Improving the Quality of Pavement Profile Measurements

Evaluation of Potential Pavement Reference Devices

and

Inertial Profiler Type Testing

November 3, 2015
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Reference Device Evaluation

Describe

- Goals
- Approach

Thank participants

Provide a sample report

Reference Device Evaluation

Goals

- Obtain a cost effective, portable way to measure a reference profile.

- Provide incentive for innovation.

- Measure profile for current and expected applications **related to vehicle response.**
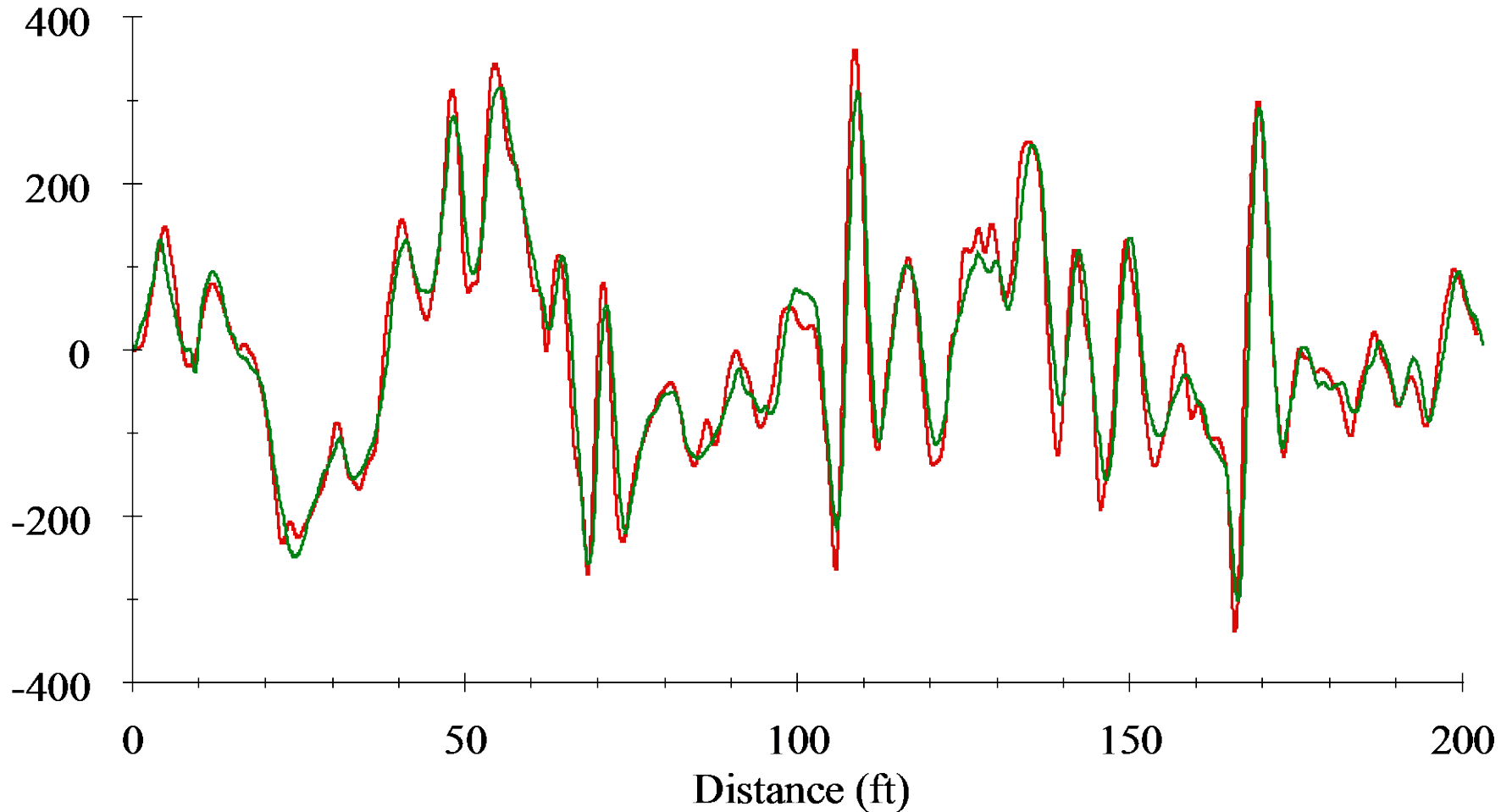
Reference Device Evaluation

