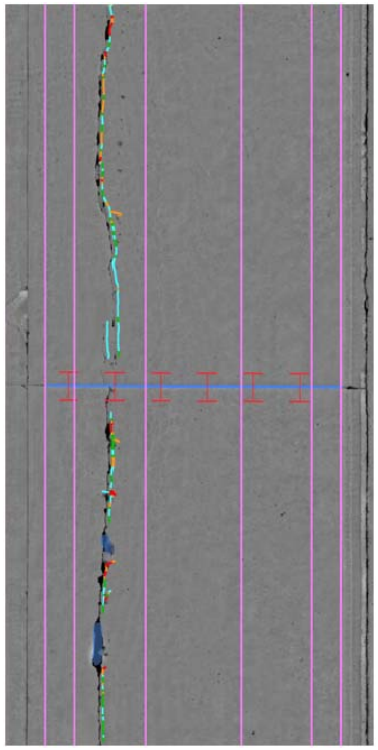
Standard LCMS Deliverables

- Crack detection
- Transverse Profiles
- Rutting
- Transverse Joint Detection
- Faulting
- Longitudinal Joint Detection
- Macrotexture Evaluation (MPD, MTD)
- Detection of Raveling
- Pothole and Delamination Detection
- Bleeding Detection

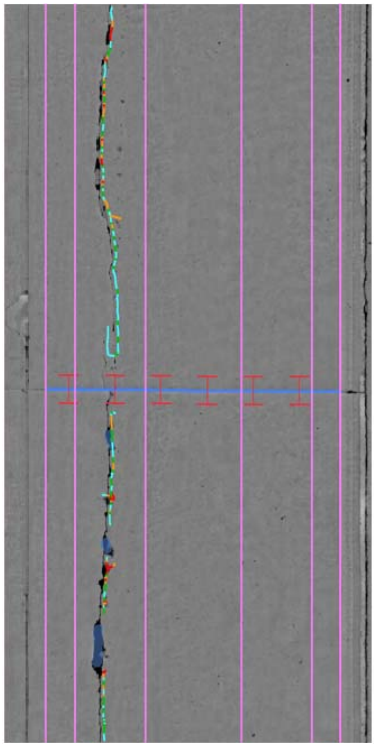
Deliverables Added with IMUs

- Longitudinal Profile
- IRI
- Curve and Grade
- Cross Slope
- Water Entrapment Depth

