

Benchmark Test Evaluation Report

Federal Highway Administration Project “Improving the Quality of Pavement Profiler Measurement”

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September, 2011

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Acknowledgements

The author of this report would like to thank all the participants in this experiment. The author is particularly grateful for the assistance of Bruce Wasill (Federal Highway Administration (FHWA), Western Federal Lands highway Division) and John Andrews (Maryland State Highway Administration) for their help in the 2009 experiment and Robert Orthmeyer (FHWA) for his help with the 2009 and 2010 experiment. Bruce, John, and Robert assisted with the set-up and monitoring of the 2009 experiment, and endured unreasonable long hours through by challenging weather. Without their help, the 2009 experiment would not have been completed.

The author is also very grateful for the generous access to test pavements offered by the Minnesota Department of Transportation (DOT) and the Wisconsin DOT. Terry Treutel (Wisconsin DOT) also assisted with set-up, marking, and monitoring that the Wisconsin site. The people at Mn/Road were excellent hosts throughout both experiments, and were very generous with active assistance during the testing. Jack Herndon, Ben Worel, Steve Olsen, Eddie Johnson, Doug Lindenfelser, and Tim Clyne are among the people who assisted with the experiments at Mn/Road.

The author would also like to thank members of the staff at the University of Michigan Transportation Research Institute, including Dan Huddleson, John Koch, and John Hall, who monitored the Mn/Road test sections during the 2010 experiment; Chris Winkler and Scott Bogard, who operated the Benchmark Profiler during both experiments; and; Chris Winkler, Mark Gilbert, Mike Hagan, John Koch, Dan Huddleson, and Mike Campbell, who were all involved in either the design or fabrication of the Benchmark Profiler (or both).

The author also thanks Rohan Perera (Soil and Materials Engineers, Inc.) for his technical advice during the project, and for providing access to the surveyor's rod and level. The author also thanks Mel Zahrob from Instrument Sales & Service in Redford, Michigan for sharing his abundant knowledge of optical survey equipment.

The author would like to thank all of the profiling crews who participated in the experiments, including Phillip Barton and Matt Bertucci from Soil and Materials Engineers, Inc.; Mike and Dan Freeman from APR Consultants; Tom Nordstum and Greg Schneider from the Minnesota DOT; Paul Toom and Erwin Kung from EBA Engineering Consultants; Santiago, Flint, and Dennis Scott from Surface Systems and Instruments, LLC; John Ferris, Heather Chemistruck, Ma Rui and Robert Binns from Virginia Technical University; Jesse Dickes from Stantec, Inc.; and Bruce Wasill from the FHWA Western Federal Lands Highway Division.

Lastly, the author would like to thank the members of Pooled Fund Project TPF-5(063) for their support of this work. This job placed sufficient pressure on the state of the art in profile measurement and analysis that many things were learned with implications beyond the needs of the project. The authors is grateful for the advice of all members of TPF-5(063) provided throughout the benchmark profiler study.

Background

State and federal highway agencies are using pavement longitudinal profilers for monitoring and evaluating contractor compliance with smoothness specifications on pavement construction projects. These specifications often involve bonuses or penalties for the paving contractor and therefore may have a direct, immediate, and significant financial impact on the project participants. As a result, verification of the precision and accuracy of these profilers have become a high priority. For this purpose, highway agencies need a valid, portable, and efficient standard for providing reference measurements that serve as a basis for certifying production profiling equipment.

In the fall of 2002, the Federal Highway Administration (FHWA) initiated a transportation pooled fund (TPF) study TPF-5(063) titled “Improving the Quality of Pavement Profiler Measurement.” Twenty state highway agencies and the FHWA pooled their resources and their technical talent to develop a set of priorities to assist in accomplishing the study mission. Their number one priority was to provide support to build valid reference device(s) with a preference for multiple equipment manufacturers meeting the specified requirements. In turn, participants could select a reference profiler that satisfied their requirements to use locally for verifying production profilers.

To accomplish this priority TPF-5(063) developed requirements for a valid reference profiler through FHWA Western Federal Lands Highway Division (WFLHD) Agreement No: 04-A-17-0002. The “Critical Profiler Accuracy Requirements” (CPAR) report documents these requirements. (1) The core of these requirements called for verification of profile measurement accuracy, profile repeatability, and longitudinal distance measurement accuracy through comparison to benchmark measurements on a set of smooth pavements with diverse macrotexture types.

Subsequently, FHWA Contract DTFH61-07-C-00024, on behalf of the TPF-5(063) Technical Advisory Committee (TAC), supported the design and development of the Benchmark Profiler. The contract also included two profiler comparison experiments, in which the Benchmark Profiler provided “ground truth” measurements for verification of candidate reference profilers. These experiments were performed in October 2009 and September 2010 at the Mn/Road research facility in Albertville, MN and an unopened section of US 10 near Junction City, WI.

Three documents describe the products of FHWA Contract DTFH61-07-C-00024:

1. The Benchmark Testing Plan defines the experimental design, field procedures, test conditions, analytical methods, and benchmark measurement methods for the two experiments. (2)
2. The Benchmark Profiler Field Manual describes the benchmark profiling device in detail, and provides step-by-step instructions for operating and maintaining it. (3)
3. This document provides the results of the two benchmark profiler experiments. The “Report Cards” provided herein serve as the official results for each candidate reference device.

The FHWA provided direct support for four candidate reference profilers: (1) the APR Consultants, Inc., Auto Rod and Level, (2) the International Cybernetics Corp. (ICC) SurPro 3000, (3) the Surface Systems & Instruments (SSI), LLC, CS8800 Walking Profiler, and (4) a custom terrain measurement system built by the Virginia Technical University's Vehicle Terrain Performance Laboratory (VTPL). All four of these profilers participated in the October 2009 experiment. None of them satisfied the requirements defined in the CPAR report on any of the test sections. All four devices returned for a second round of evaluation in the fall of 2010.

An Australian Road Research Board (ARRB) Walking Profiler and a specialized surveyor's rod and level also participated in the 2009 experiment. This report includes results for these unofficial candidate reference devices. However, the report does not include results for three inertial profilers that participated in the 2010 experiment.

Test Sites

The testing covered six pavement sections, including five pavement sections at the Mn/Road research facility in Albertville, MN and one section of US 10 near Junction City, WI. The dominant criteria for selecting test sections were macrotexture type and smoothness. The texture types included dense graded asphalt (DGA), a fresh ship seal (CS), pervious hot mix asphalt (PHMA), transversely tined concrete (TT), longitudinally tined concrete (LT), and diamond ground concrete (DGC).

The following provides details about these sections.

DGA – This section appeared along eastbound Cells 29 through 31 on the low-volume loop at Mn/Road. The track on interest appeared in the right wheel path.

CS – This section appeared in the right wheel path within eastbound Cell 27 on the low-volume loop at Mn/Road, but it was measured in the westbound direction. The track of interest appeared in the right wheel path about 46 inches inboard of the inner fog line edge.

PHMA – This section appeared within eastbound Cell 88 on the low-volume loop at Mn/Road. The track of interest appeared in the right wheel path about 46 inches inboard of the inner fog line edge.

TT – This section appeared along eastbound Cells 36 and 37 on the low-volume loop at Mn/Road. The track on interest appeared in the right wheel path about 52 inches left of the inner line edge. The tine spacing was irregular with a 1-inch nominal value, and the joints were skewed with a 1:6 ratio. In 2009, ratings of agreement to the Benchmark Profiler were only calculated for the first 164.7 feet of the section.

LT – This appeared at a closed construction site on US-10 near Junction City, WI. This pavement included longitudinal tining with a regular spacing of about 1 inch (23 mm, actually) and perpendicular joints spaced 15 feet apart. In 2009, the test section was placed on the westbound side in the driving lane. The measurements were performed against the direction of traffic, and the track of interest was placed about 114 inches north of the longitudinal saw cut between lanes.

In 2010, the test section was moved to the Wisconsin Department of Transportation (DOT) profiler certification section at the same site, which appeared in the driving lane of the eastbound side.

DGC – This section appeared within westbound Cell 8 on the mainline at Mn/Road. The track of interest appeared in the right wheel path of the driving lane. The texture included about 5 ridges per 8 inches of width, and the jointed were skewed with a 1:6 ratio.

Appendix A provides photos of the test sections. Table 1 lists the approximate and the International Roughness Index (IRI) and length of each test section.

Table 1. Test Section Length and Roughness.

Texture Type	2009 Experiment		2010 Experiment	
	IRI (in/mi)	Length (ft)	IRI (in/mi)	Length (ft)
DGA	89.8	1231.2	95.4	1111.4
CS	117.4	496.2	96.2	504.8
PHMA	128.0	160.3	127.4	167.5
TT	64.8	164.7	76.7	538.5
LT	77.1	490.1	82.7	499.7
DGC	55.2	461.6	60.5	434.0

Devices

Table 2 lists the devices that participated in the experiments, the organization that operated them, and an abbreviation used to identify them in the main body of this report and the summary tables in Appendix D and F. The rod and level consisted of an Invar rod and Leica NA03 Level.

Table 2. Candidate Reference Devices.

Device	Organization	R&L
rod and level	Soil and Materials Engineers, Inc.	R&L
ARRB Walking Profiler	Minnesota DOT	ARRB WP
DipStick Model 2000	Stantec, Inc.	Dipstick 2000
Auto Rod and Level	APR Consultants, Inc.	APR Auto R&L
CS 8800 Walking Profiler	Surface Systems and Instruments, LLC	SSI CS8800
SurPro 3000	EBA Engineering Consultants	SurPro 3000
custom terrain measurement system	Virginia Technical University	VTPL TMS
	VTPL	

Test Section Coverage

Tables 3 and 4 list the number of repeat measurements performed by each device at each experiment. In 2009, the standard number of runs was ten, but fewer runs were performed in a few cases due to scheduling problems. In other cases, vendors performed

extra runs because of difficult weather or concern about their results. In 2010, the standard number of runs was changed to five. The analysis included all of the runs that were submitted.

The Benchmark Profiler typically performed three passes over each segment of road. (Strictly, these are not three repeat measurements, since the final profiles all share the same rod and level survey data from road segment endpoints.) In 2009, concern about repeatability from the first set of runs motivated an additional set of runs on the dense graded asphalt, diamond ground concrete, and transversely tine sections.

Table 3. Test Section Coverage by Each Device, 2009.

	DGA	CS	PHMA	TT	LT	DGC
R&L	1	—	—	—	—	—
ARRB WP	3	5	5	5	—	5
APR Auto R&L	5	10	10	10	10	10
SSI CS8800	12	16	10	11	8	12
SurPro 3000	10	10	—	10	10	10
VTPL TMS	10	10	10	11	—	—

Table 4. Test Section Coverage by Each Device, 2010.

	DGA	CS	PHMA	TT	LT	DGC
Dipstick 2000	2	—	—	—	—	—
APR Auto R&L	5	5	5	5	5	5
SSI CS8800	6	6	5	5	6	6
SurPro 3000+	6	6	5	5	5	10
VTPL TMS	10	10	10	10	10	10

Detailed Results

Appendix F and G provide very detailed results from the 2009 and 2010 experiments, respectively. The appendices include a “Benchmark Test Evaluation Report” for each set of measurements on a given section by a given profiling device throughout the two experiments. Thus, up to twelve Evaluation Reports, including visits of up to six test sections in two experiments, appear per device. Evaluation Reports are also provided for the Benchmark Profiler itself, to help characterize its run-to-run consistency.

The Evaluation Reports list the test section, device, operators, measurement dates, key device specifications (e.g., recording interval, native filtering), notes pertinent to the analysis, and relevant observations made during the testing. The report cards also provide profile repeatability scores, profile accuracy scores, longitudinal distance measurement agreement scores, and all the individual comparisons that make up the scores. The Benchmark Testing Plan (2) defines the analysis procedures for making these comparisons in detail. Appendix C provides a concise guide for interpreting the report cards.

Appendix D and E provide a “Benchmark Test Evaluation Summaries,” which organize the results by device, for the 2009 and 2010 experiments, respectively. These

help characterize a device's overall performance in each experiment over all the test sections. The Summaries include overall profile repeatability scores, profile accuracy scores, and longitudinal distance measurement agreement scores. The Summaries also include special observation from comparison of slope spectral density measured by each device to the benchmark measurement.

Summary Results

This section lists the candidate reference profilers that passed the longitudinal distance measurement, profile repeatability, and profile accuracy requirements on each test section. The listings provided here are “pass/fail,” in that the tables below do not provide the relative scores obtained in each category.

In the 2009 and 2010 experiment, a passing score for repeatability or accuracy required average cross correlation above 0.98 for the IRI, long, and medium wavebands and 0.95 for the short waveband.

Please consult Appendix D and E, which provide a complete characterization of each device, for more detail. Often, knowing which candidate reference profilers nearly met each criterion and which did not come close is more helpful than which simply passed. For example, in the 2009 experiment the SSI CS8800 achieved a repeatability score of 0.979 in the medium waveband on the dense graded asphalt section, which narrowly missed the cut off value of 0.98. The absence of a listing for “passed” is less useful than knowledge of the actual score. In addition, the SurPro 3000+ achieved several repeatability scores that far exceeded a passing score, which are listed in Appendix D and E, but not in this summary.

2009 Experiment

Tables 5 and 6 list the wavebands for which each device achieved a passing accuracy score and repeatability score, respectively. Longitudinal distance measurement performance is not listed, because of an error in the layout of the longitudinal distance measurement calibration section in 2009. Please also note that in some cases the Benchmark Profiler itself did not achieve exceptional repeatability in 2009, such that exceptional accuracy scores were more difficult to achieve.

Table 5. Passing accuracy scores by waveband.

Device	DGA	CS	PHMA	TT	LT	DGC
R&L	—	—	—	—	—	—
ARRB WP	L	—	—	—	—	—
APR Auto R&L	—	—	—	—	—	—
SSI CS8800	—	—	—	—	—	—
SurPro 3000	L	—	—	—	—	L
VTPL TMS	—	—	—	—	—	—

I – IRI; L – Long; M – Medium; S – Short; (—) – No data

Table 6. Passing repeatability scores by waveband.

Device	DGA	CS	PHMA	TT	LT	DGC
ARRB WP	L		L		—	L
APR Auto R&L	ALL			ALL		L
SSI CS8800	I, L		S			
SurPro 3000	L	L	—	I, L, M		L
VTPL TMS	I, L, M		I, L, M	L	—	—

I – IRI; L – Long; M – Medium; S – Short; (—) – No data

2010 Experiment

Tables 7 and 8 list the wavebands for which each device achieved a passing accuracy score and repeatability score, respectively. Longitudinal distance measurement performance is in Table 9.

Table 7. Passing accuracy scores by waveband.

	DGA	CS	PHMA	TT	LT	DGC
Dipstick 2000	I, L	—	—	—	—	—
APR Auto R&L	L	L	L			L
SSI CS8800	L	L		L		L
SurPro 3000+	I, L, M	I, L	L	L		L
VTPL TMS						L

I – IRI; L – Long; M – Medium; S – Short; (—) – No data

Table 8. Passing repeatability scores by waveband.

	DGA	CS	PHMA	TT	LT	DGC
Dipstick 2000		—	—	—	—	—
APR Auto R&L	L	L	L	L		L
SSI CS8800	I, L			I, L, M	I, L, M	L
SurPro 3000+	I, L, M	I, L, M	ALL	I, L, M	ALL	I, L
VTPL TMS	I, L	L	L	I, L, M	I, L, M	L

I – IRI; L – Long; M – Medium; S – Short; (—) – No data

Table 9. Passing measurement of longitudinal distance.

	DGA	CS	PHMA	TT	LT	DGC
APR Auto R&L	P	P	P	P	P	P
SSI CS8800				P	P	P
SurPro 3000+	P			P	P	
VTPL TMS	P	P	P	P	P	P

P – Passed

Conclusions

None of the candidate reference profiles achieved a passing score on all of the criteria. The SurPro 3000+ achieved passing repeatability and accuracy scores for profile over the broadest range of conditions in the 2010 experiment, and it achieved a passing repeatability score for all but the short waveband in nearly every case. However, the unit did not achieve passing scores for longitudinal distance measurement on all of the test sections.

Accuracy scores were reduced for all devices in the 2010 experiment in the transversely tined section and the diamond ground section due to diurnal changes in the level of slab curl.

Profile accuracy and repeatability were consistently lowest in the “short” waveband. The experimental results confirm that the IRI can be measured accurately without passing performance in the short waveband. However, inaccurate measurement of the short waveband reduces the effectiveness of a profiler for identifying the cause of localized roughness. Inaccurate measurement of the short waveband, as it was defined for this experiment, compromises the potential of a profiler for measurement of other roughness indices of interest, such as Ride Number and potential future roughness indices that characterize functional pavement performance at lower travel speed.

The effort put forth by the candidate reference device developers and the overall improvement in results from 2009 to 2010 justified the continuation of this effort. A follow-up benchmark test evaluation is recommended to: (1) motivate further improvement of devices that showed promise, particularly in the short waveband, (2) provide more development time for devices that had not matured to the point where they could demonstrate their full potential, and (3) attempt to include devices that had not yet been evaluated. The same set of conditions (i.e., mix of pavement surfaces), test procedures, and analysis procedures are recommended for the next experiment.

References

1. Karamihas, S. M., “Critical Profiler Accuracy Requirements.” University of Michigan Transportation Research Institute Report UMTRI-2005-24 (2005) 115 pp.
2. Karamihas, S. M., “Benchmark Testing Plan.” FHWA Contract DTFH61-07-C-00024 Task B Report, University of Michigan Transportation Research Institute (2009) 51 p.
3. Winkler, C. B. and S. M. Karamihas, “Benchmark Profiler Field Manual.” University of Michigan Transportation Research Institute (2011).

Appendix A: Test Section Photographs

This appendix displays photos of the test section used in the 2009 and 2010 benchmark profiler experiments. The photos were provided by Steve Karamihas (UMTRI), Bob Orthmeyer (FHWA), Terry Truetel (Wisconsin DOT), and members of the Soil and Materials Engineers, Inc. rod and level survey crew.



Figure A–1. Dense graded asphalt, downstream view with rod and level guide tape, 2009.



Figure A–2. Dense graded asphalt, with Benchmark Profiler guide tape, 2010.



Figure A–3. Chip seal, texture close-up, 2009.



Figure A–4. Chip seal, starting mark, 2009.



Figure A–5. Chip seal, upstream view with cart guide tape, 2009.

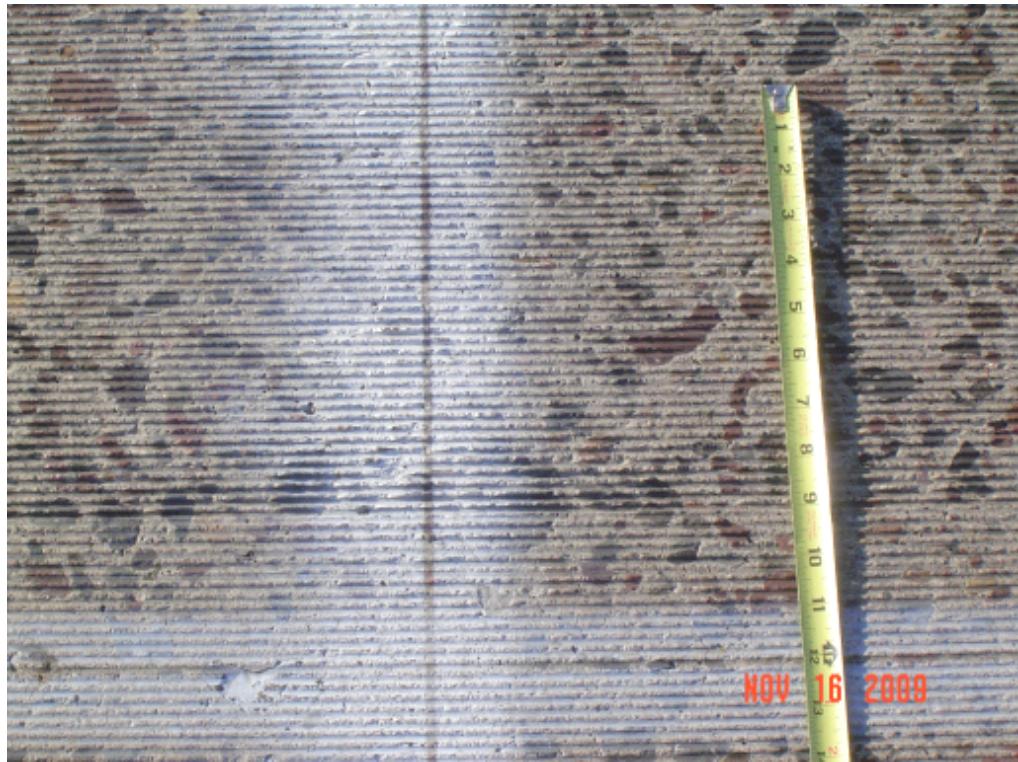


Figure A-6. Diamond ground, texture close-up and starting mark, 2009.



Figure A-7. Diamond ground, downstream view with vendor chalk mark, 2010.

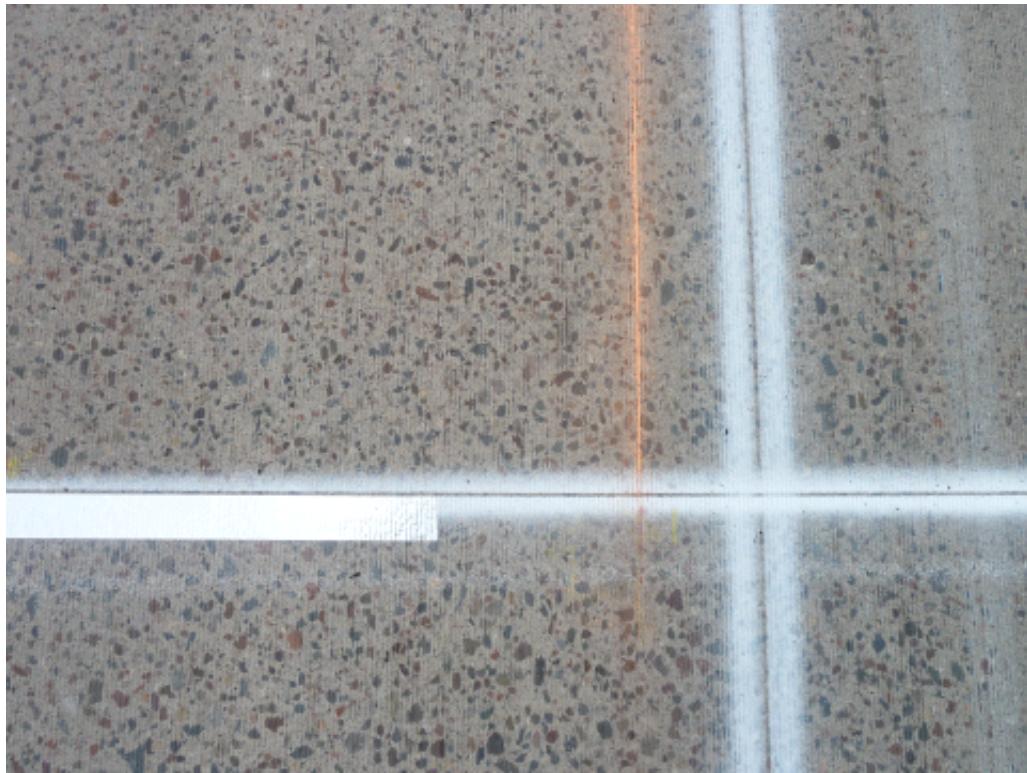


Figure A-8. Diamond ground, starting mark with vendor chalk mark, 2010.



Figure A-9. Longitudinal tining, downstream view, 2009.



Figure A–10. Longitudinal tining, texture close-up, 2009.



Figure A–11. Longitudinal tining, downstream view with vendor chalk mark, 2010.



Figure A–12. Longitudinal tining, texture close-up, 2010.