Approach

- Comparison to a benchmark measurement
- Evaluation of profile:
  - profile trace accuracy
  - profile trace repeatability
  - longitudinal distance measurement accuracy
- Evaluation on diverse surface textures
- 6 passes on each test section

Cross Correlation: "Good" Agreement

AC Surfaces

PCC Surfaces

RPUG 2015

Markings

Profiling Cart

Reference Laser
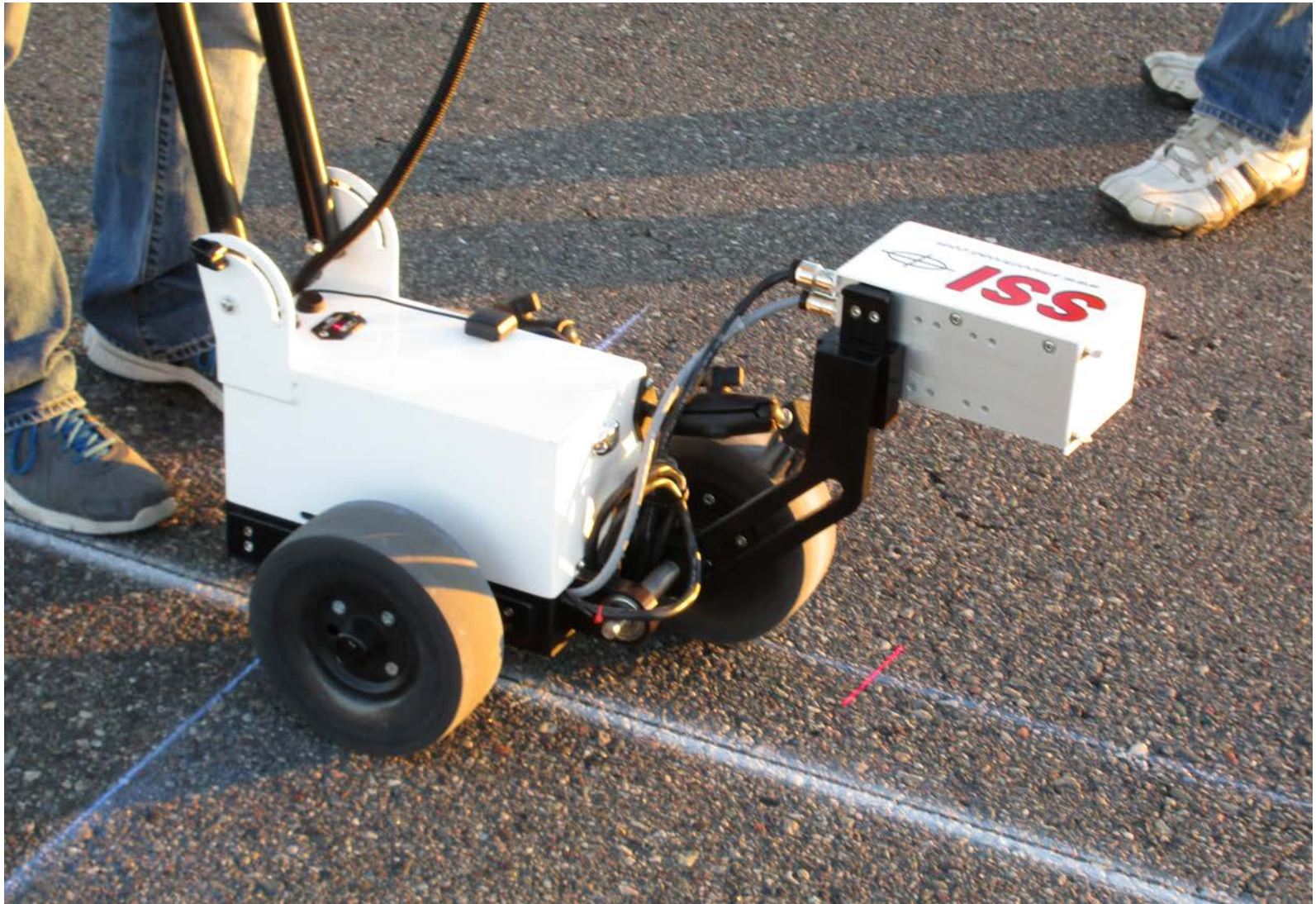
Rod and Level

RPUG 2015

SSI CS 8800 with Laser
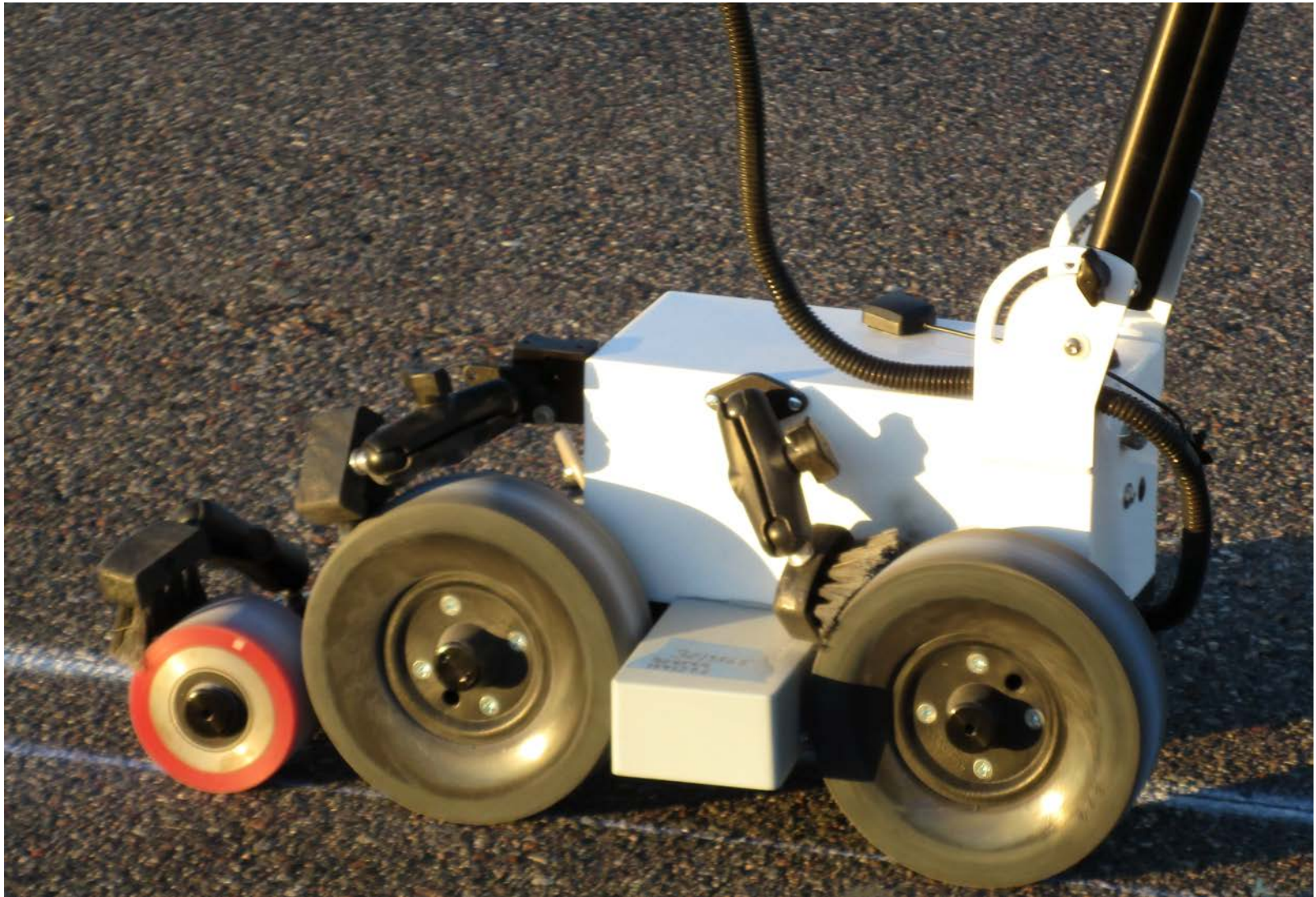

RPUG 2015

SSI CS 8800 with Laser

RPUG 2015

SSI CS 8800 with Wheel

RPUG 2015

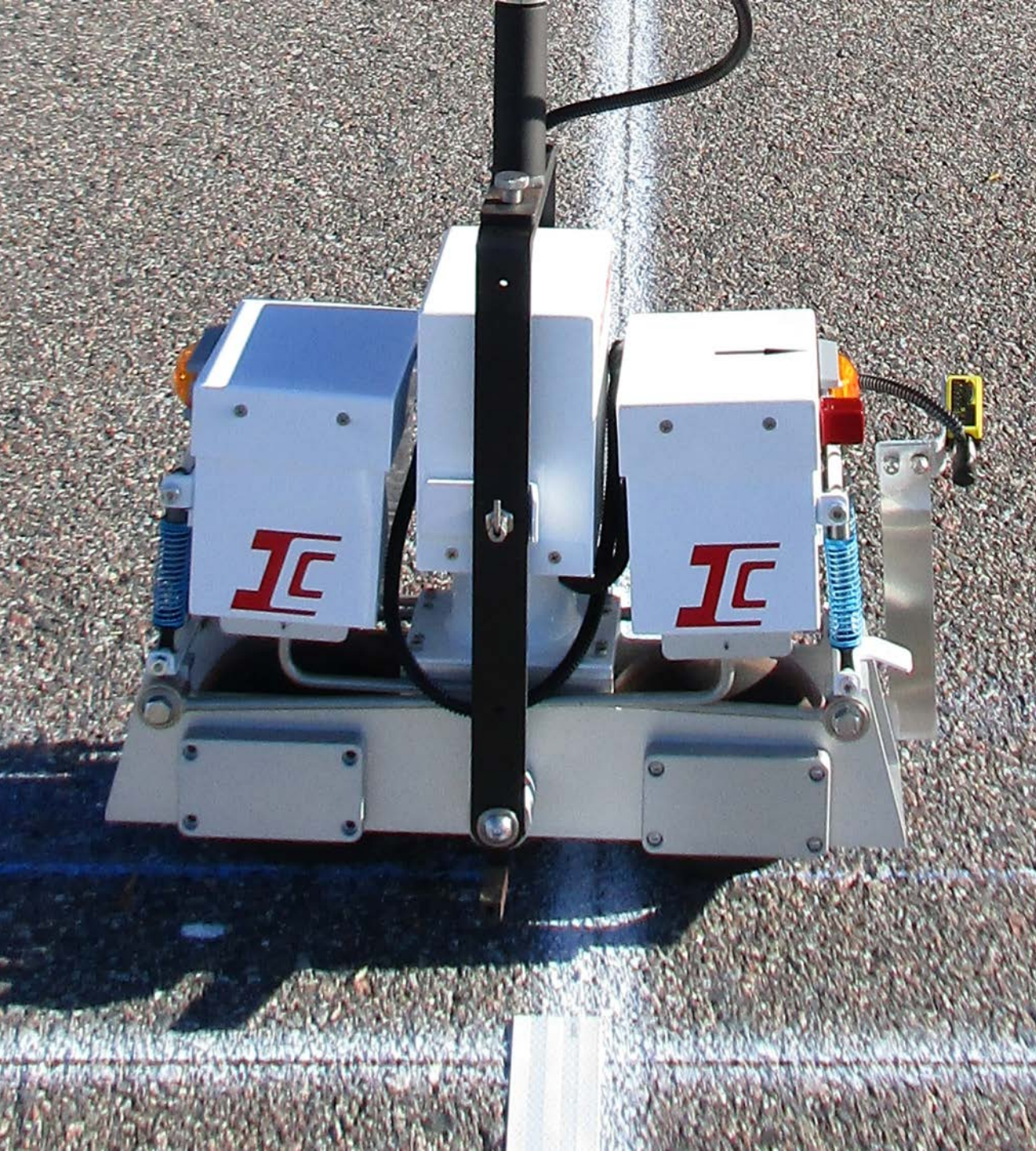# SSI CS 8800 with Wheel