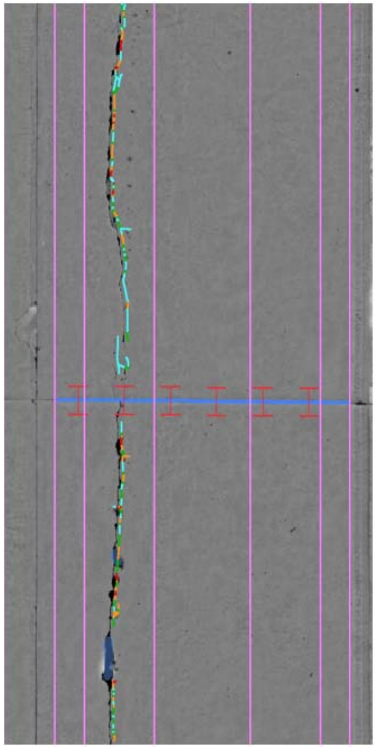
Crack Detection Repeatability



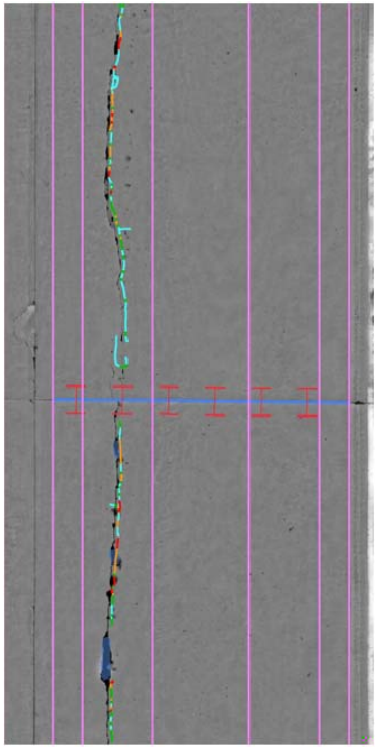
Run 1



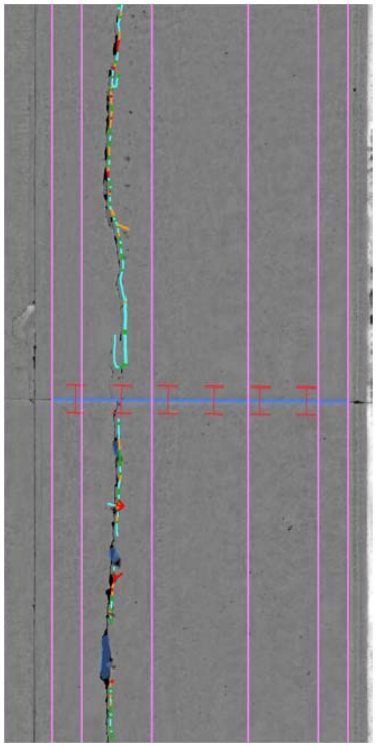
Run 2



Run 3



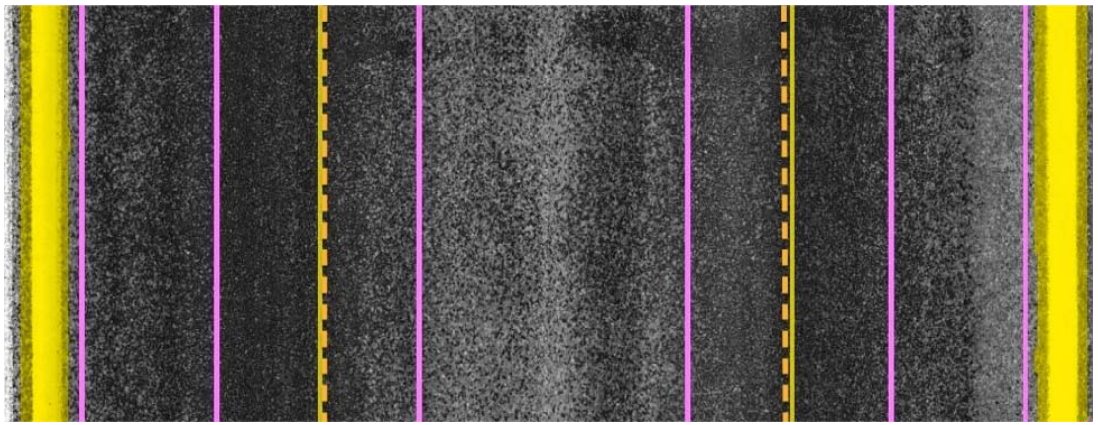
Run 4



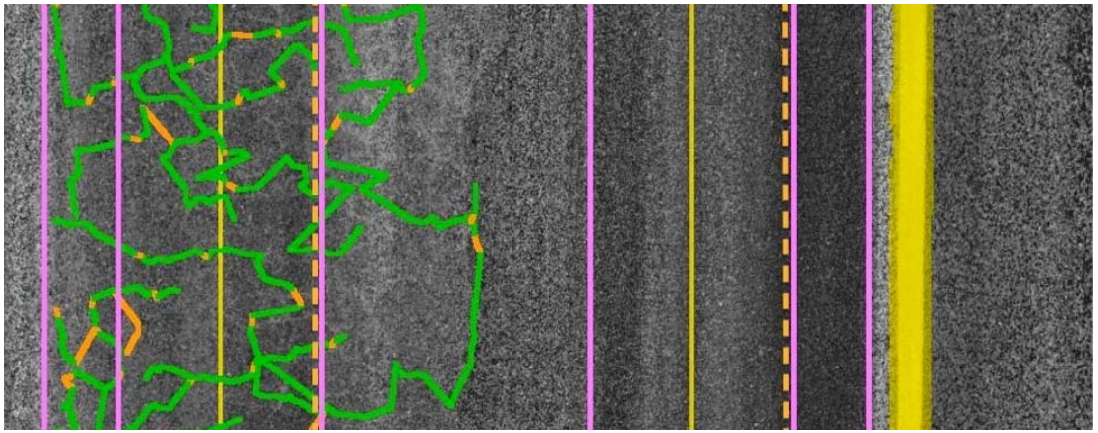
Run 5

Accounts for Driver-Wander

Ideal conditions:
Centered on lane



Not ideal conditions:
Driver wanders to the right



Full Lane of Profiles

Single Point

4,000 Points

Standard Review: AASHTO R56

- Equipment (Section 5)
- Equipment Calibration Verification (Section 6)
- Operator Certification (Section 7)
- Equipment Certification (Section 8)