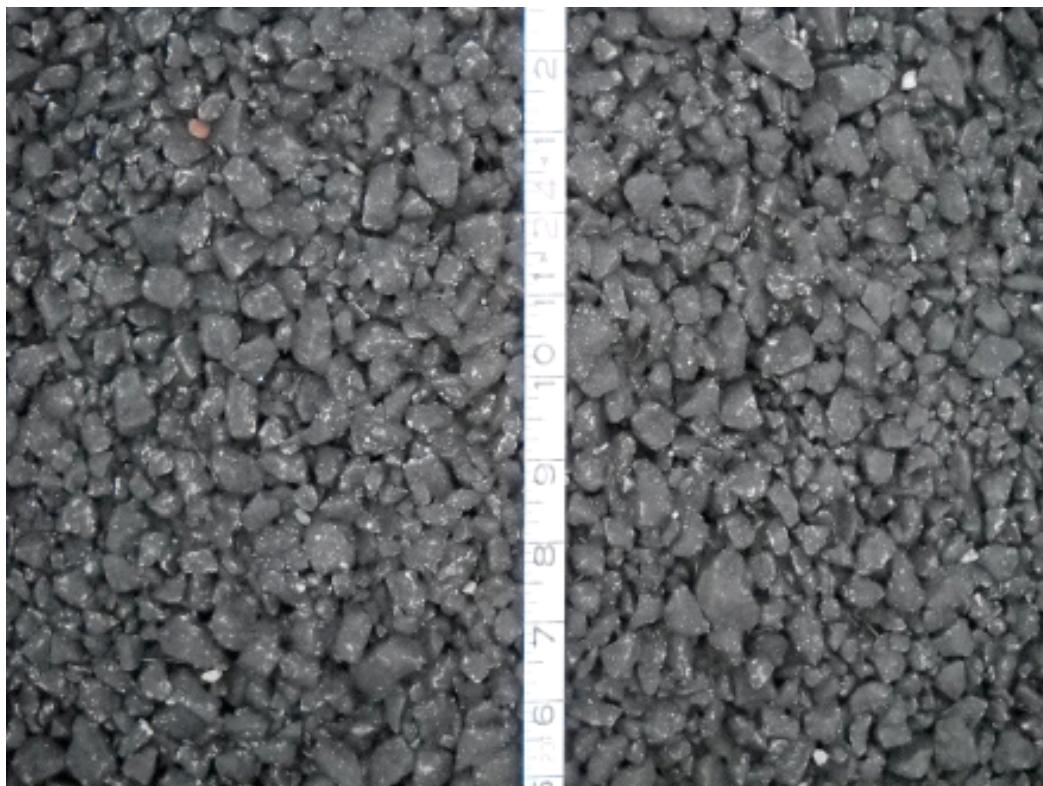


Figure A–13. Pervious hot mix asphalt, texture close-up, 2009.

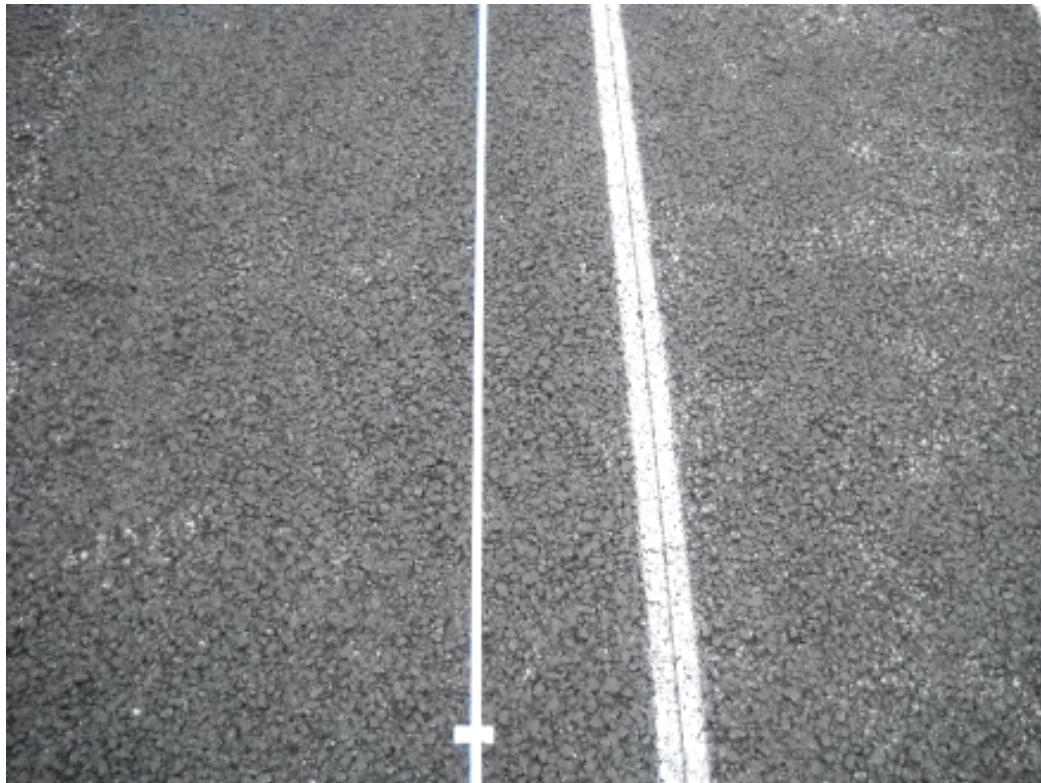


Figure A–14. Pervious hot mix asphalt, with rod and level guide tape, 2009.



Figure A–15. Pervious hot mix asphalt, starting mark, 2010.

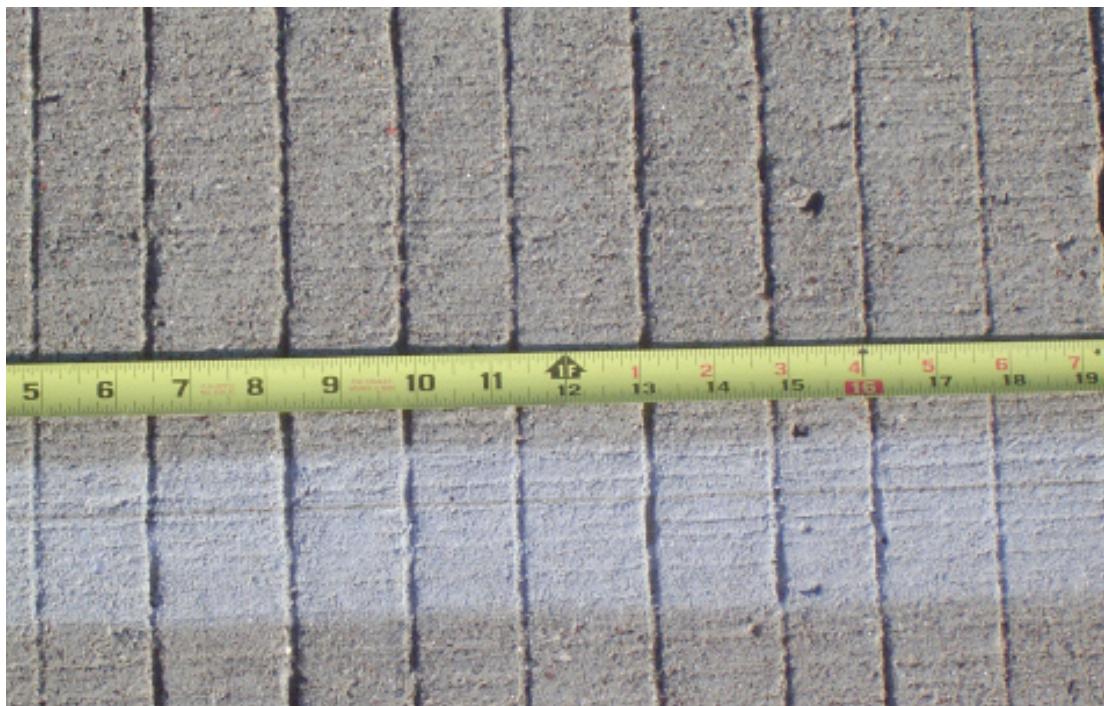


Figure A–16. Transverse tining, texture close-up, 2009.



Figure A–17. Transverse tining, with Benchmark Profiler guide tape, 2010.

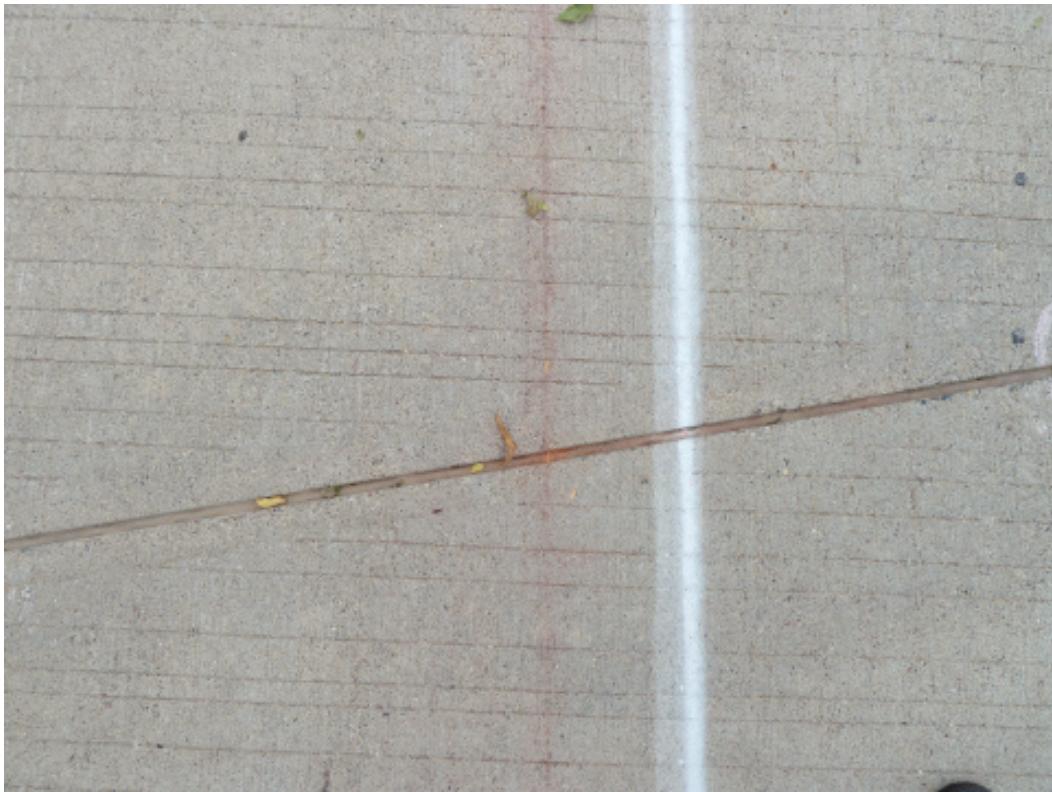


Figure A–18. Transverse tining, skewed joint, 2010.



Figure A–19 Transverse tining, downstream view, 2010.

Appendix B: Profiler Photographs

This appendix displays photos of the profilers that participated in the 2009 and 2010 benchmark profiler experiments. The photos were provided by Steve Karamihas (UMTRI), Bob Orthmeyer (FHWA), Terry Truetel (Wisconsin DOT), and members of the Soil and Materials Engineers, Inc. rod and level survey crew.



Figure B–1. Benchmark Profiler cart, left front view, 2009.

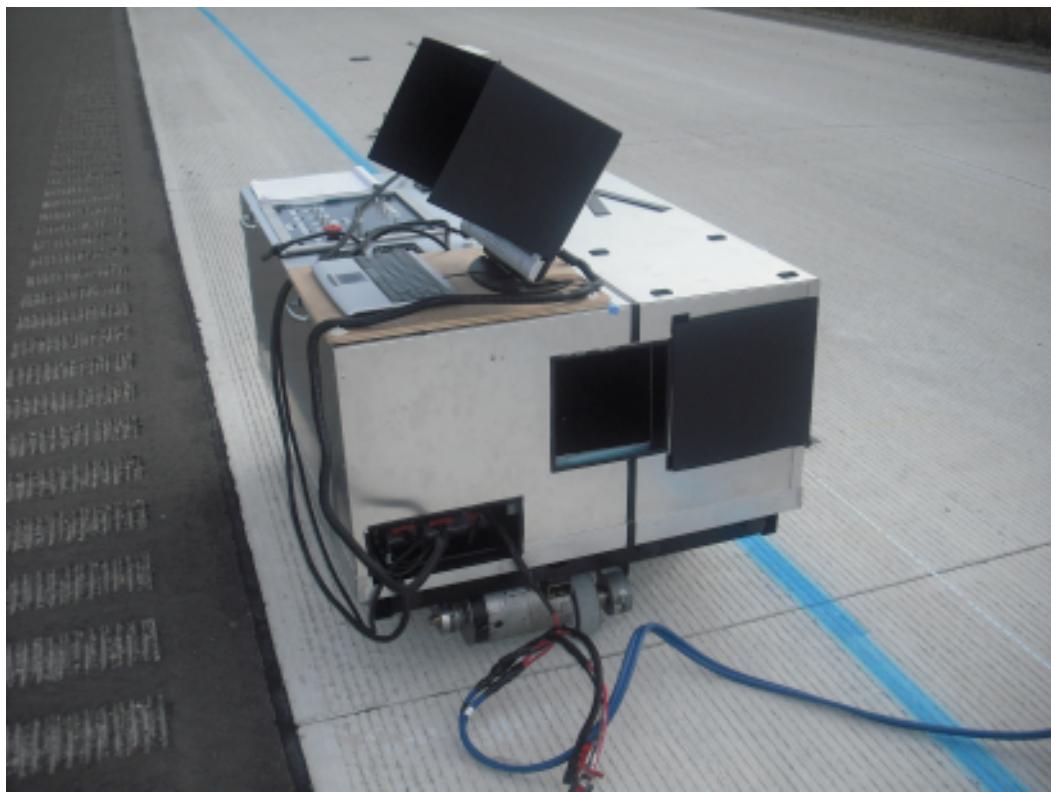


Figure B–2. Benchmark Profiler cart while charging, left rear view, 2009.



Figure B–3. Benchmark Profiler reference laser set-up, 2009.



Figure B–4. Benchmark Profiler reference laser stand and guide tape, 2010.



Figure B–5. Benchmark Profiler cart, 2010.



Figure B–6. Surveyor's level, 2009.



Figure B–7. Surveyor's rod and guide tape, 2009.



Figure B–8. Surveyor's rod and level, 2009.



Figure B–9. APR Auto Rod and Level, rear view, 2009.



Figure B–10. APR Auto Rod and Level, side view, 2009.



Figure B–11. APR Auto Rod and Level, close-up, 2009.



Figure B–12. APR Auto Rod and Level, front view, 2010.



Figure B–13. SurPro 3000, front view, 2009.



Figure B–14. SurPro 3000, side view, 2009.



Figure B–15. SurPro 3000+, parked, 2010.



Figure B–16. SurPro 3000+, front right view, 2010.



Figure B–17. SSI CS 8800, front left view, 2009.



Figure B–18. SSI CS 8800, side view, 2009.



Figure B–19. SSI CS 8800, front left view, 2010.



Figure B–20. SSI CS 8800, side view, 2010.



Figure B–21. VPTL terrain measurement system, left rear view, 2009.

Appendix C: 2009 Benchmark Test Evaluation Report Guide

This appendix provides information about the meaning of the items that appear in the Benchmark Test Evaluation Reports. The “Benchmark Testing Plan” (2) provides much more detail about the supporting calculation methods.

Test Section: This entry identifies the relevant test section by texture type..

Date: This entry lists the test date(s) of the measurements and the time window, if the information is available.

Device: This entry lists the device make and model.

Operator(s): This entry lists the name of the operator(s) and their organization.

Recording Interval: This entry lists the recording interval in the same units and precision level as it appeared in the submitted data files.

Use Moving Average: This entry explains whether the 250 mm moving average should be applied for IRI calculations, with a listing of the reasoning based on spectral analysis. If low-pass filtering is detected in the data, this section describes the filter.

Up-Sampling: This entry lists the “up-sampling interval.” Typically, the data were re-sampled using interpolation to a sample interval that is a multiple of 5.08 mm for compatibility with the benchmark profile measurements.

Results for Profile:

A table appears under this heading with the average repeatability score and accuracy score in each waveband.

The repeatability score is the average of all possible one-to-one comparisons between profiles. For example, when 10 profiles exist, 45 comparisons are possible. The score is the average of the 45 individual values.

The accuracy score is the average cross correlation to the benchmark profile. Thus, when 10 profiles exist, the accuracy score in each waveband is the average of 10 cross correlation values.

The wavebands are defined by the filtering applied before cross correlation is performed:

IRI: Apply the filters that make up the IRI algorithm. This includes a 250-mm moving average (if applicable), conversion of the profile to slope, and application of the Golden Car simulation of suspension stroke.

Long: Apply a 6th order Butterworth high-pass filter and a 6th order Butterworth low-pass filter. These are cascaded using a first order Butterworth and a complementary second order filter. The procedure applies each filter in both directions, to reverse the phase distortion caused by each component.

On pavement sections shorter than 1000 ft, the cut-off values are 125 ft for the high-pass filter and 25 ft for the low-pass filter. On pavement section longer than 1000 ft, the high-pass filter cut-off is modified to 220 ft.

Medium: Apply a 6th order Butterworth high-pass filter and a 6th order Butterworth low-pass filter. These are cascaded using a first order Butterworth and a complementary second order filter. The procedure applies each filter in both directions, to reverse the phase distortion caused by each component. The cut-off values are 25 ft for the high-pass filter and 5 ft for the low-pass filter.

Short: Apply a 6th order Butterworth high-pass filter. This is cascaded using a first order Butterworth and a complementary second order filter. The procedure applies each filter in both directions, to reverse the phase distortion caused by each component. The cut-off values is 5 ft for the high-pass filter. Note that no low-pass filter is applied. Thus, a high accuracy score depends on application of the same type of low-pass filter this is applied to the benchmark profiles. Since the high-pass filter cut-off is very short compared to the length of a typical section, the cross correlation of profiles filtered this way is applied to sub-sections 105.6 ft long.

IMPORTANT: For the long, medium, and short wavebands, the official results are obtained by converting the profiles from elevation to slope using a finite difference before the filters are applied.

Result for Longitudinal Distance: This entry lists the level of longitudinal distance measurement error observed for this section.

The reference measurement is established with a nylon-coated steel tape, corrected for ambient temperature. On most cases, the value for comparison is provided on-site by the candidate profiler operator. In some cases, the value for comparison is derived from the submitted profile files.

Run Log, DMI Results:

A table appears under this heading that provides the start and end time of the profile measurement, as observed by a monitor. If this is not available, it is not listed. The table also provides the IRI value and section length for each candidate profile measurement, and the percent error.

Notes often appear below the table to describe the source of the reference and candidate longitudinal distance measurements.

Accuracy Scores:

A table appears under this heading that lists every cross correlation value that was used to calculate the accuracy scores listed above.

Repeatability Scores:

A table appears under this heading that lists every cross correlation value that was used to calculate the repeatability scores listed above.

Special Observations:

This section lists field notes and any special observations that explain the results reported above. Examples include:

- Cases in which correcting longitudinal distance measurement error improves composite repeatability or accuracy scores significantly.
- Cases in which excluding up to three repeat measurements would have significantly increased composite repeatability or accuracy scores significantly.
- Useful diagnostic information that appears in power spectral density plots or within raw and filtered profile plots.
- Cases in which more runs were performed than were submitted.
- Information about the weather that may affect the results.

Appendix D: 2009 Benchmark Test Evaluation Summaries

APR AUTO ROD AND LEVEL	3
ARRB WALKING PROFILER	5
ICC SURPRO 3000	9
SSI CS8800 WALKING PROFILER	11
VPTL TERRAIN MEASUREMENT SYSTEM	13

Benchmark Test Evaluation Summary

Device: APR Consultants, Auto Rod & Level

Recording Interval: 0.2064 - 0.2067 ft

Use Moving Average: Yes

No redundant low-pass filtering evident.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.797	0.984	0.720	0.101
Pervious HMA	0.922	0.964	0.900	0.145
Chip Seal	0.774	0.896	0.681	0.104
Transverse Tining	0.579	0.893	0.529	0.100
Diamond Grinding	0.606	0.961	0.434	0.072
Longitudinal Tining	0.402	0.950	0.355	0.060

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.933	0.982	0.923	0.172
Pervious HMA	0.949	0.993	0.933	0.349
Chip Seal	0.875	0.965	0.850	0.287
Transverse Tining	0.701	0.784	0.682	0.271
Transverse Tining*	0.879	0.970	0.851	0.281
Diamond Grinding	0.807	0.987	0.731	0.137
Longitudinal Tining	0.939	0.968	0.939	0.274

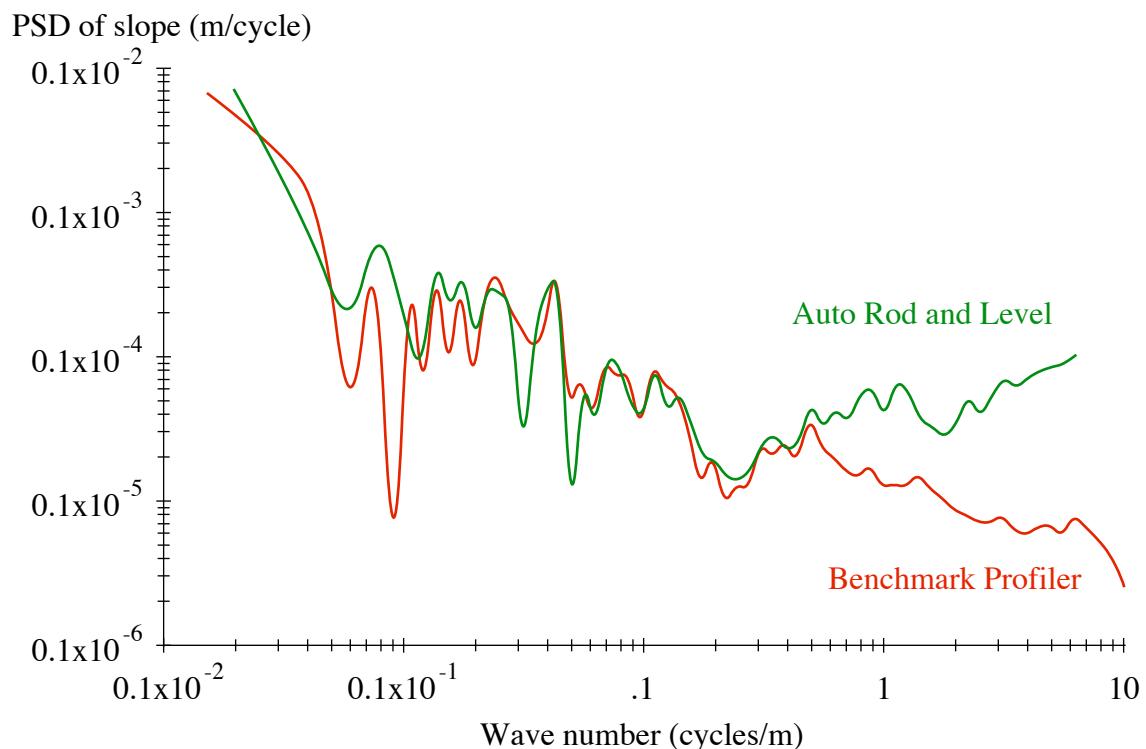
* One run removed.

Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-0.85	-0.84	-0.87
Pervious HMA	-0.85	-0.75	-0.87
Chip Seal	-0.67	-0.81	-0.65
Transverse Tining	-0.84	-0.80	-0.88
Diamond Grinding	-0.86	-0.86	-0.90
Longitudinal Tining	-0.67	-0.65	-0.69

Special Observations:

Agreement to the Benchmark Profiler was good in the long wavelength range. However, the Auto Rod and Level measured more content than the Benchmark Profiler in the short wavelength range on all test sections. This is most likely caused by the coarse resolution of the mast in relation to road elevation changes that take place over short distances. The figure below provides an example PSD from the dense graded asphalt section.