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ARRB Walking Profiler G3

SurPro 4000

SurPro 4000

RPUG 2015

Shima MRP-3000

Shima MRP-3000

ICC Roadbot
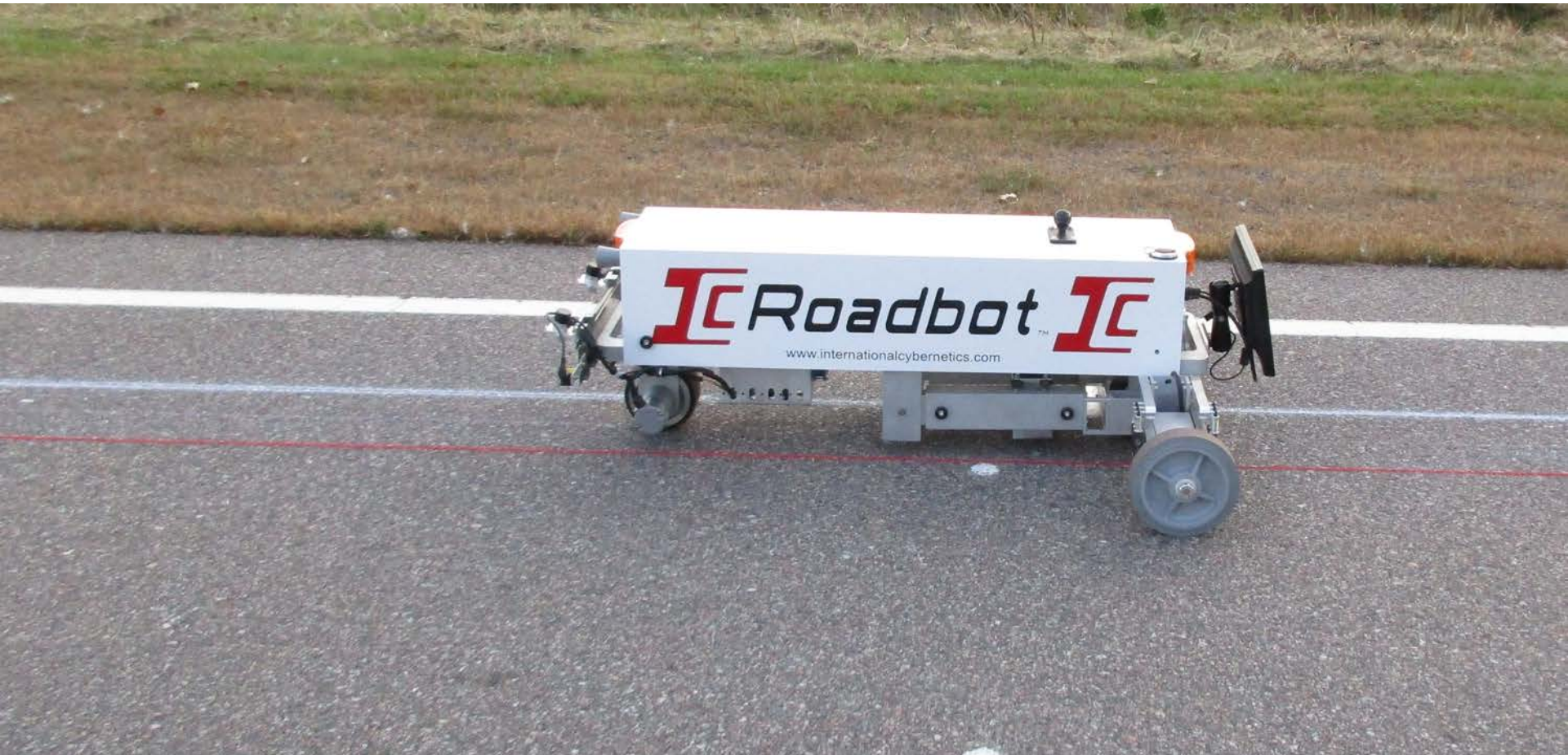
10/03/2015 16:25

Benchmark Test Evaluation Report

<u>Test Section:</u>   Long Dense-Graded Asphalt

<u>Date:</u>   2015-Oct 03

<u>Device:</u>   United Federation of Planets Standard Issue Triquarter

<u>Operator(s):</u>   Opie Rater

<u>Recording Interval:</u>   11.6 mm

<u>Use Moving Average:</u> No

<u>Up-Sampling:</u>   For comparison to the benchmark profile measurement, data were up-sampled to an interval of 5.08 mm.