Required Equipment

- AASHTO M328 is referenced for the required equipment

"The longitudinal pavement profile shall be measured using equipment in which three primary transducers are used. These transducers include:

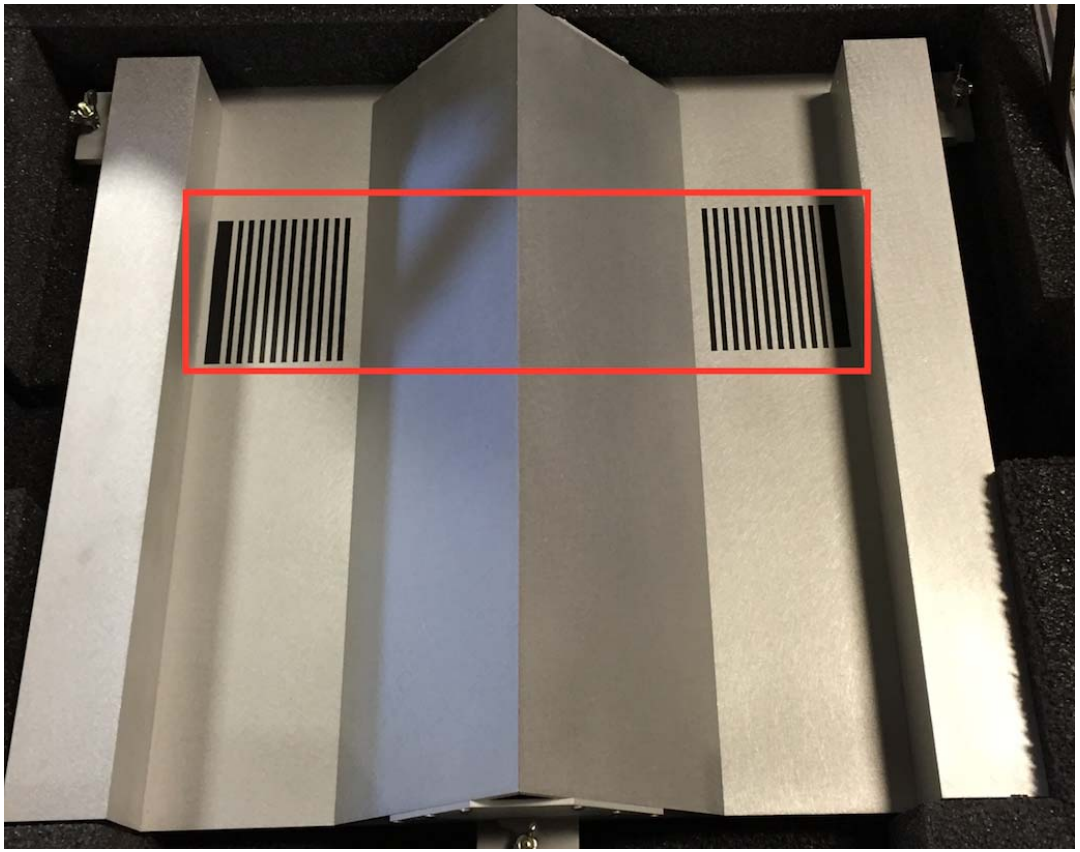
1. *A height sensor that measures the distance between a vehicle reference point and the pavement while the vehicle is traveling*
2. *An accelerometer that measures the vertical acceleration of the vehicle as it moves vertically in response to the pavement profile*
3. *A distance sensor that provides a location reference for the vehicle as it travels."*