Benchmark Test Evaluation Summary

Device: ARRB Walking Profiler

Recording Interval: 0.7917 ft

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.792	0.948	0.713	0.063
Pervious HMA	0.923	0.938	0.913	0.068
Chip Seal	0.678	0.869	0.536	0.019
Chip Seal*	0.792	0.948	0.713	0.063
Transverse Tining	0.960	0.952	0.924	0.805
Diamond Grinding	0.901	0.987	0.807	0.041
Diamond Grinding*	0.895	0.992	0.779	0.033

* Measured using two runs that were offset by half the recording interval.

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.993	0.997	0.990	0.975
Pervious HMA	0.960	0.952	0.924	0.805
Chip Seal	0.627	0.855	0.475	0.336
Chip Seal*	0.713	0.958	0.528	0.287
Transverse Tining	0.987	0.989	0.986	0.962
Diamond Grinding	0.931	0.995	0.862	0.776

* Each profile derived using two runs that were offset by half the recording interval.

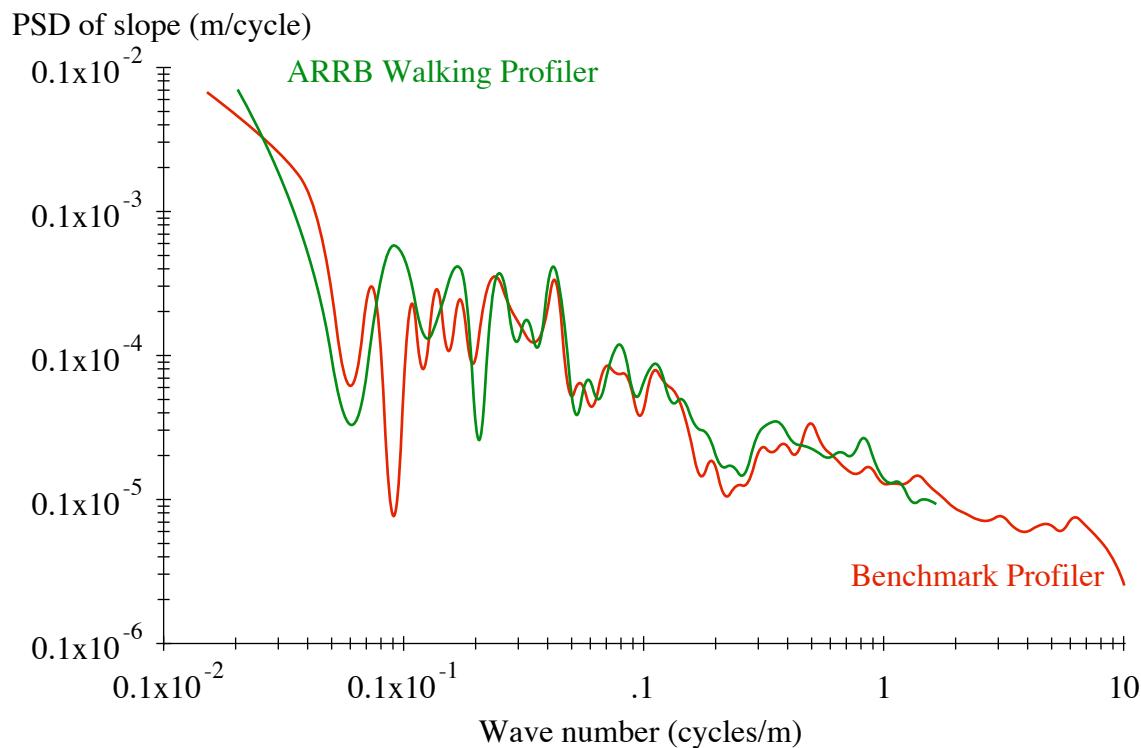
Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	0.28	0.28	0.28
Pervious HMA	0.34	0.43	-0.04
Chip Seal	0.39	0.68	0.20
Transverse Tining	0.28	0.28	0.28
Diamond Grinding	0.27	0.51	0.17

Special Observations:

DMI error levels were less than twice the sample interval in most of the runs, and can be attributed to intentional overrun of the section ending location.

Agreement to the Benchmark Profiler was good in the long wavelength range and in the medium wavelength range on some test sections. The figure below provides an example PSD from the dense graded asphalt section from the ARRB Walking Profiler and the Benchmark Profiler.



On some test sections, agreement to the IRI measured by the Benchmark Profiler was good, even if the cross correlation was not. On the chip seal, meshing two offset runs improved disagreement in IRI measurement from 11-24 percent to 0-4 percent.

Benchmark Test Evaluation Summary

Device: SurPro 3000

Recording Interval: 1 inch

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.955	0.984	0.935	0.115
Chip Seal	0.930	0.896	0.916	0.051
Transverse Tining	0.975	0.975	0.976	0.062
Diamond Grinding	0.930	0.996	0.853	0.087
Longitudinal Tining	0.969	0.963	0.963	0.204

Profile Repeatability Scores:

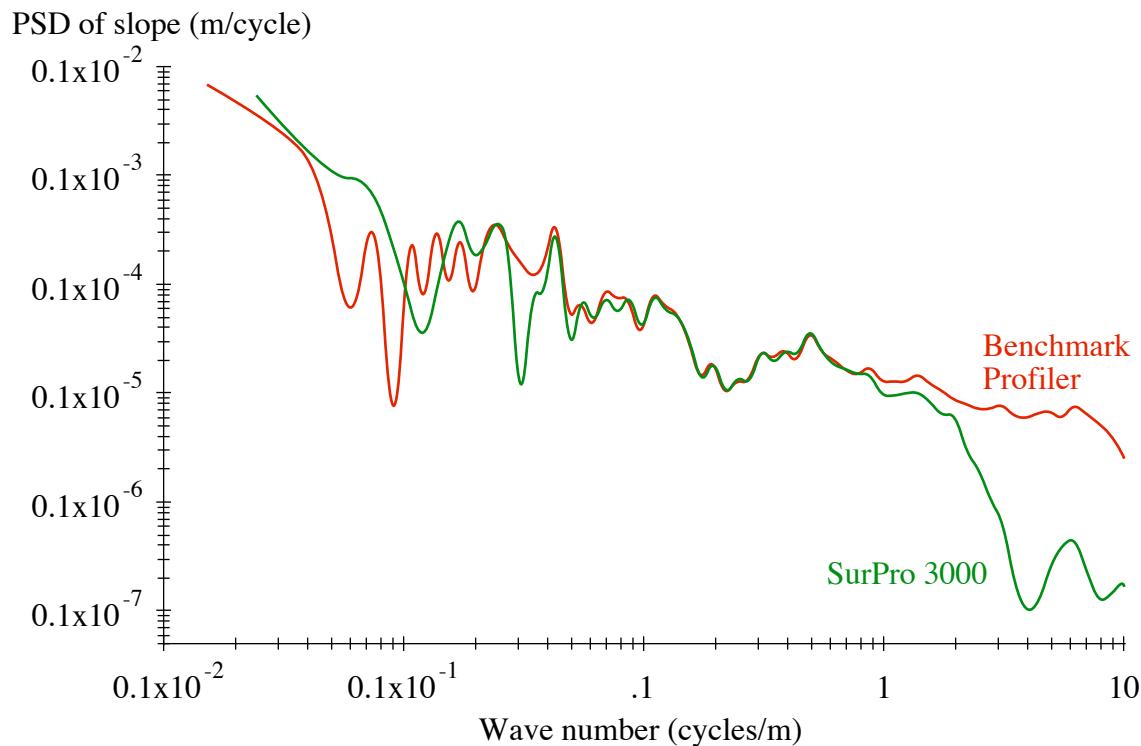
Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.969	0.997	0.960	0.898
Chip Seal	0.954	0.989	0.927	0.904
Transverse Tining	0.987	0.995	0.983	0.853
Diamond Grinding	0.957	0.997	0.900	0.870
Longitudinal Tining	0.976	0.969	0.975	0.896

Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-1.01	-0.95	-1.04
Chip Seal	0.63	0.87	0.50
Transverse Tining	-0.99	-0.97	-1.02
Diamond Grinding	-0.59	-0.56	-0.63
Longitudinal Tining	-0.80	-0.79	-0.81

Special Observations:

Agreement to the Benchmark Profiler (BP) was good, except in the short waveband. However, the SurPro 3000 measured less content than the BP in the short wavelength range on all test sections. This is because the wheelbase filtering effect modified the profile the same way as a moving average with a base length of 250 mm. The figure below provides an example PSD from the dense graded asphalt section. The waveband of interest for the IRI (0.9-35 m) is not effected by the wheelbase filtering. Some of the waveband of interest for general applications (0.15-67 m) related to vehicle dynamics and ride comfort is removed.



Benchmark Test Evaluation Summary

Device: SSI CS8800 Walking Profiler

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.857	0.963	0.806	0.033
Pervious HMA	0.848	0.915	0.805	0.039
Chip Seal	0.856	0.974	0.679	0.024
Transverse Tining	0.893	0.922	0.875	0.012
Diamond Grinding	0.856	0.974	0.679	0.024
Longitudinal Tining	0.908	0.940	0.917	0.701

Profile Repeatability Scores:

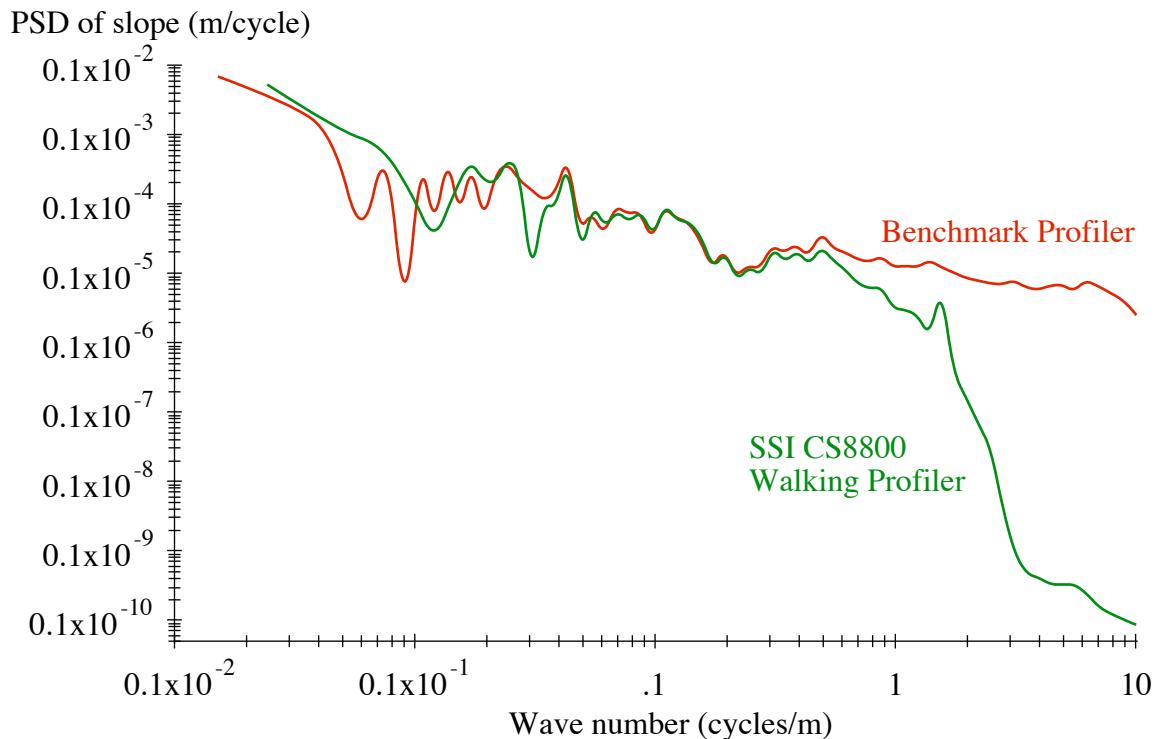
Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.981	0.986	0.979	0.810
Pervious HMA	0.965	0.945	0.968	0.959
Chip Seal	0.904	0.944	0.865	0.845
Transverse Tining	0.949	0.967	0.945	0.904
Diamond Grinding	0.894	0.963	0.773	0.571
Longitudinal Tining	0.868	0.949	0.839	0.044

Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-1.02	-1.05	-0.96
Pervious HMA	-0.82	-0.86	-0.80
Chip Seal	-0.73	-0.80	-0.68
Transverse Tining	-0.96	-0.98	-0.95
Diamond Grinding	-0.94	-0.97	-0.91
Longitudinal Tining	-0.98	-1.00	-0.96

Special Observations:

Agreement to the Benchmark Profiler (BP) was good in the long wavelength range. However, the CS8800 measured less content than the BP in the short wavelength range on all test sections. This is because of a native low-pass filter that removes some of the content in the wavelength range of interest for the IRI (0.9-35 m) and some of the waveband of interest for general applications (0.15-67 m) related to vehicle dynamics and ride comfort is removed. The figure below provides an example PSD from the dense graded asphalt section.



Benchmark Test Evaluation Summary

Device: VPTL Terrain measurement system

Recording Interval: 25 mm

Use Moving Average: Yes

No redundant low-pass filtering evident.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.873	0.873	0.774	0.022
Dense Graded AC*	0.879	0.950	0.859	0.022
Pervious HMA	0.930	0.931	0.928	0.087
Chip Seal	0.651	0.656	0.634	0.042
Transverse Tining	0.531	0.930	0.507	0.010

* One run removed.

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.979	0.821	0.787	0.499
Dense Graded AC*	0.981	0.999	0.981	0.497
Pervious HMA	0.986	0.999	0.988	0.570
Chip Seal	0.807	0.965	0.802	0.210
Transverse Tining	0.783	0.980	0.733	0.458

* One run removed.

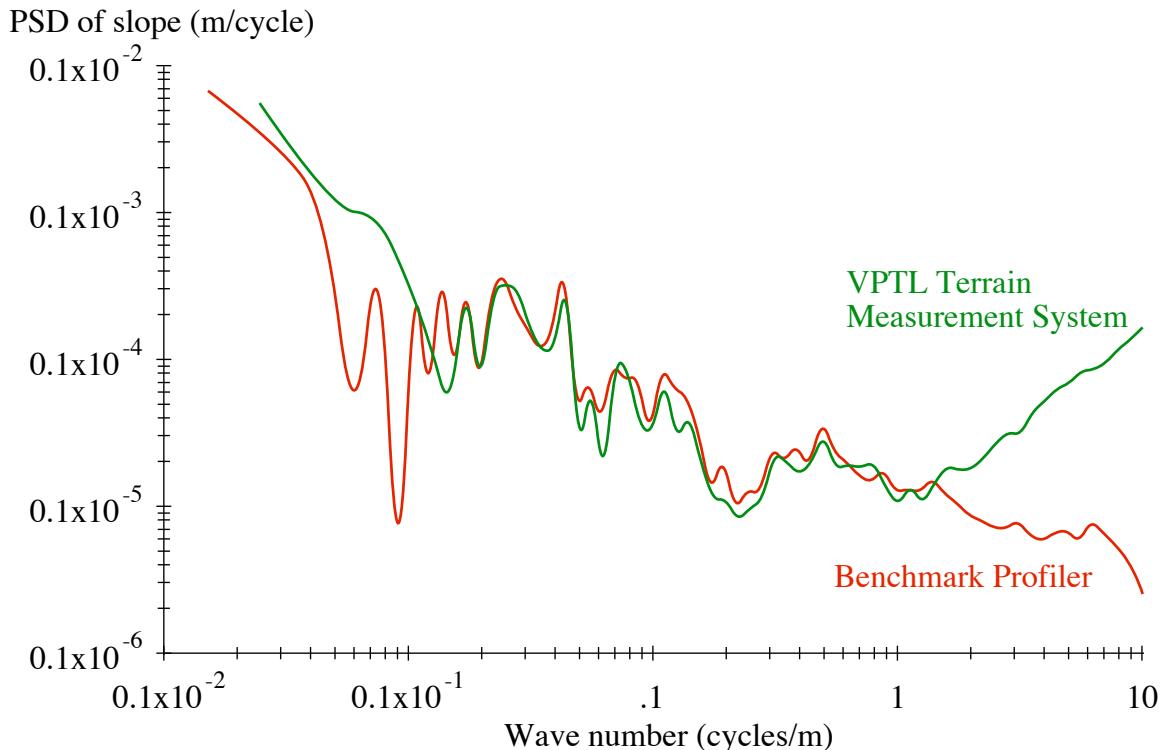
Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-0.03	-0.03	-0.03
Pervious HMA	-0.19	-0.19	-0.19
Chip Seal	-0.07	-0.07	-0.07
Transverse Tining	-0.08	-0.08	-0.08

Special Observations:

One repeat run on dense graded AC included a steep downward step change in elevation at the end of the profile. This reduced the average accuracy and repeatability score of the set. One repeat run on transverse tining included a narrow dip (1 inch deep and 0.4 ft wide). All of the repeat measurements included two short disturbances (13 ft and 88 ft from the start of the section) that did not appear in the benchmark profile.

The VTPL system measured more content than the Benchmark Profiler in the short wavelength range on all test sections. The figure below provides an example PSD from the dense graded asphalt section.



Appendix E: 2010 Benchmark Test Evaluation Summaries

APR AUTO ROD AND LEVEL	3
ICC SURPRO 3000+.....	7
SSI CS8800 WALKING PROFILER	11
VPTL TERRAIN MEASUREMENT SYSTEM.....	15

Benchmark Test Evaluation Summary

Device: APR Consultants, Auto Rod & Level

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.730	0.985	0.688	0.052
Pervious HMA	0.904	0.982	0.881	0.157
Chip Seal	0.764	0.992	0.664	0.125
Transverse Tining	0.587	0.968	0.490	0.088
Diamond Grinding	0.591	0.984	0.429	0.099
Longitudinal Tining	0.828	0.946	0.861	0.074

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.900	0.985	0.896	0.200
Pervious HMA	0.919	0.993	0.905	0.272
Chip Seal	0.879	0.996	0.860	0.305
Transverse Tining	0.868	0.984	0.871	0.267
Diamond Grinding	0.767	0.988	0.737	0.235
Longitudinal Tining	0.873	0.967	0.882	0.244

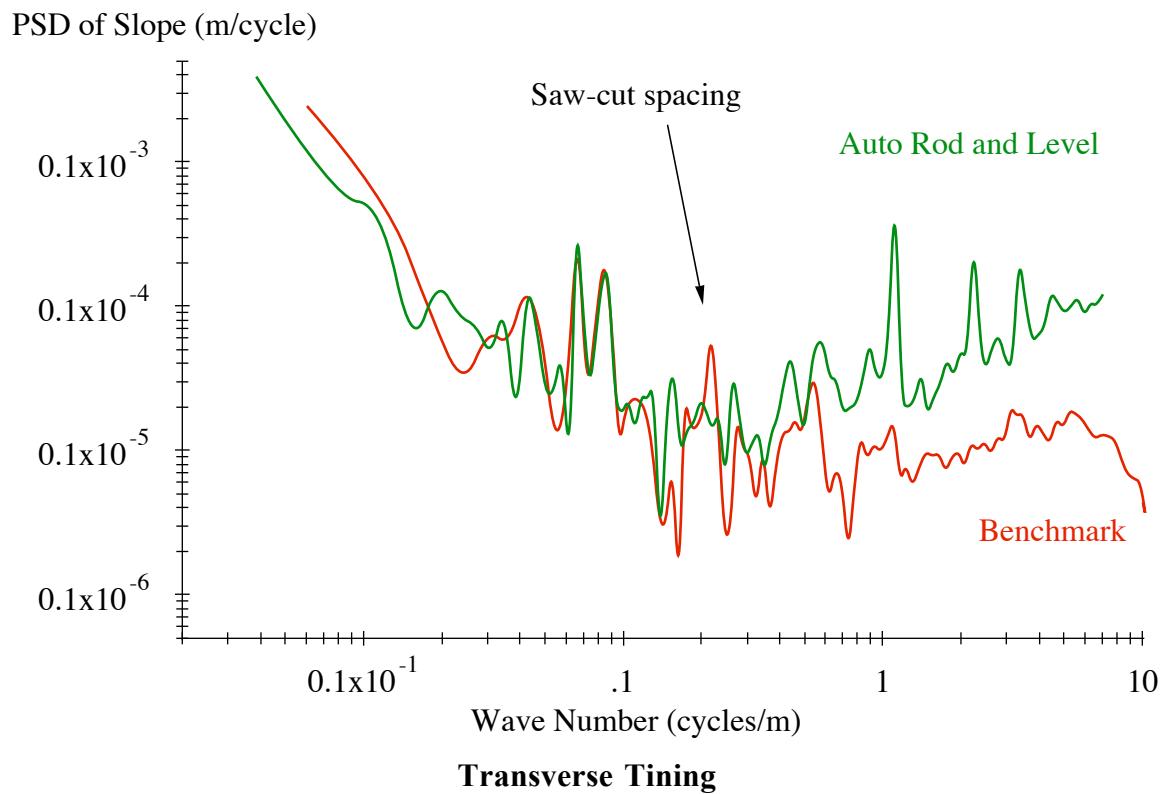
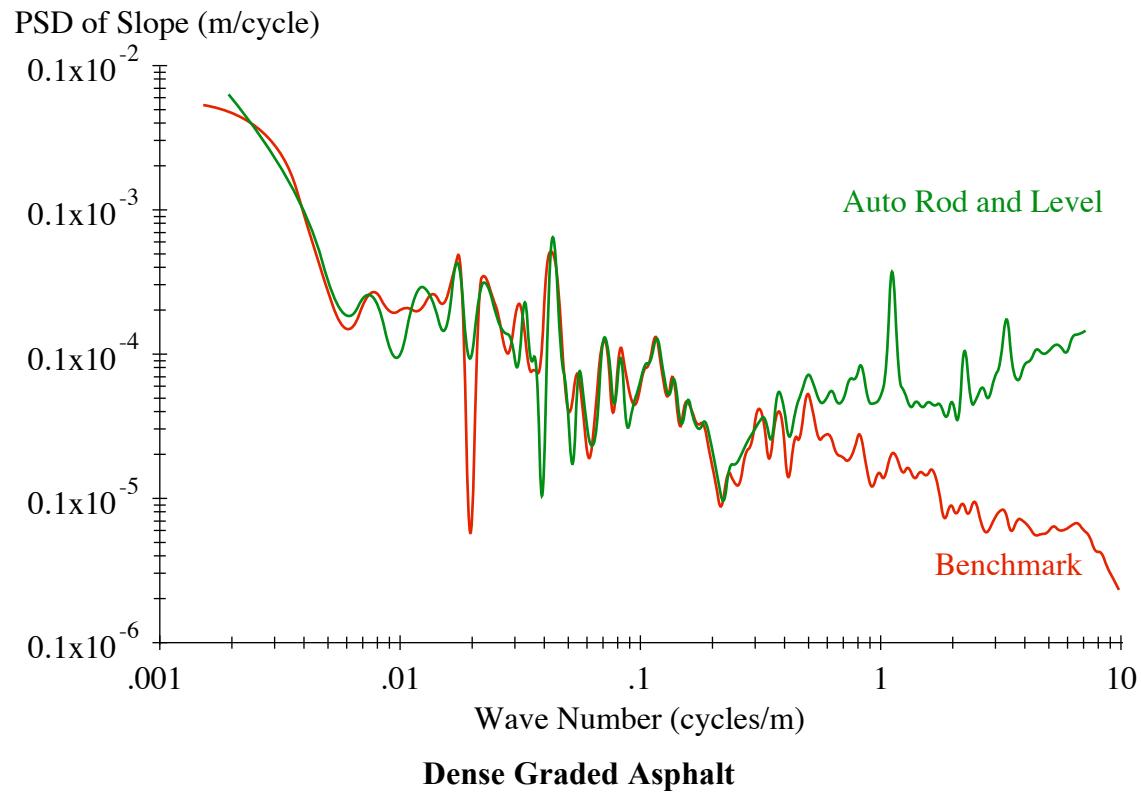
Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-0.04	-0.01	-0.09
Pervious HMA	0.01	0.01	0.01
Chip Seal	0.07	0.08	0.04
Transverse Tining	-0.05	-0.04	-0.08
Diamond Grinding	-0.02	0.03	-0.07
Longitudinal Tining	0.02	0.03	-0.01

Special Observations:

Agreement to the Benchmark Profiler (BP) was good in the long wavelength range. However, the Auto Rod and Level measured more content than the BP in the short wavelength range on all test sections. This is most likely caused by the coarse resolution of the mast in relation to road elevation changes that take place over short distances. The figure below provides an example PSD from the dense graded asphalt section. The spike in content at 1.108 m (3.64 ft) is caused by out-of-roundness in the large wheel below the mast.