<u>Results for Profile:</u>

Waveband	Repeatability Score		Accuracy Score	
	Required	Achieved	Required	Achieved
IRI	0.98	0.992	0.98	0.975
Long	0.98	0.993	0.98	0.981
Medium	0.98	0.992	0.98	0.960
Short	0.94	0.689	0.94	0.127

<u>Result for Longitudinal Distance:</u>   Passed

The average error in longitudinal distance was -0.01 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (mm/km)	Percent Error	Length (m)	Percent Error
1	11:16	11:32	1.835	-1.49	386.06	-0.02
2	11:41	11:57	1.835	-1.53	386.09	-0.01
3	12:06	12:22	1.836	-1.47	386.09	-0.01
4	12:30	12:46	1.837	-1.38	386.09	-0.01
5	12:56	13:12	1.831	-1.70	386.12	-0.01
6	13:16	13:32	1.824	-2.10	386.12	-0.01

The section length is 386.15 m, measured with a steel tape and temperature corrected.
The reference IRI value is 1.863m/km.

Accuracy Scores:

With optimal DMI correction:

Run	Cross Correlation to Benchmark Profile by Waveband						
	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.979	0.980	0.964	0.112	0.153	0.088	0.157
2	0.978	0.983	0.963	0.103	0.144	0.080	0.149
3	0.977	0.980	0.961	0.117	0.158	0.092	0.153
4	0.977	0.980	0.962	0.112	0.164	0.087	0.155
5	0.970	0.976	0.955	0.123	0.157	0.088	0.160
6	0.969	0.988	0.953	0.093	0.156	0.089	0.160
Ave.	0.975	0.981	0.960	0.110	0.155	0.087	0.156

With no DMI correction:

Run	Cross Correlation to Benchmark Profile by Waveband						
	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.976	0.980	0.958	0.126	0.175	0.089	0.154
2	0.972	0.983	0.960	0.107	0.166	0.085	0.131
3	0.972	0.980	0.958	0.125	0.176	0.095	0.137
4	0.972	0.979	0.959	0.133	0.191	0.086	0.140
5	0.970	0.975	0.956	0.130	0.154	0.075	0.155
6	0.968	0.987	0.953	0.094	0.141	0.097	0.158
Ave.	0.972	0.981	0.957	0.119	0.167	0.088	0.146

Repeatability:

With optimal DMI correction:

Run 1	Run 2	Cross Correlation by Waveband						
		IRI	Long	Med.	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.996	0.995	0.996	0.659	0.762	0.707	0.833
1	3	0.995	0.998	0.994	0.785	0.861	0.743	0.802
1	4	0.995	0.998	0.995	0.830	0.814	0.704	0.798
1	5	0.988	0.993	0.988	0.797	0.815	0.688	0.771
1	6	0.987	0.991	0.986	0.423	0.603	0.508	0.729
2	3	0.997	0.996	0.995	0.699	0.810	0.679	0.792
2	4	0.996	0.995	0.996	0.592	0.691	0.627	0.787
2	5	0.990	0.991	0.990	0.646	0.732	0.630	0.762
2	6	0.988	0.993	0.987	0.619	0.715	0.494	0.664
3	4	0.997	0.998	0.996	0.743	0.778	0.730	0.770
3	5	0.991	0.994	0.992	0.761	0.840	0.681	0.779
3	6	0.989	0.991	0.989	0.479	0.664	0.497	0.697
4	5	0.991	0.993	0.991	0.774	0.790	0.730	0.772
4	6	0.989	0.990	0.988	0.367	0.544	0.427	0.666
5	6	0.993	0.986	0.992	0.456	0.641	0.507	0.661
Average		0.992	0.993	0.992	0.642	0.737	0.623	0.752

With no DMI correction:

Run 1	Run 2	Cross Correlation by Waveband						
		IRI	Long	Med.	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.996	0.995	0.996	0.652	0.754	0.694	0.817
1	3	0.995	0.998	0.994	0.774	0.848	0.727	0.784
1	4	0.994	0.998	0.994	0.810	0.792	0.678	0.776
1	5	0.987	0.993	0.987	0.785	0.806	0.655	0.745
1	6	0.986	0.991	0.984	0.416	0.591	0.491	0.714
2	3	0.997	0.996	0.995	0.689	0.802	0.672	0.780
2	4	0.996	0.995	0.996	0.582	0.678	0.610	0.770
2	5	0.990	0.991	0.990	0.631	0.710	0.612	0.738
2	6	0.988	0.993	0.986	0.602	0.698	0.484	0.645
3	4	0.997	0.998	0.996	0.726	0.766	0.719	0.755
3	5	0.991	0.993	0.992	0.734	0.817	0.668	0.751
3	6	0.989	0.991	0.989	0.465	0.656	0.489	0.681
4	5	0.991	0.993	0.991	0.765	0.772	0.707	0.751
4	6	0.989	0.990	0.988	0.361	0.536	0.416	0.649
5	6	0.993	0.986	0.992	0.443	0.619	0.491	0.640
Average		0.992	0.993	0.991	0.629	0.723	0.608	0.733

Benchmark Test Evaluation Summary

Device: United Federation of Planets Standard Issue Triquarter

Recording Interval: 11.6 mm

Use Moving Average: No

Up-Sampling: For comparison to the benchmark profile measurement, data were up-sampled to an interval of 5.08 mm.

Profile Accuracy Scores:

	Waveband			
	IRI	Long	Medium	Short
Required	0.98	0.98	0.98	0.94
Achieved				
Dense Graded AC	0.975	0.981	0.960	0.127
Chip Seal	0.937	0.963	0.926	0.110
Porous Asphalt	0.973	0.977	0.962	0.094
Transverse Tining	0.938	0.981	0.904	0.116
Diamond Grinding	0.938	0.975	0.930	0.160
Longitudinal Tining	0.979	0.983	0.971	0.144
Smooth Asphalt	0.953	0.974	0.927	0.079

Profile Repeatability Scores:

	Waveband			
	IRI	Long	Medium	Short
Required	0.98	0.98	0.98	0.94
Achieved				
Dense Graded AC	0.992	0.993	0.992	0.689
Chip Seal	0.953	0.965	0.953	0.769
Porous Asphalt	0.977	0.992	0.975	0.605
Transverse Tining	0.967	0.968	0.958	0.443
Diamond Grinding	0.971	0.990	0.963	0.462
Longitudinal Tining	0.982	0.976	0.981	0.629
Smooth Asphalt	0.965	0.984	0.939	0.421

Longitudinal Distance Measurement:

	DMI Error (%)		
Test Section	Average	High	Low
Required	0.10		
Achieved			
Dense Graded AC	-0.01	-0.01	-0.02
Chip Seal	0.28	0.35	0.21
Porous Asphalt	0.12	0.15	0.11
Transverse Tining	0.03	0.07	0.02
Diamond Grinding	0.08	0.10	0.08
Longitudinal Tining	0.02	0.04	0.00
Smooth Asphalt	0.06	0.10	0.02

Profile Repeatability Scores:

With no DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.92	0.92	0.92	0.80
Dense Graded AC 25 mph	0.987	0.995	0.986	0.583
Dense Graded AC 50 mph	0.987	0.994	0.986	0.637
Chip Seal	0.963	0.991	0.956	0.539
Negative Textured AC	0.976	0.991	0.973	0.583
Transverse Tining	0.972	0.991	0.962	0.636
Diamond Grinding	0.980	0.983	0.984	0.590
Longitudinal Tining	0.974	0.989	0.971	0.471
Smooth Asphalt	0.986	0.987	0.982	0.483

With optimal DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.92	0.92	0.92	0.80
Dense Graded AC 25 mph	0.987	0.995	0.986	0.636
Dense Graded AC 50 mph	0.988	0.994	0.988	0.686
Negative Textured AC	0.963	0.994	0.956	0.587
Chip Seal	0.977	0.997	0.974	0.629
Transverse Tining	0.974	0.995	0.964	0.673
Diamond Grinding	0.981	0.990	0.985	0.633
Longitudinal Tining	0.974	0.995	0.972	0.506
Smooth Asphalt	0.987	0.988	0.984	0.560

Type Testing/Pilot Certification

Describe
- Goals
- Approach

Thank participants

Provide a sample report

Pilot Certification

Goals

- Expose the community to procedures that would be applied in regional network profiler certification.