Equipment Calibration Verification

- Must execute successful bounce test and block check per R57 prior to moving on to equipment certification
  - Bounce Test
    - Simulate 2,184 feet of collection; 828 feet static, 528 feet bouncing, 828 feet static
    - Static sections should be less than 3 in/mi and bounce section less than 8 in/mi (ignoring first and last 300 feet as lead-in and lead-out)
  - Block Check
    - Must measure plate, 1-inch block, and 2-inch block
    - Measurements must be within 0.01 inches of known heights

Static Validation

- Known dimensions
- Vertical and horizontal measurements
- Focus check
- Measured 6 times
  - Left, center and right for each pod



Operator Certification

- Operation of an inertial profiler should only be performed by a certified operator.
- Operator certification should include the following:
  - Completion of a training course
  - Written examination
  - Practical examination
  - Documentation of certification

Equipment Certification

- Test Sections
  - Should be at least 528 feet
  - Should be flat and without curvature
  - Should test on multiple sites with range of IRI values
    - Smooth: 30 – 75 in/mi
    - Medium-Smooth: 95 – 135 in/mi
    - Medium-Rough: <200 in/mi

Equipment Certification, Cont'd.

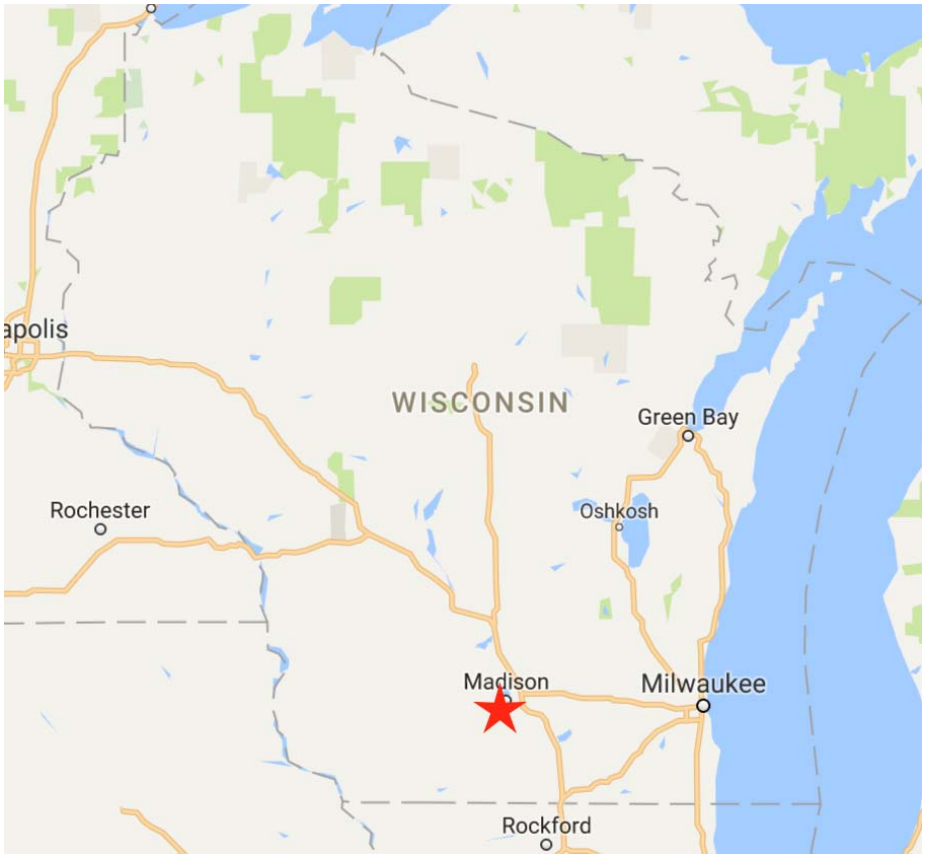
- Reference Profiles
  - Reference device must collect at 1-in intervals or better
  - Collect 3 repeat runs in each wheel path
  - Average repeatability of the 3 runs should be at least 98%

Equipment Certification, Cont'd.