Diurnal changes in the profile of the transversely tined pavement due to slab curling reduced agreement to the benchmark measurement at a wavelength of 4.6 m (15 ft). The second figure below provides a comparison of the PSD plots.



Benchmark Test Evaluation Summary

Device: SurPro 3000+

Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.980	0.993	0.960	0.235
Pervious HMA	0.964	0.985	0.948	0.100
Chip Seal	0.985	0.998	0.972	0.045
Transverse Tining	0.916	0.994	0.818	0.094
Diamond Grinding†	0.879	0.999	0.732	0.084
Diamond Grinding††	0.902	0.999	0.787	0.075
Longitudinal Tining	0.949	0.953	0.934	0.190

† First Visit

†† Second Visit

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.997	1.000	0.996	0.922
Pervious HMA	0.997	0.999	0.996	0.952
Chip Seal	0.994	0.999	0.991	0.905
Transverse Tining	0.997	0.997	0.992	0.925
Diamond Grinding†	0.981	1.000	0.945	0.792
Diamond Grinding††	0.993	1.000	0.980	0.921
Longitudinal Tining	0.997	0.998	0.997	0.945

† First Visit

†† Second Visit

Longitudinal Distance Measurement:

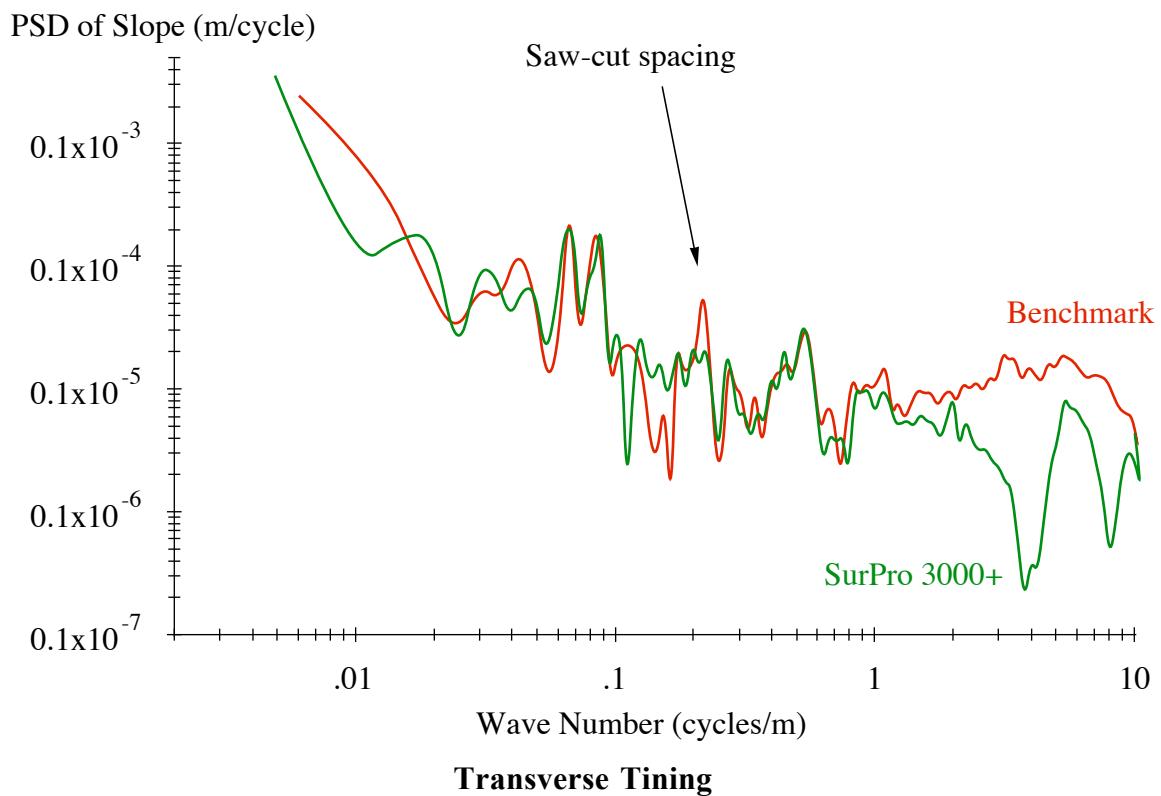
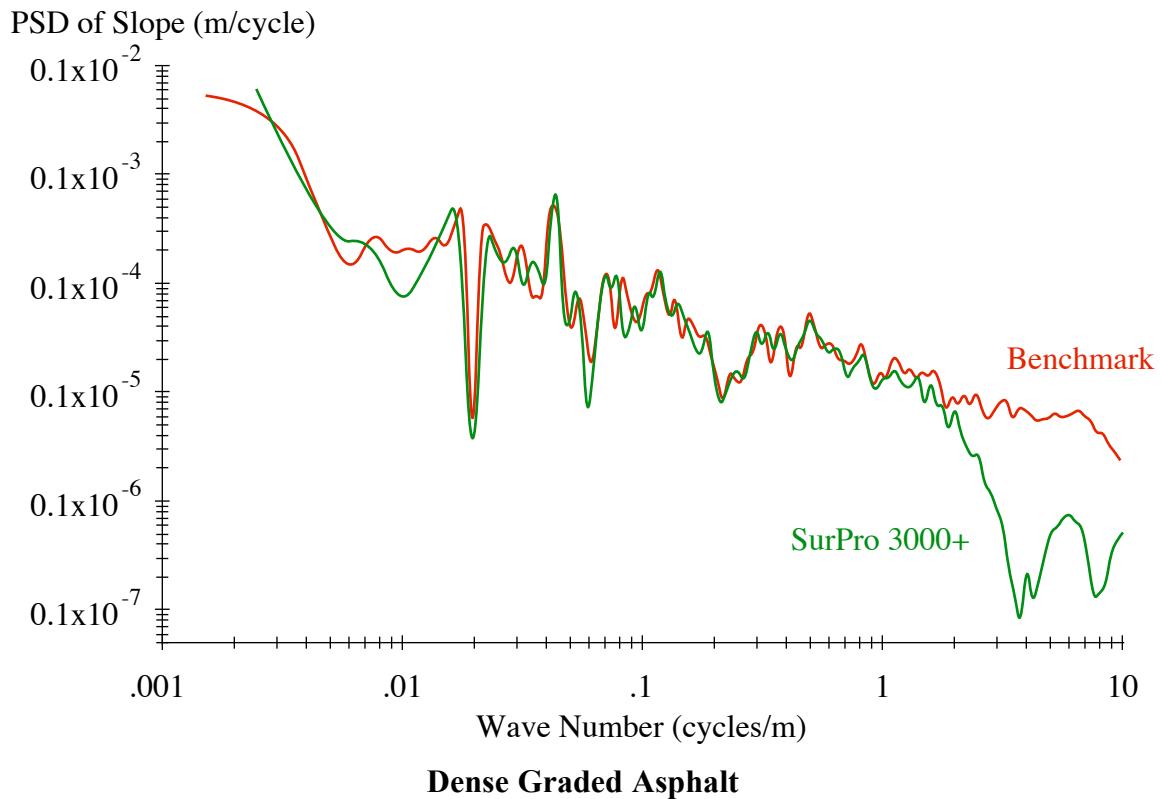
Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	0.05	0.09	0.02
Pervious HMA	0.92	0.97	0.89
Chip Seal	1.22	1.27	1.19
Transverse Tining	0.02	0.04	0.00
Diamond Grinding†	0.28	0.34	0.21
Diamond Grinding††	0.20	0.25	0.17
Longitudinal Tining	-0.08	-0.08	-0.08

† First Visit †† Second Visit

Special Observations:

Agreement to the Benchmark Profiler (BP) was good, except in the short waveband. The SurPro 3000+ measured less content than the BP in the short wavelength range on all test sections. This is because the wheelbase filtering effect modified the profile the same way as a moving average with a base length of 250 mm. The first figure below provides an example PSD from the dense graded asphalt section. The waveband of interest for the IRI (0.9-35 m) is not affected by the wheelbase filtering. Some of the waveband of interest for general applications (0.15-67 m) related to vehicle dynamics and ride comfort is removed.

Diurnal changes in the profile of the transversely tined pavement due to slab curling reduced agreement to the benchmark measurement at a wavelength of 4.6 m (15 ft). The second figure below provides a comparison of the PSD plots.



Benchmark Test Evaluation Summary

Device: SSI CS8800 Walking Profiler

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.880	0.990	0.845	0.093
Pervious HMA	0.856	0.949	0.821	0.025
Chip Seal	0.869	0.983	0.838	0.013
Transverse Tining	0.864	0.990	0.809	0.019
Diamond Grinding	0.733	0.996	0.473	0.035
Longitudinal Tining	0.897	0.931	0.904	0.034

Profile Repeatability Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.977	0.989	0.972	0.159
Pervious HMA	0.965	0.968	0.972	0.678
Chip Seal	0.940	0.967	0.953	0.591
Transverse Tining	0.986	0.995	0.978	0.314
Diamond Grinding	0.958	0.995	0.842	0.189
Longitudinal Tining	0.991	0.987	0.993	0.544

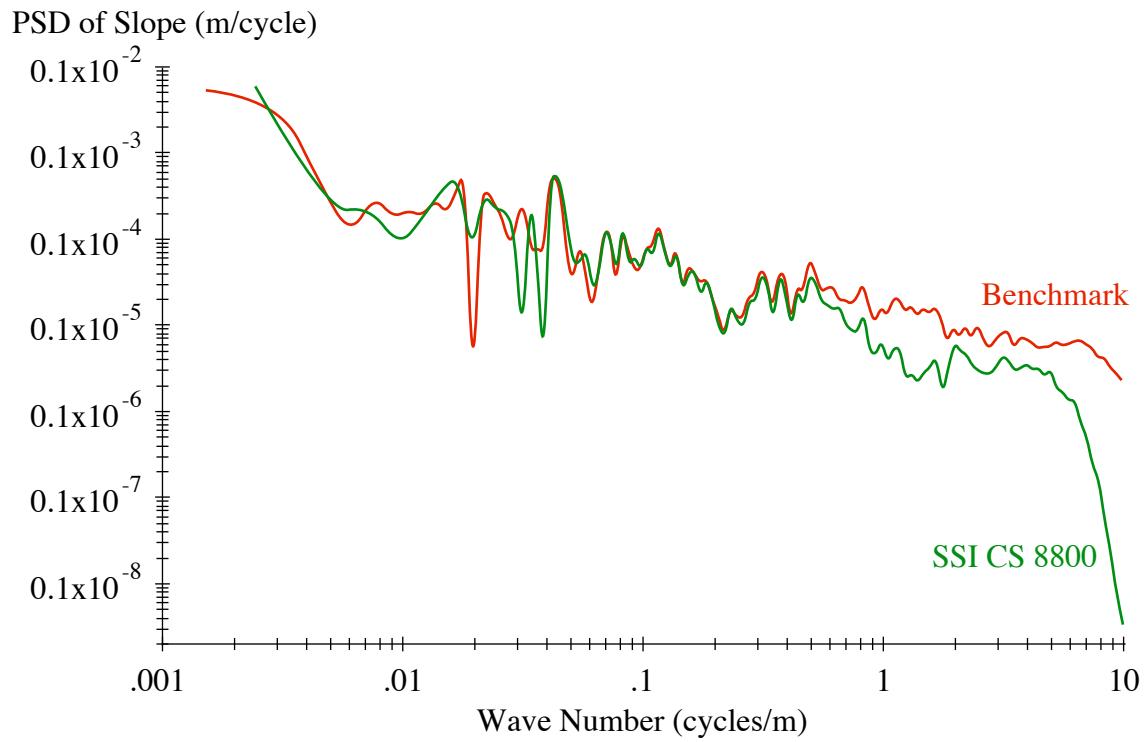
Longitudinal Distance Measurement:

Test Section	DMI Error (%)		
	Average	High	Low
Dense Graded AC	-0.27	-0.23	-0.29
Pervious HMA	-0.12	-0.11	-0.17
Chip Seal	0.24	0.31	0.14
Transverse Tining	-0.02	0.03	-0.04
Diamond Grinding	0.05	0.06	0.01
<u>Longitudinal Tining</u>	0.01	0.03	-0.01

Special Observations:

Agreement to the Benchmark Profiler (BP) was good in the long wavelength range. However, the CS8800 measured less content than the BP in the short wavelength range on all test sections. The cause of this is not clear. Content in the wavelength range of interest for the IRI (0.9-35 m) and some of the waveband of interest for general applications (0.15-67 m) related to vehicle dynamics and ride comfort was consistently removed. The figure below provides an example PSD from the dense graded asphalt section.

Diurnal changes in the profile of the transversely tined pavement due to slab curling may have reduced agreement to the benchmark measurement at a wavelength of 4.6 m (15 ft).



Benchmark Test Evaluation Summary

Device: VPTL Terrain measurement system

Recording Interval: 1 inch

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering evident.

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

Profile Accuracy Scores:

Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.868	0.847	0.864	0.040
Pervious HMA	0.885	0.921	0.886	0.053
Chip Seal	0.958	0.972	0.918	0.083
Transverse Tining	0.894	0.942	0.846	0.060
Diamond Grinding	0.758	0.991	0.522	0.056
Longitudinal Tining	0.952	0.882	0.964	0.029

Profile Repeatability Scores:

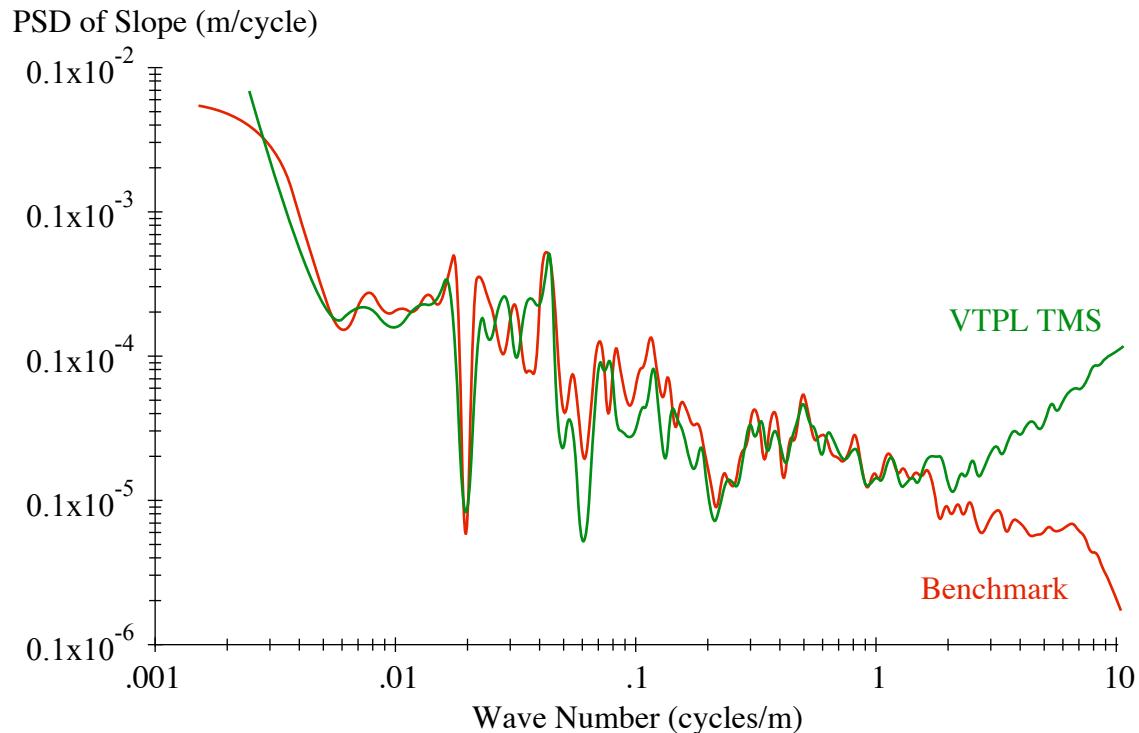
Test Section	IRI	Waveband		
		Long	Medium	Short
Dense Graded AC	0.976	0.996	0.970	0.235
Pervious HMA	0.956	0.977	0.948	0.380
Chip Seal	0.969	0.999	0.961	0.428
Transverse Tining	0.990	0.996	0.985	0.597
Diamond Grinding	0.922	0.999	0.826	0.577
Longitudinal Tining	0.975	0.991	0.976	0.424

Longitudinal Distance Measurement:

Test Section	DMI Error (%)
Dense Graded AC	-0.06
Pervious HMA	-0.09
Chip Seal	-0.04
Transverse Tining	-0.01
Diamond Grinding	0.04
Longitudinal Tining	-0.01

Special Observations:

Agreement to the Benchmark Profiler (BP) was good in the long and medium wavelength range. However, the VTPL TMS measured more content than the BP in the short wavelength range on all test sections. The difference is most likely due to the application of the bridging filter by the BP, and the absence of low-pass filtering by the VTPL TMS. Re-processing of the VTPL TMS data with application of a similar low-pass filter may improve agreement on all test sections.



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Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 10/20/2009, 09:41:16:23

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.986
Long (elev.)	0.998
Medium (elev.)	0.982
Short (elev.)	0.838
Long (slope)	0.994
Medium (slope)	0.984
Short (slope)	0.502

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	89.05	1235.30
2	89.54	1235.28
3	89.19	1235.30
Comb.	89.79	1235.30

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.982	0.998	0.975	0.763	0.661	0.969	0.946
1	3	0.984	0.998	0.982	0.799	0.643	0.972	0.961
2	3	0.991	0.999	0.990	0.759	0.663	0.963	0.959
Average		0.986	0.998	0.982	0.774	0.656	0.968	0.955

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.991	0.981	0.309	0.373	0.710	0.629
1	3	0.994	0.982	0.332	0.296	0.693	0.662
2	3	0.997	0.990	0.321	0.327	0.678	0.689
Average		0.994	0.984	0.321	0.332	0.694	0.660

Notes:

- This was the first visit to the test section.
- Section length is 1231.22 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files, which include a slight overrun.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 10/22/2009, 08:01:12:00

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.982
Long (elev.)	0.990
Medium (elev.)	0.982
Short (elev.)	0.759
Long (slope)	0.990
Medium (slope)	0.971
Short (slope)	0.301

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
4	85.47	546.28
5	85.36	546.28
6	84.89	546.32
Comb.	85.58	546.32

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	4	0.978	0.994	0.977	0.699	0.730	0.797	0.736
4	6	0.980	0.990	0.987	0.713	0.804	0.873	0.736
5	6	0.988	0.986	0.982	0.716	0.732	0.835	0.732
Average		0.982	0.990	0.982	0.709	0.755	0.835	0.735

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	5	0.995	0.965	0.245	0.282	0.306	0.334
4	6	0.989	0.979	0.267	0.355	0.270	0.296
5	6	0.986	0.969	0.340	0.263	0.334	0.319
Average		0.990	0.971	0.284	0.300	0.303	0.317

Notes:

- This was the second visit to the test section. Only about half of the test section was covered.
- Section length is 1231.22 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files. These repeats covered the upstream portion of the section.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 10/18/2009, 16:53-17:58 (Repeat 1)

10/19/2009, 11:31- 13:58 (Repeats 2, 3)

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.978
Long (elev.)	0.991
Medium (elev.)	0.954
Short (elev.)	0.862
Long (slope)	0.993
Medium (slope)	0.960
Short (slope)	0.652

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	117.44	495.60
2	117.16	495.20
3	119.39	495.25

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.978	0.998	0.967	0.875	0.754	0.863	0.910
1	3	0.982	0.988	0.960	0.821	0.808	0.892	0.900
2	3	0.974	0.987	0.936	0.886	0.844	0.868	0.925
Average		0.978	0.991	0.954	0.861	0.802	0.875	0.912

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.993	0.969	0.624	0.617	0.626	0.705
1	3	0.997	0.956	0.655	0.618	0.741	0.655
2	3	0.990	0.954	0.636	0.644	0.662	0.639
Average		0.993	0.960	0.638	0.626	0.676	0.666

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files, which include a slight overrun.
- Repeat 1 selected as the benchmark based on the target camera noise level during dwell.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 10/19/2009, 15:25-18:44
Device: Benchmark Profiler
Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas
Recording Interval: 5.08 mm
Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.869
Long (elev.)	0.998
Medium (elev.)	0.782
Short (elev.)	0.674
Long (slope)	0.994
Medium (slope)	0.758
Short (slope)	0.231

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	61.04	457.95
2	56.49	461.17
3	54.82	461.15

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.860	0.999	0.786	0.869	0.565	0.528	0.480
1	3	0.821	0.998	0.696	0.861	0.567	0.576	0.476
2	3	0.924	0.998	0.865	0.893	0.855	0.741	0.682
Average		0.869	0.998	0.782	0.874	0.663	0.615	0.546

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.998	0.744	0.315	0.168	0.127	0.107
1	3	0.992	0.678	0.312	0.162	0.132	0.085
2	3	0.993	0.853	0.365	0.542	0.278	0.183
Average		0.994	0.758	0.331	0.291	0.179	0.125

Notes:

- This was the first visit to the test section.
- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files. These repeats did not quite reach the section end.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 10/22/2009, 12:57-16:50
Device: Benchmark Profiler
Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas
Recording Interval: 5.08 mm
Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.982
Long (elev.)	1.000
Medium (elev.)	0.985
Short (elev.)	0.889
Long (slope)	1.000
Medium (slope)	0.968
Short (slope)	0.410

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
4	54.94	461.27
5	54.97	461.23
6	55.44	461.17
Comb.	55.17	461.15

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	5	0.989	1.000	0.983	0.868	0.937	0.856	0.883
4	6	0.976	1.000	0.989	0.879	0.919	0.865	0.873
5	6	0.980	1.000	0.982	0.883	0.940	0.913	0.858
Average		0.982	1.000	0.985	0.877	0.932	0.878	0.871

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4	
4	5	1.000	0.973	0.348	0.654	0.325	0.316	
4	6	0.999	0.960	0.367	0.624	0.322	0.365	
5	6	1.000	0.972	0.370	0.622	0.303	0.301	
Average		1.000	0.968	0.362	0.633	0.317	0.327	

Notes:

- This was the second visit to the test section.
- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 10/28/2009, 08:49-12:09

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.996
Long (elev.)	0.994
Medium (elev.)	0.994
Short (elev.)	0.960
Long (slope)	0.996
Medium (slope)	0.996
Short (slope)	0.776

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
4	76.88	489.75
5	76.80	489.67
6	76.54	489.72
Comb.	77.05	489.75

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.992	0.992	0.979	0.976	0.952	0.935
1	3	0.996	0.997	0.997	0.987	0.976	0.940	0.963
2	3	0.996	0.995	0.994	0.982	0.965	0.932	0.929
Average		0.996	0.994	0.994	0.983	0.972	0.941	0.942

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.994	0.996	0.794	0.792	0.799	0.748
1	3	0.999	0.996	0.804	0.778	0.783	0.753
2	3	0.994	0.997	0.836	0.783	0.784	0.659
Average		0.996	0.996	0.811	0.784	0.789	0.720

Notes:

- Section length is 490.119 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt
Date: 10/19/2009, 08:57-10:45
Device: Benchmark Profiler
Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas
Recording Interval: 5.08 mm
Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.991
Long (elev.)	0.984
Medium (elev.)	0.989
Short (elev.)	0.944
Long (slope)	0.998
Medium (slope)	0.987
Short (slope)	0.617

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	128.94	166.05
2	127.79	166.07
3	128.02	166.08
4	124.84	166.13

Repeatability:

Run 1	Run 2	Cross Correlation by Waveband, Elevation				
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.989	0.987	0.988	0.975	0.897
1	3	0.994	0.975	0.995	0.975	0.909
2	3	0.991	0.990	0.985	0.975	0.933
Average		0.991	0.984	0.989	0.975	0.913

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.998	0.984	0.614	0.614
1	3	0.998	0.987	0.648	0.605
2	3	0.999	0.992	0.587	0.634
Average		0.998	0.987	0.616	0.617

Notes:

- Section length is 160.326 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Repeat 4 covered the entire section with one laser set-up, which exceeded the guideline for distance from the laser.
- Repeat 3 selected as the benchmark based on the target camera noise level during dwell.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining
Date: 10/18/2009, 08:57-14:48
Device: Benchmark Profiler
Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas
Recording Interval: 5.08 mm
Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.883
Long (elev.)	0.813
Medium (elev.)	0.853
Short (elev.)	0.626
Long (slope)	0.895
Medium (slope)	0.866
Short (slope)	0.422

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	72.62	497.70
2	78.18	498.22
3	76.48	498.35

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.837	0.724	0.790	0.554	0.526	0.636	0.643
1	3	0.912	0.961	0.883	0.663	0.635	0.747	0.690
2	3	0.900	0.753	0.887	0.594	0.535	0.651	0.635
Average		0.883	0.813	0.853	0.604	0.565	0.678	0.656

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.842	0.815	0.393	0.389	0.456	0.446
1	3	0.986	0.876	0.388	0.453	0.579	0.407
2	3	0.857	0.907	0.333	0.337	0.458	0.419
Average		0.895	0.866	0.371	0.393	0.498	0.424

Notes:

- This was the first visit to the test section.
- Section length is 498.175 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- These data were rejected based on a lack of repeatability and excessive noise during dwell (i.e., still operation).