- Apply the dynamic testing portion of AASHTO R-56.

- Give participants an idea of the status of their equipment.

Pilot Certification

Approach

- Comparison to a benchmark/reference measurement
- Evaluation of profile:
  - profile trace accuracy
  - profile trace repeatability
  - longitudinal distance measurement accuracy
- Evaluation on diverse surface textures
- 10 passes on each test section

RPUG 2015

Replacement AC Surfaces

Chip Seal

Novachip

RPUG 2015

Mn/ROAD

MnDOT SurPro

ICC High-Speed

ICC High-Speed Footprint

Ames Engineering 8300

SSI CS 9100

ARRB Hawkeye

Mandli (LCMS, Dynatest)

Fugro ARAN

Pathway Pathrunner

Inertial Profiler Evaluation Summary

Device: ACME Pavement Network Evaluation Drone

Recording Interval: 11.6 mm

Use Moving Average: Yes

Use Bridging Filter: Not applied

   This may be applied in a subsequent pass through the short waveband analysis.

Up-Sampling: For comparison to the benchmark profile measurement, data were up-sampled to an interval of 5.08 mm.

Longitudinal Distance Measurement: Requirement $-0.1\% < \text{Error} < 0.1\%$

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC 25 mph	0.02	0.03	0.02
Dense Graded AC 50 mph	0.02	0.05	0.00
Chip Seal	0.05	0.10	0.02
Transverse Tining	0.03	0.10	0.01
Diamond Grinding	0.02	0.06	-0.04
Longitudinal Tining	0.04	0.09	0.00
Smooth Asphalt	0.05	0.10	-0.03

Profile Accuracy Scores:

With no DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.90	0.90	0.90	0.80
Dense Graded AC 25 mph	0.920	0.990	0.912	0.152
Dense Graded AC 50 mph	0.985	0.987	0.986	0.205
Chip Seal	0.916	0.971	0.924	0.207
Negative Textured AC	0.884	0.961	0.895	0.408
Transverse Tining	0.956	0.989	0.935	0.216
Diamond Grinding	0.953	0.985	0.942	0.390
Longitudinal Tining	0.967	0.979	0.964	0.198
Smooth Asphalt	0.968	0.987	0.947	0.141

With optimal DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.90	0.90	0.90	0.80
Dense Graded AC 25 mph	0.926	0.990	0.916	0.210
Dense Graded AC 50 mph	0.988	0.987	0.989	0.233
Chip Seal	0.929	0.975	0.943	0.235
Negative Textured AC	0.922	0.985	0.935	0.446
Transverse Tining	0.959	0.991	0.940	0.259
Diamond Grinding	0.956	0.992	0.946	0.500
Longitudinal Tining	0.970	0.988	0.967	0.275
Smooth Asphalt	0.970	0.988	0.951	0.152

Profile Repeatability Scores:

With no DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.92	0.92	0.92	0.80
Dense Graded AC 25 mph	0.987	0.995	0.986	0.583
Dense Graded AC 50 mph	0.987	0.994	0.986	0.637
Chip Seal	0.963	0.991	0.956	0.539
Negative Textured AC	0.976	0.991	0.973	0.583
Transverse Tining	0.972	0.991	0.962	0.636
Diamond Grinding	0.980	0.983	0.984	0.590
Longitudinal Tining	0.974	0.989	0.971	0.471
Smooth Asphalt	0.986	0.987	0.982	0.483

With optimal DMI correction:

	Waveband			
	IRI	Long	Medium	Short
Requirement	0.92	0.92	0.92	0.80
Dense Graded AC 25 mph	0.987	0.995	0.986	0.636
Dense Graded AC 50 mph	0.988	0.994	0.988	0.686
Negative Textured AC	0.963	0.994	0.956	0.587
Chip Seal	0.977	0.997	0.974	0.629
Transverse Tining	0.974	0.995	0.964	0.673
Diamond Grinding	0.981	0.990	0.985	0.633
Longitudinal Tining	0.974	0.995	0.972	0.506
Smooth Asphalt	0.987	0.988	0.984	0.560

Reference Testing/Pilot Certification

Issues

- Changes in jointed PCC profile
- Left wheel track
- Filtering
- Very smooth pavement
- Short waveband
- Data volume

Thank you.