- Van Profiles
  - Collect 10 runs, 5 runs at 2 different speeds
- Equipment Repeatability
  - Comparing 10 van runs to themselves should have an agreement score of 92% with ProVAL certification module
- Equipment Accuracy
  - Comparing 10 van runs to reference profiles should have an agreement score of 92% with ProVAL certification module

Local Certification Site

- Located in Fitchburg, WI on Lacy Road
- 2 lanes in each direction
- 35 mph speed limit
- IRI of ~80 in/mi
- 528 feet long



Certification Results – Lacy Rd

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	91.11	100.00	100.00	100.00
Mean	93.92	96.12	92.60	93.66
Minimum	90.32	92.35	90.68	91.65
Maximum	97.18	98.09	94.87	95.13
Standard Deviation	1.6	1.3	1.2	1.0
Grade	Passed	Passed	Passed	Passed

Accuracy (%)

Run	Left	Right
1	93	93
2	93	94
3	91	94
4	91	94
5	95	93
6	92	94
7	92	95
8	92	92
9	93	93
10	94	95

Repeatability - Left Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	94	96	96	92	94	94	94	94	93
2		94	93	94	97	96	94	96	94
3			97	92	95	94	93	93	93
4				**90**	93	93	94	92	**90**
5					94	93	**90**	92	95
6						97	94	95	94
7							95	96	94
8								96	92
9									93

Repeatability - Right Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	96	97	97	96	96	96	97	98	95
2		97	98	96	98	97	94	97	96
3			97	96	98	98	94	96	97
4				95	96	96	96	97	95
5					97	96	95	96	94
6						97	93	96	96
7							94	97	97
8								97	92
9									96

Certification Results – Kingfisher, OK

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	97.78	100.00	100.00	100.00
Mean	95.25	98.39	95.43	97.87
Minimum	91.44	97.02	93.00	96.90
Maximum	98.18	99.49	96.79	98.84
Standard Deviation	1.8	0.6	1.0	0.6
Grade	Passed	Passed	Passed	Passed

Accuracy (%)

Run	Left	Right
1	93	97
2	95	97
3	95	97
4	97	98
5	96	98
6	96	99
7	96	97
8	95	98
9	95	99
10	96	98

Repeatability - Left Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	92	96	93	92	95	96	97	95	**91**
2		95	97	97	95	95	93	94	97
3			95	94	97	97	97	97	93
4				98	95	96	94	95	97
5					94	94	93	94	97
6						98	96	96	95
7							97	98	95
8								98	93
9									94

Repeatability - Right Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	98	98	97	98	98	97	98	98	97
2		99	98	99	99	98	99	99	99
3			98	99	98	97	99	98	98
4				98	99	99	98	99	99
5					98	97	99	99	98
6						99	99	99	99
7							98	98	99
8								99	99
9									99

Certification Results – Piedmont, OK

Statistics

Statistic	Repeatability - Left	Repeatability - Right	Accuracy - Left	Accuracy - Right
Comparison Count	45	45	10	10
% Passing	95.56	100.00	100.00	100.00
Mean	95.67	98.10	95.16	96.84
Minimum	90.35	96.10	93.22	96.25
Maximum	98.39	99.12	96.77	97.65
Standard Deviation	1.8	0.6	1.2	0.4
Grade	Passed	Passed	Passed	Passed

Accuracy (%)

Run	Left	Right
1	95	97
2	94	97
3	94	97
4	96	97
5	97	96
6	93	97
7	95	96
8	96	98
9	96	97
10	96	97

Repeatability - Left Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	97	95	96	97	93	94	95	93	96
2		94	96	95	**91**	93	93	**90**	94
3			96	96	96	98	96	94	98
4				98	94	96	97	95	97
5					94	97	98	96	97
6						97	96	95	96
7							98	97	98
8								98	97
9									96

Repeatability - Right Correlations (%)

Run	2	3	4	5	6	7	8	9	10
1	98	98	98	98	98	98	98	97	99
2		98	97	97	97	98	98	96	98
3			98	97	98	98	99	97	99
4				99	99	99	98	99	98
5					99	99	98	99	98
6						99	98	99	98
7							98	98	98
8								98	98
9									98

Future Plans

- Establish new sites in Madison area to include various pavement types and range of IRI values
- Work in various speeds to van runs
- Work on getting reference profile repeatability to 98%
- Update collection procedure to output profile at end of run by processing in real time