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining
Date: 10/22/2009, 17:37-18:37
Device: Benchmark Profiler
Operator(s): UMTRI, Chris Winkler, Scott Bogard, Steve Karamihas
Recording Interval: 5.08 mm
Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.991
Long (elev.)	0.997
Medium (elev.)	0.996
Short (elev.)	0.895
Long (slope)	0.999
Medium (slope)	0.990
Short (slope)	0.752

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
4	64.34	164.73
5	64.56	164.72
6	64.67	164.70
Comb.	64.84	164.70

Repeatability:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
4	5	0.989	0.994	0.997	0.880
4	6	0.988	0.999	0.995	0.878
5	6	0.995	0.997	0.995	0.926
Average		0.991	0.997	0.996	0.895

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
4	5	0.999	0.993	0.727
4	6	1.000	0.987	0.737
5	6	0.999	0.989	0.792
Average		0.999	0.990	0.752

Notes:

- This was the second visit to the test section. Only about a third of the test section was covered.
- Section length is 498.175 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- Values for the medium and long waveband are somewhat dubious, given that the profiles were so short.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 11/16/2009

Device: Invar rod and Leica NA03 Level

Operator(s): Soil and Materials Engineers, Inc.

Recording Interval: 6 in

Use Moving Average: Yes

No filtering was detected.

Results for Profile:

Waveband	Accuracy Score
IRI	0.928
Long (elev.)	0.979
Medium (elev.)	0.962
Short (elev.)	0.649
Long (slope)	0.977
Medium (slope)	0.922
Short (slope)	0.201

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)
1	88.9	1.0	1219.92

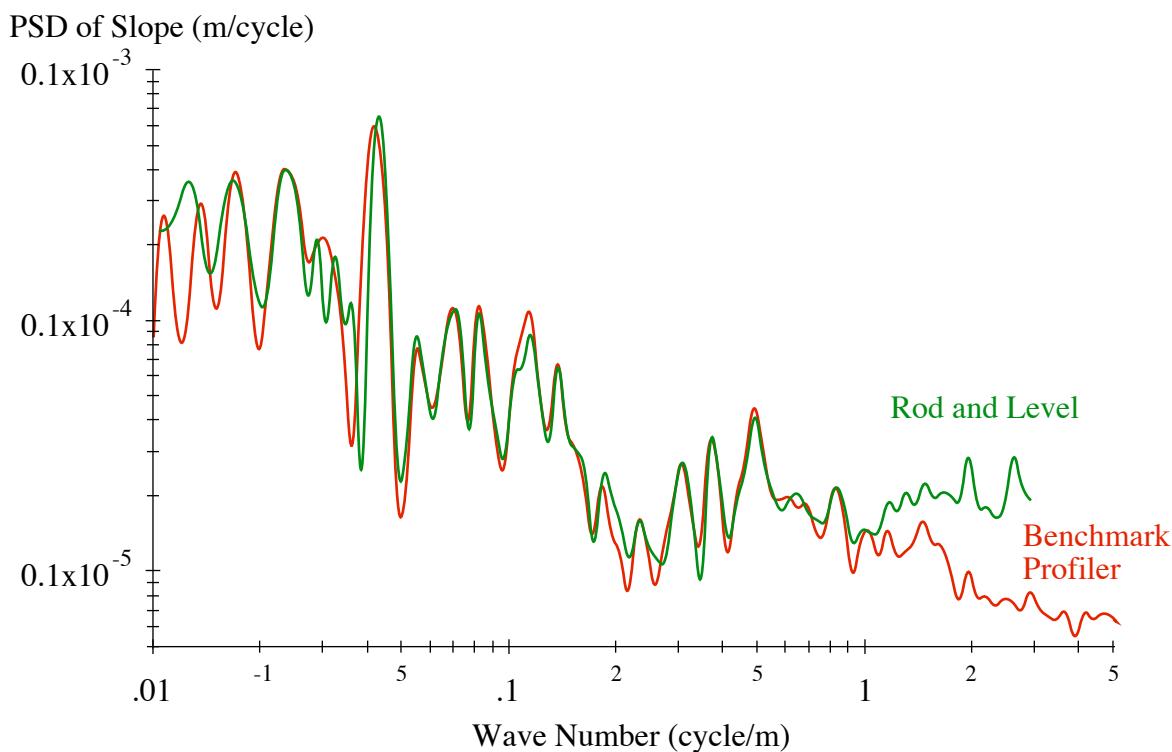
Auxiliary Information:

- Section length is 1231.22 ft, measured by a steel tape and corrected for temperature.
- The length value was derived from data files, which include a slight overrun.

- The benchmark IRI value for this section is 89.79 in/mi.

Special Observations:

- The profiles agree very well in the long wavelength range, as expected.
- The rod and level progressively underestimates content as wavelength decreases, because it “misses” profile features between the locations where the rod is placed. However, the rod and level overestimates content in the very short wavelength range because of aliasing. As such, content is somewhat lower in the rod and level than in the Benchmark Profiler for medium wavelengths, and higher than the Benchmark Profiler for short wavelengths.



Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 10/20/2009, 14:48 – 18:34

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2066 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.933	0.797
Long (elev.)	0.889	0.987
Medium (elev.)	0.749	0.889
Short (elev.)	0.360	0.277
Long (slope)	0.982	0.984
Medium (slope)	0.923	0.720
Short (slope)	0.172	0.101

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.84 to -0.87 percent.

Run Log, DMI Results:

Run	Start Time	End Time	Start Time	End Time	Start Time	End Time
1	14:48	14:54	16:09	16:18	17:29	17:38
2	14:02	15:07	—	16:37	17:45	17:56
3	15:15	15:20	16:40	16:48	18:01	18:10
4	15:27	15:32	16:52	16:59	18:13	18:21
5	15:38	15:43	17:03	17:10	18:25	18:34

The section was run in three segments, with 5 runs on each segment before proceeding to the next.

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	101.1	12.6	1221.07	-0.85
2	102.7	14.3	1221.28	-0.84
3	101.5	13.0	1221.28	-0.84
4	101.5	12.7	1220.86	-0.87
5	103.0	14.7	1221.07	-0.85

Notes:

- Section length is 1231.588 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.796	0.994	0.895	0.260	0.256	0.255	0.254
2	0.799	0.986	0.884	0.273	0.271	0.265	0.270
3	0.789	0.973	0.887	0.293	0.298	0.291	0.282
4	0.809	0.992	0.909	0.283	0.285	0.285	0.285
5	0.793	0.990	0.871	0.295	0.289	0.284	0.275
Ave.	0.797	0.987	0.889	0.281	0.280	0.276	0.273

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.975	0.712	0.077	0.077	0.077	0.088
2	0.988	0.720	0.113	0.118	0.118	0.118
3	0.986	0.720	0.115	0.119	0.119	0.106
4	0.983	0.733	0.076	0.081	0.081	0.080
5	0.987	0.715	0.113	0.115	0.115	0.110
Ave.	0.984	0.720	0.099	0.102	0.102	0.100

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.941	0.991	0.950	0.224	0.201	0.201
1	3	0.917	0.978	0.952	0.361	0.368	0.368
1	4	0.932	0.997	0.959	0.324	0.314	0.314
1	5	0.938	0.995	0.939	0.530	0.532	0.533
2	3	0.942	0.987	0.961	0.321	0.311	0.311
2	4	0.938	0.992	0.943	0.444	0.444	0.444
2	5	0.945	0.994	0.961	0.364	0.366	0.368
3	4	0.932	0.979	0.953	0.404	0.407	0.407
3	5	0.920	0.981	0.943	0.350	0.355	0.355
4	5	0.930	0.995	0.931	0.296	0.299	0.302
Average		0.933	0.989	0.949	0.362	0.360	0.360

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.974	0.937	0.088	0.116	0.109	0.109
1	3	0.971	0.906	0.117	0.192	0.125	0.126
1	4	0.988	0.913	0.195	0.192	0.192	0.192
1	5	0.985	0.929	0.258	0.261	0.261	0.262
2	3	0.995	0.928	0.140	0.132	0.124	0.123
2	4	0.980	0.923	0.180	0.179	0.205	0.179
2	5	0.983	0.933	0.161	0.163	0.120	0.166
3	4	0.976	0.925	0.158	0.137	0.146	0.162
3	5	0.979	0.914	0.178	0.180	0.181	0.171
4	5	0.990	0.918	0.215	0.221	0.221	0.224
Average		0.982	0.923	0.169	0.177	0.168	0.171

Auxiliary Information:

- John Koch observed the runs.
- The weather was mostly cloudy, windy and cold with a few light sprinkles in the early evening.
- Marked the section with a chalk line. The line was very hard for the operator to see. White chalk 1 inch wide was added in segment 2 because light rain was removing the original chalk line.
- The section was run in three segments. Five runs were performed on each segment before moving to the next segment. The border between segments was marked with chalk. The observer felt that the operators were not able to start the 2nd and 3rd segments very precisely at the end of the previous segment.
- The 1st segment was run with 2 laser set-ups. The segment was 393.18 ft long. The operator stopped in each run at 200 ft to move the laser.
- The 2nd segment was run with 2 laser set-ups. The segment was started at 393.18 ft and ended at 790.29-790.49 ft. The operator stopped in each run at 600 ft to move the laser.
- The 3rd segment was run with 2 laser set-ups. The segment was started at 790.29-790.49 ft and ended at about 1221.28 ft. The operator stopped in each run at 1000.0-1000.2 ft to move the laser.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 10/19/2009, 16:21 – 19:22

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2066 ft

Use Moving Average: Yes

No low-pass filtering evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.875	0.774
Long (elev.)	0.972	0.866
Medium (elev.)	0.912	0.867
Short (elev.)	0.511	0.257
Long (slope)	0.965	0.896
Medium (slope)	0.850	0.681
Short (slope)	0.287	0.104

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.65 to -0.81 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	16:21	16:33	120.9	3.7	492.76	-0.69
2	16:38	16:55	115.1	-1.2	492.15	-0.81
3	17:00	17:14	122.8	5.4	492.97	-0.65
4	17:18	17:30	120.3	3.2	492.76	-0.69
5	17:33	17:45	118.9	2.0	492.97	-0.65
6	17:52	18:09	123.6	6.1	492.97	-0.65
7	18:13	18:27	118.6	1.8	492.97	-0.65
8	18:32	18:44	121.7	4.4	492.97	-0.65
9	18:48	19:01	119.2	2.3	492.97	-0.65
10	19:07	19:22	120.6	3.5	493.18	-0.61

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.759	0.879	0.880	0.281	0.279	0.279	0.279
2	0.802	0.836	0.910	0.272	0.266	0.266	0.266
3	0.783	0.843	0.871	0.322	0.328	0.328	0.328
4	0.800	0.871	0.865	0.230	0.226	0.226	0.226
5	0.807	0.893	0.877	0.232	0.230	0.230	0.230
6	0.778	0.883	0.845	0.235	0.236	0.236	0.236
7	0.798	0.864	0.867	0.238	0.232	0.232	0.232
8	0.789	0.863	0.905	0.293	0.293	0.293	0.293
9	0.780	0.854	0.896	0.238	0.238	0.237	0.237
10	0.641	0.870	0.757	0.242	0.240	0.239	0.239
Ave.	0.774	0.866	0.867	0.258	0.257	0.257	0.257

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.916	0.681	0.140	0.142	0.142	0.142
2	0.850	0.704	0.102	0.100	0.100	0.100
3	0.891	0.680	0.119	0.118	0.118	0.118
4	0.911	0.705	0.110	0.107	0.107	0.107
5	0.911	0.709	0.074	0.073	0.073	0.073
6	0.928	0.679	0.114	0.117	0.117	0.117
7	0.905	0.692	0.103	0.103	0.103	0.103
8	0.888	0.693	0.114	0.116	0.116	0.116
9	0.867	0.660	0.128	0.047	0.047	0.047
10	0.892	0.610	0.094	0.098	0.098	0.098
Ave.	0.896	0.681	0.110	0.102	0.102	0.102

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.885	0.953	0.925	0.551	0.557	0.557
1	3	0.903	0.966	0.956	0.413	0.413	0.413
1	4	0.906	0.990	0.952	0.545	0.544	0.542
1	5	0.837	0.986	0.935	0.342	0.337	0.337
1	6	0.929	0.991	0.934	0.448	0.446	0.450
1	7	0.906	0.981	0.948	0.550	0.557	0.558
1	8	0.888	0.981	0.923	0.486	0.493	0.493
1	9	0.882	0.969	0.918	0.506	0.506	0.506
1	10	0.815	0.983	0.864	0.533	0.534	0.534
2	3	0.869	0.982	0.912	0.462	0.462	0.462
2	4	0.901	0.959	0.901	0.541	0.541	0.541
2	5	0.892	0.935	0.908	0.467	0.460	0.461
2	6	0.878	0.942	0.888	0.545	0.543	0.543
2	7	0.890	0.971	0.899	0.583	0.581	0.581
2	8	0.884	0.969	0.931	0.551	0.551	0.551
2	9	0.916	0.982	0.959	0.495	0.495	0.495
2	10	0.749	0.939	0.818	0.459	0.456	0.456
3	4	0.932	0.976	0.968	0.448	0.447	0.447
3	5	0.858	0.953	0.947	0.332	0.326	0.326
3	6	0.909	0.956	0.934	0.391	0.394	0.394
3	7	0.922	0.986	0.958	0.405	0.406	0.407
3	8	0.900	0.983	0.904	0.486	0.484	0.484
3	9	0.889	0.995	0.909	0.373	0.371	0.371
3	10	0.746	0.945	0.848	0.363	0.362	0.362
4	5	0.896	0.978	0.946	0.488	0.487	0.486
4	6	0.917	0.981	0.947	0.581	0.581	0.581
4	7	0.948	0.989	0.971	0.677	0.676	0.675
4	8	0.918	0.986	0.907	0.483	0.491	0.491
4	9	0.910	0.977	0.898	0.543	0.543	0.543
4	10	0.773	0.969	0.877	0.491	0.490	0.490
5	6	0.877	0.993	0.935	0.655	0.655	0.656
5	7	0.898	0.967	0.947	0.550	0.545	0.545
5	8	0.894	0.965	0.899	0.496	0.504	0.504
5	9	0.901	0.957	0.896	0.572	0.576	0.577
5	10	0.742	0.976	0.845	0.487	0.482	0.481
6	7	0.924	0.972	0.957	0.657	0.657	0.657
6	8	0.898	0.970	0.883	0.519	0.531	0.531
6	9	0.885	0.960	0.887	0.586	0.589	0.589
6	10	0.788	0.990	0.893	0.542	0.539	0.538
7	8	0.934	0.997	0.904	0.566	0.577	0.576
7	9	0.923	0.989	0.902	0.598	0.604	0.604
7	10	0.795	0.964	0.889	0.564	0.562	0.562
8	9	0.909	0.987	0.937	0.516	0.530	0.529
8	10	0.775	0.962	0.832	0.518	0.526	0.522
9	10	0.774	0.949	0.834	0.617	0.614	0.614
Average		0.875	0.972	0.912	0.511	0.512	0.512

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.932	0.857	0.351	0.374	0.375	0.374
1	3	0.980	0.878	0.188	0.198	0.130	0.198
1	4	0.991	0.890	0.254	0.256	0.262	0.262
1	5	0.983	0.780	0.188	0.187	0.186	0.187
1	6	0.984	0.897	0.282	0.297	0.297	0.297
1	7	0.983	0.889	0.324	0.329	0.329	0.329
1	8	0.968	0.857	0.383	0.384	0.384	0.384
1	9	0.946	0.865	0.353	0.352	0.352	0.352
1	10	0.985	0.808	0.303	0.309	0.308	0.309
2	3	0.942	0.844	0.267	0.254	0.254	0.254
2	4	0.927	0.867	0.239	0.246	0.246	0.246
2	5	0.931	0.854	0.240	0.234	0.234	0.234
2	6	0.914	0.851	0.310	0.314	0.314	0.314
2	7	0.946	0.838	0.316	0.315	0.317	0.316
2	8	0.954	0.830	0.378	0.386	0.386	0.386
2	9	0.982	0.859	0.320	0.321	0.321	0.321
2	10	0.939	0.720	0.235	0.224	0.235	0.235
3	4	0.981	0.908	0.326	0.315	0.315	0.315
3	5	0.981	0.806	0.154	0.153	0.153	0.153
3	6	0.963	0.885	0.270	0.275	0.275	0.275
3	7	0.991	0.908	0.208	0.211	0.211	0.211
3	8	0.972	0.866	0.261	0.256	0.256	0.256
3	9	0.953	0.872	0.276	0.257	0.257	0.257
3	10	0.977	0.763	0.215	0.236	0.222	0.223
4	5	0.978	0.846	0.126	0.213	0.213	0.213
4	6	0.979	0.901	0.362	0.363	0.363	0.363
4	7	0.978	0.916	0.418	0.424	0.424	0.424
4	8	0.961	0.887	0.264	0.268	0.267	0.268
4	9	0.940	0.888	0.304	0.294	0.297	0.298
4	10	0.977	0.802	0.270	0.242	0.266	0.266
5	6	0.969	0.832	0.303	0.301	0.301	0.301
5	7	0.984	0.842	0.220	0.218	0.218	0.218
5	8	0.966	0.840	0.228	0.222	0.221	0.222
5	9	0.945	0.829	0.256	0.249	0.249	0.249
5	10	0.975	0.745	0.231	0.229	0.229	0.229
6	7	0.968	0.904	0.430	0.428	0.428	0.428
6	8	0.950	0.872	0.310	0.315	0.315	0.315
6	9	0.931	0.865	0.251	0.248	0.248	0.248
6	10	0.977	0.785	0.333	0.335	0.335	0.335
7	8	0.982	0.898	0.342	0.353	0.353	0.353
7	9	0.963	0.894	0.312	0.314	0.314	0.314
7	10	0.983	0.837	0.297	0.298	0.298	0.298
8	9	0.969	0.880	0.320	0.320	0.323	0.323
8	10	0.974	0.793	0.286	0.294	0.293	0.293
9	10	0.954	0.811	0.347	0.351	0.351	0.351
Average		0.965	0.850	0.286	0.288	0.287	0.289

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was mostly cloudy. It was cool until the early afternoon when the sun came out.
- Marked a chalk line.
- Two reference laser set-ups were used to run this section.
- In run 2, picked up a stone chip on DMI tire.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 10/20/2009, 10:19 – 12:53

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2066 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.807	0.606
Long (elev.)	0.995	0.991
Medium (elev.)	0.829	0.524
Short (elev.)	0.270	0.218
Long (slope)	0.987	0.961
Medium (slope)	0.731	0.434
Short (slope)	0.137	0.072

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.86 to -0.90 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	10:19	10:33	70.8	28.3	457.44	-0.90
2	10:37	10:51	72.0	30.5	457.64	-0.86
3	11:03	11:13	73.8	33.7	457.64	-0.86
4	11:17	11:27	72.0	30.6	457.64	-0.86
5	11:32	11:42	75.4	36.7	457.64	-0.86
6	11:47	11:59	77.2	40.0	457.64	-0.86
7	12:03	12:12	73.5	33.3	457.64	-0.86
8	12:15	12:24	78.4	42.0	457.64	-0.86
9	12:29	12:37	74.0	34.2	457.64	-0.86
10	12:44	12:53	73.3	32.8	457.64	-0.86

Notes:

- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.624	0.997	0.537	0.198	0.198	0.197	0.198
2	0.662	0.994	0.567	0.254	0.254	0.254	0.254
3	0.595	0.976	0.532	0.250	0.250	0.250	0.249
4	0.636	0.996	0.553	0.208	0.206	0.202	0.202
5	0.616	0.996	0.509	0.205	0.202	0.203	0.202
6	0.562	0.994	0.476	0.160	0.160	0.159	0.159
7	0.600	0.986	0.522	0.194	0.192	0.191	0.192
8	0.564	0.983	0.502	0.249	0.248	0.248	0.248
9	0.581	0.989	0.487	0.217	0.215	0.212	0.212
10	0.619	0.994	0.550	0.262	0.261	0.261	0.261
Ave.	0.606	0.991	0.524	0.220	0.219	0.218	0.218

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.969	0.440	0.070	0.070	0.070	0.070
2	0.967	0.478	0.088	0.088	0.088	0.088
3	0.940	0.437	0.076	0.076	0.076	0.076
4	0.978	0.471	0.068	0.068	0.068	0.068
5	0.965	0.444	0.080	0.057	0.057	0.057
6	0.965	0.397	0.055	0.055	0.077	0.055
7	0.959	0.426	0.055	0.055	0.055	0.055
8	0.948	0.395	0.079	0.106	0.079	0.079
9	0.956	0.413	0.067	0.067	0.067	0.067
10	0.966	0.440	0.082	0.082	0.082	0.082
Ave.	0.961	0.434	0.072	0.072	0.072	0.070

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.856	0.998	0.857	0.345	0.345	0.345
1	3	0.785	0.984	0.845	0.310	0.310	0.310
1	4	0.809	0.998	0.833	0.328	0.328	0.328
1	5	0.773	0.999	0.765	0.258	0.255	0.255
1	6	0.749	0.998	0.729	0.194	0.161	0.161
1	7	0.770	0.993	0.835	0.264	0.264	0.264
	8	0.714	0.991	0.793	0.273	0.273	0.273
1	9	0.759	0.994	0.774	0.316	0.316	0.339
1	10	0.784	0.998	0.844	0.253	0.253	0.253
2	3	0.826	0.991	0.848	0.320	0.320	0.321
2	4	0.835	0.998	0.821	0.293	0.293	0.292
2	5	0.798	0.999	0.761	0.264	0.259	0.259
2	6	0.765	0.998	0.709	0.131	0.206	0.131
2	7	0.793	0.997	0.808	0.212	0.221	0.221
2	8	0.793	0.995	0.801	0.441	0.440	0.441
2	9	0.762	0.998	0.768	0.280	0.280	0.280
2	10	0.797	0.998	0.822	0.254	0.254	0.254
3	4	0.852	0.987	0.889	0.284	0.243	0.284
3	5	0.838	0.988	0.816	0.250	0.250	0.193
3	6	0.815	0.990	0.783	0.188	0.165	0.188
3	7	0.816	0.997	0.879	0.220	0.185	0.220
3	8	0.832	0.997	0.852	0.397	0.397	0.397
3	9	0.829	0.996	0.820	0.322	0.322	0.322
3	10	0.809	0.990	0.887	0.257	0.257	0.256
4	5	0.830	0.998	0.841	0.276	0.276	0.276
4	6	0.785	0.998	0.811	0.288	0.288	0.288
4	7	0.831	0.994	0.898	0.233	0.207	0.233
4	8	0.795	0.991	0.880	0.314	0.275	0.314
4	9	0.806	0.996	0.841	0.365	0.365	0.365
4	10	0.806	0.998	0.876	0.297	0.297	0.297
5	6	0.807	0.998	0.851	0.231	0.250	0.249
5	7	0.835	0.994	0.823	0.293	0.293	0.293
5	8	0.829	0.992	0.844	0.249	0.249	0.249
5	9	0.856	0.996	0.896	0.340	0.276	0.292
5	10	0.822	0.998	0.815	0.220	0.210	0.220
6	7	0.772	0.996	0.798	0.234	0.264	0.264
6	8	0.836	0.993	0.816	0.116	0.156	0.156
6	9	0.852	0.997	0.853	0.314	0.286	0.286
6	10	0.794	0.998	0.788	0.190	0.241	0.229
7	8	0.795	0.998	0.873	0.149	0.149	0.149
7	9	0.832	0.999	0.860	0.300	0.300	0.300
7	10	0.832	0.996	0.871	0.220	0.252	0.220
8	9	0.840	0.997	0.862	0.301	0.301	0.301
8	10	0.788	0.994	0.846	0.320	0.320	0.321
9	10	0.818	0.997	0.833	0.294	0.252	0.294
Average		0.807	0.995	0.829	0.271	0.269	0.271

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.995	0.779	0.158	0.158	0.148	0.158
1	3	0.971	0.707	0.160	0.160	0.160	0.160
1	4	0.989	0.702	0.136	0.136	0.136	0.136
1	5	0.993	0.650	0.218	0.218	0.218	0.218
1	6	0.989	0.637	0.144	0.121	0.144	0.144
1	7	0.987	0.677	0.158	0.160	0.159	0.159
1	8	0.982	0.596	0.093	0.093	0.093	0.093
1	9	0.984	0.664	0.158	0.158	0.158	0.158
1	10	0.992	0.672	0.142	0.142	0.142	0.142
2	3	0.978	0.792	0.108	0.108	0.108	0.108
2	4	0.990	0.750	0.124	0.124	0.124	0.124
2	5	0.995	0.703	0.113	0.113	0.113	0.113
2	6	0.989	0.685	0.096	0.096	0.096	0.096
2	7	0.992	0.695	0.114	0.114	0.114	0.110
2	8	0.986	0.710	0.189	0.189	0.189	0.189
2	9	0.988	0.679	0.166	0.166	0.166	0.166
2	10	0.992	0.699	0.106	0.106	0.106	0.106
3	4	0.969	0.829	0.133	0.167	0.133	0.133
3	5	0.978	0.730	0.165	0.165	0.165	0.165
3	6	0.975	0.700	0.125	0.125	0.125	0.125
3	7	0.988	0.761	0.100	0.100	0.100	0.100
3	8	0.991	0.724	0.185	0.185	0.185	0.185
3	9	0.988	0.720	0.168	0.168	0.168	0.144
3	10	0.977	0.736	0.148	0.148	0.148	0.148
4	5	0.988	0.770	0.093	0.093	0.093	0.093
4	6	0.989	0.719	0.146	0.146	0.146	0.147
4	7	0.986	0.782	0.174	0.174	0.174	0.174
4	8	0.974	0.741	0.134	0.134	0.134	0.134
4	9	0.982	0.744	0.152	0.152	0.152	0.152
4	10	0.990	0.732	0.140	0.139	0.140	0.139
5	6	0.988	0.752	0.158	0.158	0.158	0.158
5	7	0.989	0.745	0.112	0.112	0.112	0.112
5	8	0.983	0.791	0.096	0.096	0.096	0.096
5	9	0.988	0.822	0.151	0.117	0.151	0.117
5	10	0.991	0.761	0.148	0.097	0.108	0.108
6	7	0.991	0.682	0.194	0.194	0.194	0.194
6	8	0.983	0.785	0.102	0.102	0.102	0.096
6	9	0.991	0.788	0.166	0.166	0.166	0.166
6	10	0.992	0.737	0.138	0.138	0.138	0.138
7	8	0.992	0.727	0.085	0.085	0.098	0.099
7	9	0.995	0.760	0.140	0.140	0.140	0.140
7	10	0.991	0.762	0.138	0.138	0.138	0.122
8	9	0.990	0.795	0.146	0.146	0.146	0.146
8	10	0.984	0.736	0.118	0.118	0.118	0.118
9	10	0.989	0.773	0.106	0.090	0.106	0.090
Average		0.987	0.731	0.139	0.137	0.138	0.136

Auxiliary Information:

- John Koch observed the runs.
- The weather was mostly cloudy, windy and cold with a few light sprinkles in the early evening.
- Marked the section with a chalk line.
- Stopped run 1 at 66 ft the re-started.
- In each run, stopped to switch the laser after running the first 232.43 ft.

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 10/22/2009, ~12:00 – 14:30

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2066 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.939	0.402
Long (elev.)	0.981	0.973
Medium (elev.)	0.960	0.737
Short (elev.)	0.742	0.056
Long (slope)	0.968	0.950
Medium (slope)	0.939	0.355
Short (slope)	0.274	0.060

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.65 to -0.69 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	—	—	111.7	45.0	486.7	-0.69
2	—	—	110.9	43.9	487.0	-0.65
3	—	—	110.0	42.7	487.0	-0.65
4	—	—	112.7	46.2	486.7	-0.69
5	—	—	111.2	44.4	487.0	-0.65
6	—	—	110.4	43.3	486.7	-0.69
7	—	—	112.5	46.0	486.7	-0.69
8	—	—	111.7	45.0	486.7	-0.69
9	—	—	111.3	44.5	486.7	-0.69
10	—	—	109.8	42.5	487.0	-0.65

Notes:

- Section length is 490.119 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.398	0.986	0.734	0.045	0.045	0.045	0.045
2	0.409	0.978	0.737	0.043	0.043	0.078	0.078
3	0.389	0.971	0.728	0.071	0.071	0.071	0.071
4	0.406	0.961	0.740	0.047	0.047	0.047	0.047
5	0.408	0.962	0.739	0.063	0.063	0.063	0.063
6	0.408	0.976	0.747	0.051	0.051	0.051	0.051
7	0.387	0.963	0.714	0.045	0.045	0.045	0.045
8	0.405	0.962	0.740	0.061	0.061	0.061	0.061
9	0.398	0.980	0.743	0.046	0.074	0.048	0.048
10	0.414	0.987	0.750	0.062	0.062	0.073	0.073
Ave.	0.402	0.973	0.737	0.053	0.056	0.058	0.058

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.966	0.350	0.034	0.034	0.034	0.030
2	0.962	0.360	0.065	0.065	0.065	0.065
3	0.946	0.343	0.082	0.082	0.082	0.082
4	0.920	0.362	0.059	0.059	0.059	0.059
5	0.947	0.358	0.068	0.068	0.068	0.068
6	0.984	0.358	0.032	0.032	0.060	0.060
7	0.933	0.347	0.043	0.043	0.043	0.043
8	0.947	0.359	0.064	0.064	0.064	0.064
9	0.923	0.350	0.050	0.051	0.051	0.050
10	0.968	0.359	0.092	0.092	0.092	0.092
Ave.	0.950	0.355	0.059	0.059	0.062	0.061

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.939	0.987	0.967	0.735	0.735	0.735
1	3	0.957	0.988	0.972	0.810	0.810	0.810
1	4	0.937	0.974	0.960	0.747	0.747	0.748
1	5	0.923	0.978	0.968	0.731	0.731	0.731
1	6	0.944	0.986	0.965	0.763	0.763	0.763
1	7	0.961	0.979	0.963	0.728	0.728	0.728
1	8	0.940	0.975	0.963	0.731	0.731	0.730
1	9	0.944	0.993	0.965	0.710	0.710	0.710
1	10	0.936	0.997	0.971	0.792	0.792	0.792
2	3	0.950	0.978	0.969	0.762	0.762	0.761
2	4	0.937	0.966	0.959	0.732	0.732	0.732
2	5	0.945	0.967	0.965	0.742	0.742	0.743
2	6	0.937	0.994	0.958	0.705	0.705	0.705
2	7	0.929	0.967	0.948	0.779	0.779	0.780
2	8	0.932	0.963	0.952	0.657	0.657	0.657
2	9	0.941	0.982	0.960	0.783	0.783	0.783
2	10	0.951	0.988	0.973	0.751	0.751	0.751
3	4	0.936	0.981	0.946	0.802	0.801	0.802
3	5	0.934	0.983	0.962	0.783	0.783	0.783
3	6	0.936	0.978	0.963	0.759	0.759	0.759
3	7	0.948	0.986	0.954	0.739	0.739	0.739
3	8	0.943	0.980	0.960	0.712	0.712	0.712
3	9	0.946	0.990	0.963	0.731	0.731	0.731
3	10	0.945	0.988	0.975	0.806	0.806	0.806
4	5	0.922	0.992	0.960	0.729	0.729	0.729
4	6	0.940	0.964	0.954	0.765	0.762	0.765
4	7	0.943	0.987	0.948	0.734	0.734	0.734
4	8	0.956	0.987	0.958	0.760	0.760	0.760
4	9	0.952	0.978	0.958	0.747	0.747	0.747
4	10	0.911	0.975	0.955	0.752	0.752	0.752
5	6	0.937	0.968	0.951	0.699	0.699	0.698
5	7	0.912	0.992	0.953	0.707	0.707	0.707
5	8	0.928	0.992	0.956	0.652	0.652	0.651
5	9	0.929	0.976	0.958	0.668	0.667	0.668
5	10	0.947	0.976	0.963	0.803	0.803	0.803
6	7	0.932	0.970	0.947	0.722	0.722	0.722
6	8	0.954	0.963	0.971	0.797	0.797	0.797
6	9	0.946	0.982	0.970	0.760	0.760	0.759
6	10	0.942	0.988	0.964	0.740	0.740	0.740
7	8	0.943	0.989	0.951	0.709	0.709	0.709
7	9	0.948	0.982	0.952	0.811	0.811	0.811
7	10	0.917	0.979	0.946	0.686	0.686	0.686
8	9	0.962	0.975	0.977	0.743	0.743	0.743
8	10	0.917	0.972	0.959	0.728	0.728	0.727
9	10	0.924	0.993	0.967	0.690	0.690	0.690
Average		0.939	0.981	0.960	0.742	0.742	0.742

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.995	0.937	0.259	0.259	0.259	0.259
1	3	0.978	0.957	0.359	0.359	0.359	0.359
1	4	0.947	0.935	0.257	0.257	0.257	0.233
1	5	0.980	0.930	0.228	0.228	0.228	0.228
1	6	0.970	0.939	0.239	0.239	0.239	0.239
1	7	0.965	0.962	0.264	0.264	0.264	0.264
1	8	0.979	0.939	0.234	0.234	0.234	0.234
1	9	0.953	0.956	0.275	0.275	0.275	0.275
1	10	0.995	0.942	0.243	0.243	0.243	0.243
2	3	0.976	0.949	0.303	0.303	0.303	0.303
2	4	0.949	0.924	0.251	0.251	0.251	0.252
2	5	0.980	0.948	0.280	0.280	0.280	0.251
2	6	0.967	0.932	0.198	0.198	0.198	0.185
2	7	0.961	0.931	0.300	0.300	0.300	0.300
2	8	0.977	0.925	0.217	0.217	0.217	0.217
2	9	0.951	0.933	0.294	0.294	0.294	0.294
2	10	0.994	0.960	0.284	0.284	0.284	0.284
3	4	0.957	0.934	0.367	0.249	0.367	0.367
3	5	0.987	0.937	0.293	0.293	0.293	0.293
3	6	0.957	0.928	0.211	0.185	0.211	0.212
3	7	0.981	0.952	0.313	0.255	0.313	0.314
3	8	0.992	0.940	0.219	0.219	0.219	0.219
3	9	0.967	0.951	0.273	0.273	0.273	0.274
3	10	0.981	0.951	0.333	0.333	0.333	0.333
4	5	0.958	0.920	0.249	0.249	0.249	0.249
4	6	0.921	0.927	0.235	0.219	0.235	0.232
4	7	0.964	0.948	0.277	0.277	0.277	0.278
4	8	0.962	0.949	0.273	0.273	0.273	0.273
4	9	0.983	0.954	0.268	0.271	0.268	0.271
4	10	0.949	0.910	0.311	0.309	0.311	0.311
5	6	0.956	0.934	0.222	0.190	0.222	0.191
5	7	0.972	0.924	0.286	0.286	0.286	0.286
5	8	0.988	0.934	0.204	0.206	0.204	0.206
5	9	0.960	0.934	0.302	0.279	0.302	0.302
5	10	0.979	0.944	0.424	0.417	0.424	0.424
6	7	0.944	0.926	0.222	0.222	0.222	0.222
6	8	0.954	0.947	0.334	0.334	0.334	0.334
6	9	0.928	0.935	0.320	0.320	0.320	0.320
6	10	0.972	0.935	0.236	0.236	0.236	0.236
7	8	0.984	0.942	0.259	0.258	0.259	0.259
7	9	0.979	0.958	0.339	0.339	0.339	0.339
7	10	0.967	0.925	0.283	0.283	0.283	0.283
8	9	0.971	0.955	0.335	0.335	0.335	0.335
8	10	0.978	0.922	0.244	0.244	0.244	0.244
9	10	0.955	0.926	0.287	0.287	0.287	0.288
Average		0.968	0.939	0.276	0.270	0.276	0.274

Auxiliary Information:

- John Andrews observed the testing.
- Pavement was damp with blotchy moisture that dried by run 8.
- The temperature was in the 40s (F). It was heavily overcast with blustery wind.
- The operators performed 10 runs in the same direction.
- Run 1 was 30 minutes long with redo of center section due to bad step to third laser.
- Run 2 was 20 minutes long with no incidents.
- Runs 3-10 averaged 15 minutes including 2-3 minutes to reset at the start.
- Whenever a glitch occurred (very seldom) the operator just backed up a few steps then continued as before.
- Tear down and storage in the pick-up took 15 minutes.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 10/20/2009, 08:02 – 09:25

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2066 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.949	0.922
Long (elev.)	0.993	0.962
Medium (elev.)	0.958	0.945
Short (elev.)	0.722	0.687
Long (slope)	0.993	0.964
Medium (slope)	0.933	0.900
Short (slope)	0.349	0.145

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from -0.75 to -0.87 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:02	08:07	129.7	1.3	164.88	-0.87
2	08:12	08:17	123.2	-3.7	164.88	-0.87
3	08:19	08:24	131.1	2.4	165.08	-0.75
4	08:33	08:37	128.2	0.1	164.88	-0.87
5	08:39	08:43	126.8	-1.0	165.08	-0.75
6	08:46	08:50	126.6	-1.1	164.88	-0.87
7	08:56	09:00	127.7	-0.3	164.88	-0.87
8	09:05	09:11	124.3	-2.9	164.88	-0.87
9	09:13	09:17	127.3	-0.6	164.88	-0.87
10	09:20	09:25	128.0	0.0	164.88	-0.87

Notes:

- Section length is 166.326 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.934	0.960	0.954	0.681	0.681
2	0.903	0.955	0.947	0.634	0.634
3	0.922	0.974	0.933	0.706	0.706
4	0.935	0.973	0.954	0.687	0.687
5	0.933	0.971	0.960	0.732	0.732
6	0.925	0.966	0.943	0.685	0.685
7	0.882	0.953	0.926	0.694	0.691
8	0.931	0.955	0.913	0.672	0.672
9	0.924	0.957	0.957	0.676	0.676
10	0.930	0.956	0.969	0.708	0.708
Ave.	0.922	0.962	0.945	0.688	0.687

Run	Cross Correlation to Benchmark Profile, Slope			
	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.968	0.920	0.142	0.142
2	0.961	0.883	0.136	0.135
3	0.969	0.884	0.152	0.152
4	0.978	0.914	0.158	0.158
5	0.966	0.913	0.124	0.124
6	0.962	0.887	0.167	0.167
7	0.960	0.871	0.148	0.167
8	0.954	0.904	0.140	0.140
9	0.960	0.910	0.135	0.135
10	0.963	0.916	0.143	0.143
Ave.	0.964	0.900	0.145	0.146

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation				
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.932	0.998	0.978	0.743	0.744
1	3	0.962	0.984	0.956	0.761	0.761
1	4	0.972	0.993	0.979	0.717	0.717
1	5	0.949	0.995	0.965	0.689	0.689
1	6	0.960	0.999	0.968	0.660	0.660
1	7	0.948	0.997	0.958	0.755	0.755
1	8	0.961	0.997	0.933	0.759	0.759
1	9	0.964	0.999	0.985	0.802	0.808
1	10	0.963	0.997	0.981	0.740	0.745
2	3	0.912	0.976	0.942	0.706	0.706
2	4	0.924	0.987	0.964	0.663	0.664
2	5	0.932	0.989	0.954	0.658	0.653
2	6	0.932	0.995	0.981	0.713	0.714
2	7	0.890	0.998	0.941	0.694	0.694
2	8	0.936	0.993	0.916	0.666	0.666
2	9	0.951	1.000	0.982	0.733	0.733
2	10	0.944	0.999	0.971	0.683	0.683
3	4	0.961	0.995	0.961	0.803	0.803
3	5	0.941	0.995	0.970	0.739	0.739
3	6	0.949	0.990	0.936	0.700	0.700
3	7	0.962	0.978	0.970	0.750	0.750
3	8	0.941	0.988	0.965	0.751	0.751
3	9	0.937	0.982	0.945	0.725	0.728
3	10	0.953	0.978	0.953	0.809	0.809
4	5	0.958	0.999	0.977	0.711	0.716
4	6	0.960	0.998	0.959	0.724	0.724
4	7	0.934	0.990	0.961	0.715	0.715
4	8	0.957	0.992	0.932	0.745	0.745
4	9	0.951	0.992	0.973	0.732	0.732
4	10	0.964	0.991	0.981	0.735	0.740
5	6	0.957	0.998	0.953	0.680	0.680
5	7	0.917	0.989	0.955	0.743	0.743
5	8	0.964	0.994	0.941	0.667	0.666
5	9	0.965	0.993	0.962	0.701	0.701
5	10	0.976	0.991	0.972	0.757	0.757
6	7	0.931	0.995	0.943	0.670	0.670
6	8	0.963	0.995	0.912	0.686	0.686
6	9	0.952	0.997	0.972	0.668	0.668
6	10	0.964	0.996	0.966	0.671	0.671
7	8	0.924	0.990	0.951	0.742	0.742
7	9	0.931	0.999	0.954	0.730	0.730
7	10	0.927	0.998	0.956	0.794	0.794
8	9	0.971	0.995	0.921	0.717	0.720
8	10	0.976	0.991	0.922	0.752	0.757
9	10	0.974	0.999	0.980	0.727	0.730
Average		0.949	0.993	0.958	0.722	0.723

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.997	0.924	0.481	0.481
1	3	0.992	0.936	0.317	0.310
1	4	0.990	0.958	0.286	0.285
1	5	0.997	0.947	0.287	0.282
1	6	0.994	0.947	0.361	0.361
1	7	0.996	0.937	0.338	0.372
1	8	0.990	0.942	0.386	0.380
1	9	0.994	0.961	0.422	0.429
1	10	0.994	0.965	0.298	0.298
2	3	0.985	0.888	0.351	0.351
2	4	0.983	0.910	0.289	0.289
2	5	0.998	0.898	0.299	0.299
2	6	0.996	0.902	0.394	0.394
2	7	0.996	0.879	0.375	0.375
2	8	0.991	0.883	0.414	0.414
2	9	0.997	0.936	0.465	0.474
2	10	0.996	0.927	0.316	0.312
3	4	0.994	0.925	0.392	0.392
3	5	0.990	0.936	0.412	0.410
3	6	0.989	0.934	0.322	0.322
3	7	0.988	0.946	0.331	0.333
3	8	0.993	0.958	0.309	0.309
3	9	0.989	0.911	0.286	0.286
3	10	0.987	0.935	0.433	0.433
4	5	0.986	0.947	0.382	0.382
4	6	0.987	0.932	0.364	0.363
4	7	0.987	0.919	0.340	0.340
4	8	0.984	0.917	0.282	0.282
4	9	0.986	0.941	0.297	0.297
4	10	0.986	0.962	0.336	0.336
5	6	0.996	0.945	0.331	0.331
5	7	0.993	0.934	0.404	0.405
5	8	0.991	0.936	0.275	0.275
5	9	0.995	0.936	0.325	0.325
5	10	0.996	0.952	0.448	0.449
6	7	0.998	0.945	0.308	0.308
6	8	0.993	0.942	0.403	0.403
6	9	0.999	0.922	0.362	0.362
6	10	0.999	0.942	0.307	0.307
7	8	0.992	0.947	0.344	0.344
7	9	0.999	0.926	0.291	0.292
7	10	0.998	0.930	0.400	0.407
8	9	0.995	0.918	0.344	0.345
8	10	0.991	0.931	0.286	0.286
9	10	0.999	0.963	0.313	0.302
Average		0.993	0.933	0.349	0.350

Auxiliary Information:

- Bruce Wasill observed runs 1-6. John Koch took over after that.
- The weather was mostly cloudy, windy and cold with a few light sprinkles in the early evening.
- The pavement surface was slightly damp from overnight rain.
- Marked the center line with a chalk line.
- The sun came out and due to the direction and angle of the sun the chalk line virtually disappeared. A much heavier chalk line was placed in order to see it. From the reverse direction the line could easily be seen but the operators did not want to mix the directions of the runs.
- During run 8, backed up from 155 ft to 145 ft to replace part of the run to make up for someone crossing in front of the laser.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 10/19/2009, 12:23 – 15:27

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan

Recording Interval: 0.2064 - 0.2067 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.701	0.579
Long (elev.)	0.792	0.750
Medium (elev.)	0.709	0.750
Short (elev.)	0.637	0.090
Long (slope)	0.784	0.893
Medium (slope)	0.682	0.529
Short (slope)	0.271	0.100

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from -0.80 to -0.88 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Length (ft)	Percent Error
1	12:23	12:48	103.5	534.09	-0.84
2	12:53	13:07	102.5	534.29	-0.80
3	13:18	13:30	100.6	534.29	-0.80
4	13:35	13:46	106.2	533.88	-0.88
5	13:50	14:05	105.5	534.09	-0.84
6	14:08	14:22	724.1	534.29	-0.80
7	14:26	14:38	103.1	534.09	-0.84
8	14:42	14:54	102.6	534.09	-0.84
9	14:58	15:09	103.1	533.88	-0.88
10	15:13	15:27	105.1	534.09	-0.84

Notes:

- Section length is 538.596 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The benchmark profile only covered 164.7 ft. Accuracy scores for the IRI waveband and the long waveband do not represent expected performance over a longer segment of road.
- Run 6 included a deep narrow dip that did not appear in the others. With run 6 eliminated, the Results for Profile change to:

Waveband	Repeatability Score	Accuracy Score
IRI	0.876	0.577
Long (elev.)	0.974	0.749
Medium (elev.)	0.884	0.747
Short (elev.)	0.642	0.087
Long (slope)	0.970	0.892
Medium (slope)	0.851	0.529
Short (slope)	0.281	0.097

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.498	0.790	0.772	0.072
2	0.523	0.775	0.788	0.103
3	0.559	0.710	0.723	0.053
4	0.568	0.757	0.756	0.072
5	0.620	0.748	0.709	0.090
6	0.594	0.757	0.776	0.116
7	0.620	0.754	0.727	0.104
8	0.601	0.718	0.737	0.106
9	0.606	0.762	0.806	0.090
10	0.597	0.725	0.702	0.095
Ave.	0.579	0.750	0.750	0.090

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.924	0.413	0.063
2	0.899	0.491	0.132
3	0.859	0.552	0.100
4	0.906	0.510	0.047
5	0.887	0.540	0.081
6	0.899	0.528	0.129
7	0.914	0.549	0.155
8	0.875	0.561	0.105
9	0.894	0.588	0.109
10	0.873	0.552	0.078
Ave.	0.893	0.529	0.100

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.925	0.969	0.884	0.709
1	3	0.872	0.959	0.902	0.556
1	4	0.905	0.969	0.946	0.530
1	5	0.875	0.937	0.911	0.539
1	6	0.004	0.063	0.006	0.657
1	7	0.867	0.992	0.902	0.562
1	8	0.854	0.959	0.839	0.534
1	9	0.854	0.962	0.837	0.494
1	10	0.848	0.948	0.833	0.558
2	3	0.878	0.987	0.917	0.604
2	4	0.904	0.995	0.855	0.626
2	5	0.890	0.967	0.869	0.628
2	6	0.005	0.075	0.005	0.649
2	7	0.869	0.968	0.875	0.664
2	8	0.830	0.984	0.830	0.628
2	9	0.862	0.990	0.917	0.626
2	10	0.847	0.974	0.888	0.563
3	4	0.881	0.991	0.907	0.715
3	5	0.850	0.973	0.896	0.753
3	6	0.005	0.061	0.007	0.608
3	7	0.884	0.964	0.913	0.584
3	8	0.902	0.997	0.907	0.664
3	9	0.882	0.994	0.894	0.669
3	10	0.886	0.983	0.904	0.677
4	5	0.911	0.967	0.916	0.756
4	6	0.004	0.061	0.008	0.596
4	7	0.855	0.973	0.903	0.621
4	8	0.888	0.990	0.896	0.782
4	9	0.881	0.991	0.848	0.756
4	10	0.871	0.978	0.861	0.672
5	6	0.006	0.082	0.008	0.615
5	7	0.823	0.940	0.884	0.592
5	8	0.853	0.971	0.867	0.723
5	9	0.852	0.969	0.846	0.714
5	10	0.838	0.983	0.862	0.685
6	7	0.005	0.061	0.007	0.623
6	8	0.003	0.057	0.008	0.578
6	9	0.003	0.064	0.005	0.583
6	10	0.003	0.067	0.006	0.648
7	8	0.884	0.964	0.875	0.634
7	9	0.886	0.962	0.878	0.627
7	10	0.892	0.954	0.901	0.606
8	9	0.886	0.993	0.849	0.734
8	10	0.924	0.986	0.909	0.681
9	10	0.920	0.980	0.915	0.630
Average		0.701	0.792	0.709	0.637

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.981	0.910	0.251
1	3	0.962	0.830	0.222
1	4	0.971	0.903	0.202
1	5	0.936	0.868	0.207
1	6	0.036	0.003	0.374
1	7	0.982	0.844	0.221
1	8	0.966	0.817	0.256
1	9	0.983	0.822	0.258
1	10	0.960	0.821	0.281
2	3	0.978	0.860	0.232
2	4	0.985	0.879	0.298
2	5	0.958	0.869	0.318
2	6	0.040	0.004	0.230
2	7	0.962	0.869	0.377
2	8	0.979	0.807	0.303
2	9	0.988	0.850	0.362
2	10	0.977	0.843	0.218
3	4	0.994	0.836	0.353
3	5	0.968	0.814	0.308
3	6	0.037	0.004	0.183
3	7	0.951	0.848	0.185
3	8	0.992	0.866	0.286
3	9	0.973	0.839	0.294
3	10	0.989	0.842	0.276
4	5	0.962	0.901	0.363
4	6	0.037	0.003	0.185
4	7	0.960	0.841	0.230
4	8	0.994	0.854	0.409
4	9	0.980	0.846	0.386
4	10	0.989	0.844	0.227
5	6	0.048	0.007	0.216
5	7	0.923	0.808	0.225
5	8	0.958	0.821	0.337
5	9	0.944	0.824	0.377
5	10	0.966	0.817	0.300
6	7	0.035	0.004	0.205
6	8	0.038	0.003	0.203
6	9	0.038	0.003	0.195
6	10	0.043	0.002	0.282
7	8	0.959	0.849	0.294
7	9	0.971	0.867	0.267
7	10	0.957	0.871	0.242
8	9	0.978	0.848	0.322
8	10	0.990	0.900	0.249
9	10	0.971	0.914	0.195
Average		0.784	0.682	0.271

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was mostly cloudy. It was cool until the early afternoon when the sun came out.
- Partial setup of the equipment was completed in about 10 minutes.
- Calibrated the DMI over 100 ft along a chalk line.
- Set up a chalk line along the middle of the lane.
- A nearby vehicle was asked to turn the lights off and to use his flashers only.
- The device passed along three reference lasers over the section. During run 1, swapped the third laser before using it because of observed chatter.
- During run 5, UMTRI was asked to shroud their laser on a nearby section due to interference. The device allowed the operators to simply stop, deal with the problem, then continue from that point.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt
Date: 10/28/2009, 09:00 – 11:30
Device: ARRB Walking Profiler
Operator(s): Minnesota DOT, Tom Nordstrum and Greg Schneider
Recording Interval: 0.7917 ft
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.993	0.792
Long (elev.)	0.996	0.976
Medium (elev.)	0.992	0.786
Short (elev.)	0.983	0.483
Long (slope)	0.997	0.948
Medium (slope)	0.990	0.713
Short (slope)	0.975	0.063

Result for Longitudinal Distance:

Error in longitudinal distance was 0.28 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	91.6	2.1	1235.05	0.28
2	91.4	1.8	1235.05	0.28
3	90.9	1.2	1235.05	0.28

Notes:

- Section length is 1231.588 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Note that section overrun was not measured to fine-tune the estimate of section length.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.792	0.975	0.789	0.501	0.490	0.488	0.474
2	0.791	0.974	0.782	0.502	0.489	0.485	0.469
3	0.792	0.978	0.788	0.483	0.474	0.473	0.461
Ave.	0.792	0.976	0.786	0.496	0.485	0.482	0.468

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.946	0.715	0.067	0.064	0.064	0.060
2	0.946	0.712	0.067	0.063	0.063	0.058
3	0.950	0.714	0.065	0.062	0.062	0.059
Ave.	0.948	0.713	0.066	0.063	0.063	0.059

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.998	0.991	0.986	0.981	0.979	0.978
1	3	0.991	0.996	0.996	0.975	0.983	0.982	0.982
2	3	0.990	0.995	0.989	0.978	0.990	0.990	0.990
Average		0.993	0.996	0.992	0.980	0.985	0.984	0.983

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.999	0.995	0.971	0.966	0.963	0.963
1	3	0.995	0.989	0.973	0.983	0.983	0.982
2	3	0.995	0.986	0.984	0.977	0.976	0.976
Average		0.997	0.990	0.976	0.975	0.974	0.974

Auxiliary Information:

- The weather was very similar to what we experienced while collecting data for the other test sections. The temperature was in the forties and there was very light, sporadic rain.
- The pavement was dry and free of debris.
- The temporary line that was used for this test section was no longer visible, so Greg and I measured 10 1/16" to the right of the inverted line and laid out a chalk line.
- Tom collected data for the first and third runs (33-1 and 33-3); Greg collected data for the second run (33-2).

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal
Date: 10/22/2009
Device: ARRB Walking Profiler
Operator(s): Minnesota DOT, Tom Nordstrum and Greg Schneider
Recording Interval: 0.7917 ft
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.627	0.678
Long (elev.)	0.879	0.869
Medium (elev.)	0.634	0.735
Short (elev.)	0.381	0.392
Long (slope)	0.855	0.869
Medium (slope)	0.475	0.536
Short (slope)	0.336	0.019

Result for Longitudinal Distance:

Error in longitudinal distance was 0.20-0.68 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	144.7	24.2	497.98	0.36
2	133.2	14.3	498.77	0.52
3	131.9	13.1	497.19	0.20
4	131.5	12.8	499.56	0.68
5	130.3	11.8	497.19	0.20
1-4	117.0	0.4	—	—
2-5	120.8	3.6	—	—

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Note that section overrun was not measured to fine-tune the estimate of section length.
- Runs 4 and 5 offset by half the foot spacing.
- Run 1-4 was generated by combining offset runs 1 and 4.
- Run 2-5 was generated by combining offset runs 2 and 5.
- Using the meshed runs, the Results for Profile change to:

Waveband	Repeatability Score*	Accuracy Score
IRI	0.713	0.792
Long (elev.)	0.955	0.976
Medium (elev.)	0.750	0.786
Short (elev.)	0.241	0.483
Long (slope)	0.958	0.948
Medium (slope)	0.528	0.713
Short (slope)	0.287	0.063

* Based on only 1 comparison.

Detailed Accuracy Scores, Conventional Runs:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.556	0.846	0.555	0.406	0.397	0.397	0.397
2	0.654	0.828	0.721	0.359	0.381	0.381	0.381
3	0.738	0.863	0.817	0.352	0.348	0.348	0.348
4	0.669	0.888	0.734	0.474	0.466	0.466	0.466
5	0.774	0.922	0.848	0.372	0.368	0.368	0.368
Ave.	0.678	0.869	0.735	0.393	0.392	0.392	0.392

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.868	0.386	0.017	0.017	0.017	0.017
2	0.866	0.496	0.021	0.020	0.020	0.020
3	0.826	0.605	0.022	0.021	0.021	0.021
4	0.888	0.537	0.022	0.021	0.021	0.021
5	0.895	0.656	0.019	0.018	0.018	0.018
Ave.	0.869	0.536	0.020	0.019	0.019	0.019

Detailed Repeatability Scores, Conventional Runs:

Run 1	Run 2	Cross Correlation by Waveband, Elevation						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.538	0.912	0.512	0.385	0.387	0.387	0.387
1	3	0.540	0.798	0.521	0.386	0.383	0.383	0.383
1	4	0.564	0.923	0.604	0.366	0.364	0.364	0.364
1	5	0.567	0.909	0.558	0.301	0.362	0.362	0.362
2	3	0.670	0.783	0.664	0.382	0.385	0.385	0.385
2	4	0.626	0.900	0.662	0.304	0.306	0.306	0.306
2	5	0.654	0.878	0.672	0.464	0.456	0.456	0.456
3	4	0.681	0.846	0.674	0.428	0.425	0.425	0.425
3	5	0.757	0.881	0.745	0.341	0.323	0.324	0.324
4	5	0.678	0.957	0.726	0.429	0.426	0.426	0.426
Average		0.627	0.879	0.634	0.379	0.382	0.382	0.382

Detailed Repeatability Scores, Conventional Runs (cont):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.875	0.346	0.339	0.334	0.334	0.334
1	3	0.795	0.388	0.397	0.403	0.403	0.403
1	4	0.906	0.396	0.293	0.276	0.276	0.276
1	5	0.852	0.405	0.304	0.286	0.286	0.286
2	3	0.791	0.548	0.352	0.356	0.356	0.356
2	4	0.916	0.414	0.255	0.266	0.266	0.266
2	5	0.841	0.516	0.395	0.392	0.392	0.392
3	4	0.812	0.564	0.365	0.357	0.357	0.357
3	5	0.889	0.622	0.294	0.269	0.269	0.269
4	5	0.875	0.554	0.411	0.406	0.406	0.406
Average		0.855	0.475	0.340	0.334	0.335	0.334

Detailed Accuracy Scores, Combined Files:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1-4	0.728	0.895	0.796	0.184	0.176	0.176	0.176
2-5	0.820	0.892	0.879	0.219	0.219	0.219	0.219
Ave.	0.792	0.976	0.786	0.496	0.485	0.482	0.468

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1-4	0.907	0.578	0.017	0.016	0.016	0.016
2-5	0.944	0.739	0.014	0.014	0.014	0.014
Ave.	0.948	0.713	0.066	0.063	0.063	0.059

Detailed Repeatability Scores, Combined Files:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1-4	2-5	0.713	0.955	0.750	0.238	0.242	0.242
Run 1		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.958	0.528	0.280	0.290	0.290	0.290

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 10/22/2009
Device: ARRB Walking Profiler
Operator(s): Minnesota DOT, Tom Nordstrum and Greg Schneider
Recording Interval: 0.7917 ft
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.931	0.901
Long (elev.)	0.998	0.993
Medium (elev.)	0.903	0.908
Short (elev.)	0.802	0.400
Long (slope)	0.995	0.987
Medium (slope)	0.862	0.807
Short (slope)	0.776	0.041

Result for Longitudinal Distance:

Error in longitudinal distance was 0.17-0.51 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	54.1	-2.0	462.35	0.17
2	54.2	-1.8	463.94	0.51
3	53.2	-3.6	462.35	0.17
4	53.0	-3.9	463.14	0.34
5	54.0	-2.1	462.35	0.17
1-4	52.2	-5.4	—	—

Notes:

- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Note that section overrun was not measured to fine-tune the estimate of section length.
- Run 4 was offset by half the foot spacing.
- Run 1-4 was generated by combining offset runs 1 and 4.
- Using the meshed runs, the Accuracy Scores change to:

Waveband	Accuracy Score*
IRI	0.895
Long (elev.)	0.997
Medium (elev.)	0.903
Short (elev.)	0.291
Long (slope)	0.992
Medium (slope)	0.779
Short (slope)	0.033

* Based on only 1 comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.919	0.994	0.931	0.400	0.400	0.400	0.400
2	0.890	0.987	0.842	0.412	0.412	0.412	0.412
3	0.902	0.996	0.917	0.391	0.391	0.391	0.391
4	0.888	0.994	0.923	0.388	0.388	0.388	0.388
5	0.907	0.994	0.926	0.411	0.410	0.409	0.409
Ave.	0.901	0.993	0.908	0.401	0.400	0.400	0.400

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.988	0.811	0.041	0.041	0.041	0.041
2	0.978	0.799	0.041	0.041	0.041	0.041
3	0.992	0.803	0.040	0.040	0.040	0.040
4	0.991	0.802	0.041	0.041	0.041	0.041
5	0.987	0.821	0.042	0.042	0.042	0.042
Ave.	0.987	0.807	0.041	0.041	0.041	0.041

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.918	0.996	0.842	0.831	0.831	0.831
1	3	0.956	0.999	0.943	0.914	0.913	0.913
1	4	0.936	0.999	0.951	0.711	0.711	0.710
1	5	0.949	0.999	0.945	0.855	0.853	0.852
2	3	0.908	0.996	0.839	0.789	0.787	0.786
2	4	0.880	0.996	0.852	0.620	0.619	0.619
2	5	0.911	0.997	0.837	0.791	0.789	0.789
3	4	0.954	0.999	0.934	0.788	0.788	0.787
3	5	0.964	0.999	0.954	0.923	0.922	0.922
4	5	0.936	0.999	0.931	0.804	0.804	0.804
Average		0.931	0.998	0.903	0.803	0.802	0.802

Detailed Repeatability Scores (cont):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.993	0.797	0.847	0.847	0.847	0.847
1	3	0.997	0.925	0.897	0.893	0.890	0.888
1	4	0.996	0.916	0.665	0.673	0.669	0.666
1	5	0.998	0.908	0.813	0.809	0.806	0.802
2	3	0.993	0.794	0.793	0.793	0.793	0.793
2	4	0.990	0.770	0.620	0.620	0.620	0.621
2	5	0.994	0.804	0.785	0.783	0.783	0.783
3	4	0.998	0.901	0.715	0.714	0.713	0.713
3	5	0.997	0.915	0.904	0.904	0.904	0.904
4	5	0.997	0.886	0.737	0.735	0.733	0.732
Average		0.995	0.862	0.778	0.777	0.776	0.775

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt
Date: 10/22/2009
Device: ARRB Walking Profiler
Operator(s): Minnesota DOT, Tom Nordstrum and Greg Schneider
Recording Interval: 0.7917 ft
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.960	0.923
Long (elev.)	0.977	0.937
Medium (elev.)	0.922	0.936
Short (elev.)	0.837	0.692
Long (slope)	0.952	0.938
Medium (slope)	0.924	0.913
Short (slope)	0.805	0.068

Result for Longitudinal Distance:

Error in longitudinal distance was 0.34 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	120.2	-6.1	166.26	-0.04
2	124.5	-2.8	167.05	0.43
3	124.5	-2.7	167.05	0.43
4	123.5	-3.6	167.05	0.43
5	125.9	-1.7	167.05	0.43

Notes:

- Section length is 166.326 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Note that section overrun was not measured to fine-tune the estimate of section length.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.906	0.969	0.958	0.641	0.641
2	0.921	0.944	0.872	0.747	0.747
3	0.932	0.925	0.921	0.710	0.710
4	0.922	0.924	0.949	0.664	0.664
5	0.934	0.921	0.982	0.696	0.696
Ave.	0.923	0.937	0.936	0.692	0.691

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Slope			
	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.993	0.860	0.065	0.065
2	0.894	0.920	0.073	0.073
3	0.930	0.922	0.069	0.069
4	0.934	0.922	0.063	0.063
5	0.941	0.938	0.069	0.069
Ave.	0.938	0.913	0.068	0.068

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation				
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.938	0.971	0.862	0.709	0.709
1	3	0.933	0.953	0.913	0.746	0.746
1	4	0.969	0.956	0.962	0.848	0.848
1	5	0.950	0.952	0.965	0.759	0.759
2	3	0.970	0.991	0.931	0.928	0.928
2	4	0.962	0.985	0.893	0.821	0.821
2	5	0.966	0.979	0.876	0.893	0.893
3	4	0.957	0.989	0.931	0.836	0.836
3	5	0.989	0.992	0.932	0.965	0.965
4	5	0.967	0.996	0.957	0.860	0.860
Average		0.960	0.977	0.922	0.837	0.837

Run 1	Run 2	Cross Correlation by Waveband, Slope				
		Long	Medium	Short, Seg. 1	Short, Seg. 2	
1	2	0.890	0.867	0.665	0.665	
1	3	0.930	0.852	0.694	0.694	
1	4	0.939	0.912	0.776	0.776	
1	5	0.947	0.886	0.703	0.703	
2	3	0.966	0.966	0.913	0.913	
2	4	0.947	0.939	0.811	0.811	
2	5	0.940	0.965	0.884	0.884	
3	4	0.985	0.925	0.808	0.808	
3	5	0.985	0.976	0.972	0.972	
4	5	0.991	0.953	0.824	0.827	
Average		0.952	0.924	0.805	0.805	

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining
Date: 10/22/2009
Device: ARRB Walking Profiler
Operator(s): Minnesota DOT, Tom Nordstrum and Greg Schneider
Recording Interval: 0.7917 ft
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average. Further, the sample interval is large, so only 1 point would be used.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.987	0.960
Long (elev.)	0.996	0.977
Medium (elev.)	0.988	0.922
Short (elev.)	0.960	0.837
Long (slope)	0.989	0.952
Medium (slope)	0.986	0.924
Short (slope)	0.962	0.805

Result for Longitudinal Distance:

Error in longitudinal distance was 0.28 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)	Percent Error
1	70.6	499.56	0.28
2	70.9	499.56	0.28
3	70.9	499.56	0.28
4	70.8	499.56	0.28
5	70.0	499.56	0.28

Notes:

- Section length is 498.175 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Note that section overrun was not measured to fine-tune the estimate of section length.
- The benchmark profile only covered 164.7 ft. Accuracy scores for the IRI waveband and the long waveband do not represent expected performance over a longer segment of road.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.948	0.816	0.913	0.502
2	0.979	0.799	0.921	0.492
3	0.964	0.801	0.930	0.474
4	0.948	0.788	0.936	0.475
5	0.958	0.818	0.917	0.478
Ave.	0.959	0.804	0.923	0.484

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.967	0.951	0.027
2	0.936	0.969	0.026
3	0.962	0.963	0.026
4	0.944	0.941	0.026
5	0.959	0.958	0.026
Ave.	0.954	0.956	0.026

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.985	0.995	0.984	0.969
1	3	0.995	0.994	0.984	0.943
1	4	0.991	0.998	0.980	0.959
1	5	0.988	0.996	0.989	0.952
2	3	0.985	0.997	0.992	0.947
2	4	0.988	0.994	0.989	0.954
2	5	0.976	0.999	0.991	0.941
3	4	0.991	0.993	0.992	0.977
3	5	0.989	0.998	0.992	0.988
4	5	0.982	0.994	0.986	0.976
Average		0.987	0.996	0.988	0.960

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.981	0.988	0.954
1	3	0.998	0.990	0.948
1	4	0.981	0.982	0.963
1	5	0.999	0.983	0.958
2	3	0.984	0.991	0.955
2	4	0.998	0.985	0.960
2	5	0.982	0.983	0.946
3	4	0.985	0.986	0.975
3	5	0.999	0.989	0.985
4	5	0.982	0.989	0.976
Average		0.989	0.986	0.962

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 10/21/2009, 17:40 – 20:04

Device: SurPro 3000

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 1 inch

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.969	0.955
Long (elev.)	0.994	0.985
Medium (elev.)	0.982	0.964
Short (elev.)	0.951	0.656
Long (slope)	0.997	0.984
Medium (slope)	0.960	0.935
Short (slope)	0.898	0.115

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.96 to -1.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	17:40	17:46	92.1	2.6	1219.92	-0.95
2	17:54	18:01	89.5	-0.4	1219.00	-1.02
3	18:09	18:16	90.9	1.2	1218.83	-1.04
4	18:24	18:31	89.5	-0.3	1219.08	-1.02
5	18:39	18:46	91.9	2.3	1218.75	-1.04
6	18:54	19:03	89.8	0.0	1219.00	-1.02
7	19:12	19:19	89.7	-0.2	1219.17	-1.01
8	19:27	19:34	89.4	-0.5	1219.42	-0.99
9	19:43	19:49	90.7	1.0	1219.17	-1.01
10	19:57	20:04	89.4	-0.4	1219.75	-0.96

Notes:

- Section length is 1231.588 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values derived from submitted data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.941	0.999	0.958	0.660	0.634	0.633	0.624
2	0.954	0.985	0.964	0.684	0.648	0.647	0.638
3	0.962	0.986	0.963	0.681	0.643	0.642	0.636
4	0.957	0.984	0.971	0.674	0.642	0.640	0.634
5	0.951	0.983	0.972	0.693	0.666	0.666	0.652
6	0.963	0.980	0.967	0.683	0.642	0.641	0.633
7	0.950	0.982	0.957	0.679	0.654	0.653	0.648
8	0.962	0.981	0.964	0.702	0.663	0.662	0.656
9	0.955	0.985	0.968	0.691	0.658	0.657	0.651
10	0.959	0.983	0.958	0.691	0.654	0.653	0.648
Ave.	0.955	0.985	0.964	0.684	0.650	0.649	0.642

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.989	0.933	0.122	0.115	0.115	0.108
2	0.985	0.928	0.123	0.118	0.117	0.109
3	0.984	0.936	0.119	0.114	0.113	0.107
4	0.984	0.934	0.120	0.111	0.111	0.108
5	0.983	0.948	0.117	0.114	0.114	0.109
6	0.983	0.939	0.127	0.116	0.116	0.113
7	0.983	0.923	0.117	0.111	0.112	0.109
8	0.980	0.941	0.127	0.119	0.118	0.113
9	0.985	0.932	0.120	0.112	0.111	0.107
10	0.982	0.936	0.121	0.114	0.114	0.107
Ave.	0.984	0.935	0.121	0.114	0.114	0.109

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.951	0.984	0.986	0.934	0.949	0.948
1	3	0.954	0.985	0.985	0.952	0.960	0.960
1	4	0.956	0.984	0.987	0.919	0.928	0.927
1	5	0.969	0.983	0.973	0.918	0.927	0.927
1	6	0.957	0.980	0.986	0.906	0.922	0.922
1	7	0.947	0.981	0.979	0.924	0.930	0.930
1	8	0.955	0.980	0.983	0.901	0.913	0.915
1	9	0.953	0.985	0.980	0.906	0.915	0.915
1	10	0.955	0.982	0.978	0.918	0.928	0.926
2	3	0.970	0.999	0.988	0.976	0.977	0.977
2	4	0.988	0.999	0.988	0.972	0.969	0.969
2	5	0.950	0.999	0.974	0.969	0.965	0.965
2	6	0.986	0.995	0.994	0.955	0.954	0.954
2	7	0.973	0.997	0.988	0.965	0.959	0.959
2	8	0.986	0.996	0.992	0.957	0.954	0.954
2	9	0.970	0.999	0.982	0.949	0.944	0.944
2	10	0.990	0.998	0.987	0.958	0.956	0.956
3	4	0.972	0.998	0.985	0.957	0.957	0.948
3	5	0.956	0.998	0.973	0.951	0.952	0.952
3	6	0.975	0.994	0.987	0.943	0.948	0.948
3	7	0.964	0.996	0.980	0.957	0.956	0.940
3	8	0.974	0.995	0.984	0.943	0.945	0.945
3	9	0.970	0.999	0.980	0.941	0.941	0.941
3	10	0.972	0.997	0.979	0.958	0.960	0.960
4	5	0.952	0.999	0.980	0.957	0.957	0.960
4	6	0.989	0.996	0.988	0.962	0.965	0.965
4	7	0.973	0.997	0.980	0.964	0.961	0.954
4	8	0.990	0.997	0.985	0.943	0.945	0.945
4	9	0.973	0.999	0.988	0.946	0.945	0.947
4	10	0.992	0.999	0.980	0.956	0.957	0.962
5	6	0.955	0.996	0.974	0.958	0.958	0.953
5	7	0.947	0.998	0.967	0.963	0.965	0.963
5	8	0.953	0.997	0.970	0.963	0.964	0.972
5	9	0.951	0.998	0.977	0.952	0.950	0.950
5	10	0.953	0.999	0.966	0.959	0.960	0.961
6	7	0.979	0.998	0.987	0.963	0.966	0.967
6	8	0.991	0.999	0.992	0.947	0.945	0.941
6	9	0.976	0.995	0.982	0.964	0.962	0.962
6	10	0.990	0.997	0.987	0.971	0.968	0.968
7	8	0.977	0.999	0.985	0.944	0.951	0.960
7	9	0.965	0.996	0.975	0.956	0.958	0.968
7	10	0.976	0.999	0.979	0.963	0.966	0.966
8	9	0.974	0.995	0.978	0.958	0.960	0.960
8	10	0.990	0.998	0.990	0.954	0.957	0.961
9	10	0.973	0.997	0.974	0.969	0.969	0.970
Average		0.969	0.994	0.982	0.950	0.952	0.952

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.994	0.938	0.932	0.934	0.934	0.931
1	3	0.993	0.940	0.943	0.943	0.943	0.942
1	4	0.993	0.946	0.838	0.838	0.838	0.829
1	5	0.992	0.955	0.913	0.911	0.911	0.907
1	6	0.991	0.945	0.802	0.805	0.805	0.797
1	7	0.992	0.933	0.900	0.900	0.900	0.892
1	8	0.989	0.945	0.856	0.858	0.858	0.854
1	9	0.993	0.942	0.880	0.879	0.879	0.872
1	10	0.991	0.944	0.863	0.868	0.868	0.860
2	3	0.999	0.961	0.932	0.931	0.931	0.930
2	4	0.999	0.981	0.901	0.899	0.899	0.893
2	5	0.998	0.934	0.955	0.952	0.952	0.950
2	6	0.998	0.981	0.854	0.857	0.857	0.851
2	7	0.998	0.962	0.935	0.933	0.933	0.926
2	8	0.995	0.979	0.897	0.898	0.898	0.895
2	9	0.999	0.958	0.917	0.915	0.915	0.910
2	10	0.997	0.983	0.888	0.892	0.892	0.886
3	4	0.999	0.967	0.874	0.875	0.874	0.865
3	5	0.999	0.941	0.905	0.905	0.905	0.905
3	6	0.998	0.967	0.837	0.842	0.842	0.833
3	7	0.998	0.954	0.924	0.924	0.924	0.929
3	8	0.996	0.969	0.888	0.890	0.890	0.885
3	9	0.999	0.960	0.919	0.919	0.919	0.911
3	10	0.998	0.966	0.909	0.915	0.915	0.908
4	5	0.999	0.939	0.901	0.904	0.904	0.898
4	6	0.999	0.987	0.902	0.907	0.907	0.906
4	7	0.999	0.966	0.919	0.919	0.919	0.918
4	8	0.996	0.985	0.903	0.905	0.905	0.908
4	9	0.999	0.964	0.935	0.935	0.935	0.933
4	10	0.998	0.988	0.913	0.917	0.917	0.915
5	6	0.999	0.941	0.836	0.843	0.843	0.837
5	7	0.999	0.930	0.924	0.925	0.925	0.919
5	8	0.996	0.941	0.901	0.903	0.903	0.902
5	9	0.998	0.938	0.907	0.908	0.908	0.903
5	10	0.998	0.940	0.857	0.864	0.864	0.858
6	7	0.999	0.969	0.878	0.883	0.883	0.882
6	8	0.997	0.987	0.877	0.882	0.882	0.875
6	9	0.998	0.965	0.895	0.900	0.900	0.898
6	10	0.999	0.988	0.918	0.917	0.917	0.916
7	8	0.997	0.971	0.882	0.885	0.885	0.886
7	9	0.998	0.952	0.949	0.949	0.949	0.950
7	10	0.999	0.968	0.916	0.920	0.920	0.919
8	9	0.995	0.965	0.885	0.888	0.888	0.888
8	10	0.998	0.985	0.901	0.900	0.900	0.901
9	10	0.997	0.963	0.926	0.932	0.932	0.930
Average		0.997	0.960	0.897	0.899	0.899	0.896

Auxiliary Information:

- Bob Orthmeyer observed the runs.
- Operator ran a check on the system overnight after difficulties on 10/20. Set up a test run in one of the large truck bays at the MnROAD facility. Used an old version of their firmware and compared to the new version that was being used on October 20th. The old version did not act up and very good correlation. ICC will be using the older version of firmware for the remainder of the evaluation.
- Worked will work through the rain. The section was not swept 10/21 and has leaf debris and earthworms over the section. As a team, second person uses umbrella to protect operator and device and also remove debris from the area of interest. Operator is using outrigger with wheel on right side of device and outrigger bar on the left side of device to follow the painted line of interest instead of trying to maintain a chalk line.
- Thursday October 22, 2009: Vendor is not satisfied with results from rain collected data. One of the operators was unfamiliar with the outrigger with the wheel attached. Vendor was unable to use a chalk line because of the rain. Is attempting to rerun this section five more times with the first run starting at 9:21PM. Made 6 more runs, not analyzed here.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 10/20/2009, 10:18 – 14:14

Device: SurPro 3000

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 1 inch

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.954	0.930
Long (elev.)	0.992	0.909
Medium (elev.)	0.961	0.911
Short (elev.)	0.959	0.551
Long (slope)	0.989	0.896
Medium (slope)	0.927	0.916
Short (slope)	0.904	0.051

Result for Longitudinal Distance:

Error in longitudinal distance ranged from 0.50 to 0.87 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	10:18	10:42	107.9	-7.4	498.92	0.55
2	10:44	11:09	108.3	-7.1	499.50	0.67
3	11:11	11:34	109.0	-6.5	498.75	0.52
4	11:35	11:59	110.9	-4.8	499.58	0.68
5	12:01	12:23	109.4	-6.2	498.67	0.50
6	12:24	12:47	111.8	-4.1	500.50	0.87
7	12:49	13:13	111.2	-4.6	498.50	0.47
8	13:14	13:38	108.1	-7.2	500.08	0.79
9	13:40	14:01	112.1	-3.8	498.50	0.47
10	14:03	14:25	111.0	-4.7	500.08	0.79

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values derived from submitted data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.932	0.914	0.905	0.542	0.535	0.536	0.536
2	0.916	0.901	0.889	0.555	0.547	0.547	0.547
3	0.923	0.907	0.904	0.554	0.545	0.545	0.545
4	0.940	0.926	0.929	0.557	0.549	0.549	0.549
5	0.928	0.911	0.914	0.555	0.550	0.550	0.550
6	0.937	0.897	0.920	0.542	0.537	0.537	0.537
7	0.937	0.899	0.901	0.566	0.557	0.558	0.559
8	0.923	0.919	0.905	0.546	0.541	0.541	0.541
9	0.924	0.907	0.916	0.581	0.572	0.572	0.571
10	0.937	0.914	0.925	0.560	0.554	0.554	0.554
Ave.	0.930	0.909	0.911	0.556	0.549	0.549	0.549

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.898	0.918	0.062	0.031	0.031	0.031
2	0.881	0.916	0.028	0.029	0.029	0.029
3	0.891	0.914	0.064	0.031	0.031	0.031
4	0.914	0.932	0.063	0.063	0.063	0.063
5	0.894	0.925	0.060	0.060	0.060	0.060
6	0.890	0.917	0.064	0.027	0.027	0.065
7	0.889	0.922	0.063	0.064	0.064	0.064
8	0.901	0.906	0.062	0.063	0.063	0.063
9	0.896	0.896	0.061	0.061	0.061	0.061
10	0.906	0.916	0.062	0.039	0.039	0.039
Ave.	0.896	0.916	0.059	0.047	0.047	0.051

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.946	0.990	0.959	0.938	0.938	0.938
1	3	0.962	0.995	0.978	0.958	0.962	0.962
1	4	0.968	0.992	0.960	0.955	0.955	0.955
1	5	0.964	0.998	0.974	0.952	0.950	0.950
1	6	0.956	0.984	0.962	0.947	0.946	0.946
1	7	0.958	0.986	0.975	0.920	0.921	0.921
1	8	0.951	0.999	0.968	0.969	0.968	0.968
1	9	0.955	0.994	0.969	0.926	0.928	0.928
1	10	0.954	0.999	0.946	0.938	0.936	0.936
2	3	0.960	0.997	0.963	0.970	0.967	0.967
2	4	0.940	0.979	0.936	0.978	0.978	0.978
2	5	0.950	0.995	0.953	0.979	0.981	0.981
2	6	0.934	0.996	0.938	0.962	0.964	0.964
2	7	0.936	0.997	0.960	0.958	0.958	0.958
2	8	0.961	0.988	0.951	0.963	0.964	0.964
2	9	0.923	0.998	0.943	0.950	0.951	0.951
2	10	0.937	0.992	0.926	0.965	0.963	0.963
3	4	0.952	0.984	0.953	0.981	0.978	0.978
3	5	0.966	0.999	0.970	0.979	0.974	0.974
3	6	0.943	0.992	0.953	0.963	0.966	0.966
3	7	0.956	0.993	0.980	0.954	0.951	0.951
3	8	0.968	0.992	0.970	0.962	0.966	0.966
3	9	0.938	1.000	0.960	0.956	0.955	0.955
3	10	0.950	0.996	0.944	0.964	0.959	0.959
4	5	0.960	0.987	0.965	0.985	0.984	0.984
4	6	0.974	0.974	0.976	0.974	0.975	0.975
4	7	0.962	0.974	0.950	0.957	0.957	0.957
4	8	0.951	0.994	0.958	0.968	0.969	0.969
4	9	0.967	0.983	0.974	0.957	0.959	0.959
4	10	0.974	0.989	0.974	0.974	0.972	0.972
5	6	0.956	0.990	0.968	0.967	0.966	0.966
5	7	0.953	0.990	0.969	0.954	0.957	0.957
5	8	0.962	0.995	0.974	0.967	0.967	0.967
5	9	0.949	0.999	0.979	0.955	0.959	0.959
5	10	0.955	0.999	0.955	0.970	0.971	0.971
6	7	0.955	0.999	0.955	0.940	0.943	0.943
6	8	0.947	0.982	0.962	0.965	0.964	0.964
6	9	0.953	0.992	0.973	0.933	0.936	0.936
6	10	0.969	0.986	0.967	0.954	0.955	0.955
7	8	0.948	0.983	0.972	0.934	0.936	0.936
7	9	0.953	0.994	0.963	0.977	0.977	0.977
7	10	0.958	0.987	0.945	0.953	0.956	0.956
8	9	0.930	0.992	0.961	0.934	0.937	0.937
8	10	0.950	0.998	0.949	0.959	0.959	0.959
9	10	0.961	0.996	0.960	0.958	0.963	0.963
Average		0.954	0.992	0.961	0.958	0.959	0.959

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.982	0.929	0.895	0.892	0.892	0.892
1	3	0.992	0.942	0.926	0.923	0.923	0.923
1	4	0.985	0.954	0.891	0.892	0.892	0.892
1	5	0.997	0.948	0.921	0.921	0.921	0.921
1	6	0.991	0.926	0.861	0.863	0.863	0.863
1	7	0.989	0.923	0.893	0.894	0.894	0.894
1	8	0.998	0.917	0.878	0.877	0.877	0.877
1	9	0.998	0.919	0.936	0.940	0.940	0.940
1	10	0.993	0.918	0.887	0.887	0.887	0.887
2	3	0.990	0.944	0.919	0.917	0.917	0.917
2	4	0.966	0.932	0.924	0.927	0.927	0.927
2	5	0.986	0.928	0.934	0.937	0.937	0.937
2	6	0.989	0.910	0.869	0.868	0.868	0.868
2	7	0.994	0.910	0.913	0.912	0.912	0.912
2	8	0.979	0.940	0.914	0.917	0.917	0.917
2	9	0.985	0.889	0.905	0.903	0.903	0.903
2	10	0.974	0.913	0.916	0.915	0.915	0.915
3	4	0.977	0.936	0.918	0.920	0.920	0.920
3	5	0.996	0.941	0.920	0.922	0.922	0.922
3	6	0.998	0.912	0.874	0.870	0.870	0.870
3	7	0.997	0.928	0.935	0.932	0.932	0.932
3	8	0.990	0.941	0.890	0.892	0.892	0.892
3	9	0.995	0.900	0.933	0.931	0.931	0.931
3	10	0.983	0.923	0.904	0.905	0.905	0.905
4	5	0.981	0.951	0.933	0.933	0.933	0.933
4	6	0.976	0.950	0.890	0.889	0.889	0.889
4	7	0.973	0.938	0.916	0.917	0.917	0.917
4	8	0.986	0.929	0.930	0.930	0.930	0.930
4	9	0.982	0.930	0.909	0.909	0.909	0.909
4	10	0.991	0.943	0.911	0.912	0.912	0.912
5	6	0.996	0.933	0.872	0.872	0.872	0.872
5	7	0.993	0.925	0.908	0.908	0.908	0.908
5	8	0.994	0.929	0.914	0.915	0.915	0.915
5	9	0.999	0.923	0.931	0.933	0.933	0.933
5	10	0.989	0.930	0.909	0.911	0.911	0.911
6	7	0.996	0.930	0.892	0.889	0.889	0.889
6	8	0.990	0.914	0.866	0.867	0.867	0.867
6	9	0.994	0.918	0.879	0.877	0.877	0.877
6	10	0.984	0.947	0.866	0.863	0.863	0.863
7	8	0.987	0.909	0.890	0.891	0.891	0.891
7	9	0.991	0.923	0.927	0.925	0.925	0.925
7	10	0.981	0.935	0.895	0.895	0.895	0.895
8	9	0.995	0.882	0.897	0.897	0.897	0.897
8	10	0.994	0.914	0.899	0.898	0.898	0.898
9	10	0.990	0.930	0.906	0.906	0.906	0.906
Average		0.989	0.927	0.904	0.904	0.904	0.904

Auxiliary Information:

- Bob Orthmeyer observed the runs.
- Operator conducted DMI check on 300 foot section of 1000 foot DMI course. Completed DMI check at 9:49 using two runs and a third closed loop run.
- Operators did not bring chalk line and did not bring tape measure. Used string line provided by MnDOT and tape measure provided by MnDOT.
- Felt like low 40s, mostly cloudy, wind at SE < 10 mph (estimate).

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 10/22/2009, 17:40 – 20:04
Device: SurPro 3000
Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung
Recording Interval: 1 inch

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.957	0.930
Long (elev.)	0.998	0.998
Medium (elev.)	0.908	0.880
Short (elev.)	0.954	0.608
Long (slope)	0.997	0.996
Medium (slope)	0.900	0.853
Short (slope)	0.870	0.087

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.58 to -0.63 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	17:40	17:46	54.8	-0.6	458.67	-0.63
2	17:54	18:01	54.7	-0.9	458.83	-0.60
3	18:09	18:16	53.4	-3.3	458.75	-0.62
4	18:24	18:31	53.1	-3.8	458.83	-0.60
5	18:39	18:46	54.7	-0.9	458.92	-0.58
6	18:54	19:03	54.2	-1.8	458.92	-0.58
7	19:12	19:19	54.2	-1.8	458.92	-0.58
8	19:27	19:34	53.2	-3.5	459.00	-0.56
9	19:43	19:49	54.4	-1.4	458.83	-0.60
10	19:57	20:04	53.6	-2.9	459.00	-0.56

Notes:

- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.949	0.997	0.934	0.619	0.619	0.619	0.619
2	0.935	0.998	0.850	0.613	0.613	0.613	0.613
3	0.925	0.999	0.884	0.598	0.598	0.598	0.598
4	0.916	0.997	0.835	0.602	0.602	0.602	0.602
5	0.932	0.999	0.873	0.608	0.608	0.608	0.608
6	0.934	0.998	0.888	0.621	0.621	0.621	0.621
7	0.928	0.999	0.891	0.593	0.593	0.593	0.593
8	0.924	0.999	0.892	0.615	0.615	0.615	0.615
9	0.931	0.999	0.887	0.602	0.602	0.602	0.602
10	0.925	0.996	0.869	0.608	0.608	0.608	0.608
Ave.	0.930	0.998	0.880	0.608	0.608	0.608	0.608

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.994	0.890	0.086	0.089	0.089	0.089
2	0.996	0.837	0.088	0.096	0.096	0.096
3	0.996	0.865	0.085	0.085	0.085	0.085
4	0.996	0.823	0.084	0.083	0.083	0.083
5	0.997	0.849	0.087	0.083	0.087	0.083
6	0.997	0.866	0.082	0.090	0.082	0.090
7	0.998	0.843	0.082	0.079	0.079	0.079
8	0.997	0.856	0.099	0.099	0.099	0.099
9	0.997	0.853	0.083	0.086	0.086	0.086
10	0.996	0.847	0.087	0.081	0.081	0.081
Ave.	0.996	0.853	0.086	0.087	0.087	0.087

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.967	0.999	0.889	0.959	0.959	0.959
1	3	0.953	0.998	0.904	0.956	0.956	0.956
1	4	0.950	0.999	0.880	0.962	0.962	0.962
1	5	0.968	0.998	0.908	0.970	0.970	0.970
1	6	0.971	1.000	0.935	0.965	0.965	0.965
1	7	0.960	0.998	0.926	0.944	0.944	0.944
1	8	0.954	0.998	0.923	0.952	0.952	0.952
1	9	0.962	0.996	0.918	0.965	0.965	0.965
1	10	0.954	0.999	0.890	0.975	0.975	0.975
2	3	0.949	0.998	0.882	0.917	0.917	0.917
2	4	0.941	0.999	0.903	0.941	0.941	0.941
2	5	0.964	0.999	0.922	0.960	0.960	0.960
2	6	0.962	0.999	0.885	0.965	0.965	0.965
2	7	0.959	0.999	0.905	0.947	0.947	0.947
2	8	0.961	0.999	0.893	0.957	0.957	0.957
2	9	0.961	0.997	0.887	0.948	0.947	0.948
2	10	0.958	0.999	0.894	0.958	0.958	0.958
3	4	0.963	0.998	0.872	0.971	0.971	0.971
3	5	0.956	0.999	0.913	0.950	0.950	0.950
3	6	0.945	0.999	0.903	0.936	0.936	0.936
3	7	0.973	1.000	0.945	0.966	0.966	0.966
3	8	0.958	1.000	0.904	0.919	0.920	0.919
3	9	0.963	0.999	0.941	0.969	0.969	0.969
3	10	0.962	0.997	0.902	0.955	0.955	0.955
4	5	0.944	0.998	0.904	0.947	0.947	0.947
4	6	0.941	0.999	0.880	0.938	0.938	0.938
4	7	0.961	0.998	0.879	0.964	0.965	0.964
4	8	0.950	0.998	0.854	0.936	0.936	0.936
4	9	0.950	0.996	0.877	0.970	0.970	0.970
4	10	0.954	0.999	0.882	0.956	0.956	0.956
5	6	0.952	0.999	0.915	0.959	0.959	0.959
5	7	0.962	1.000	0.930	0.960	0.960	0.960
5	8	0.953	1.000	0.906	0.940	0.940	0.940
5	9	0.967	0.999	0.915	0.965	0.965	0.965
5	10	0.958	0.998	0.927	0.978	0.978	0.978
6	7	0.946	0.999	0.924	0.938	0.938	0.938
6	8	0.952	0.999	0.934	0.964	0.964	0.964
6	9	0.956	0.997	0.925	0.950	0.950	0.950
6	10	0.954	0.999	0.916	0.960	0.960	0.960
7	8	0.965	1.000	0.932	0.923	0.923	0.923
7	9	0.966	0.999	0.955	0.966	0.966	0.966
7	10	0.965	0.998	0.924	0.959	0.959	0.959
8	9	0.953	0.999	0.920	0.934	0.934	0.934
8	10	0.969	0.998	0.930	0.945	0.945	0.945
9	10	0.956	0.995	0.900	0.967	0.967	0.967
Average		0.957	0.998	0.908	0.954	0.954	0.954

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.905	0.894	0.894	0.894	0.894
1	3	0.990	0.921	0.838	0.838	0.838	0.838
1	4	0.996	0.892	0.849	0.849	0.849	0.849
1	5	0.997	0.919	0.901	0.901	0.901	0.901
1	6	0.997	0.931	0.899	0.899	0.899	0.899
1	7	0.996	0.909	0.826	0.826	0.827	0.827
1	8	0.994	0.920	0.919	0.919	0.919	0.919
1	9	0.995	0.915	0.894	0.894	0.894	0.894
1	10	0.997	0.907	0.897	0.897	0.897	0.897
2	3	0.991	0.878	0.754	0.754	0.754	0.754
2	4	0.995	0.892	0.815	0.815	0.814	0.814
2	5	0.998	0.895	0.905	0.905	0.905	0.905
2	6	0.997	0.879	0.876	0.876	0.876	0.876
2	7	0.997	0.923	0.838	0.838	0.838	0.838
2	8	0.995	0.904	0.916	0.916	0.916	0.916
2	9	0.996	0.887	0.854	0.854	0.854	0.854
2	10	0.997	0.891	0.862	0.862	0.862	0.862
3	4	0.996	0.879	0.917	0.916	0.917	0.917
3	5	0.995	0.907	0.810	0.810	0.810	0.810
3	6	0.996	0.891	0.858	0.858	0.858	0.858
3	7	0.996	0.911	0.877	0.877	0.877	0.877
3	8	0.997	0.902	0.808	0.808	0.808	0.808
3	9	0.996	0.929	0.878	0.878	0.878	0.878
3	10	0.994	0.908	0.879	0.879	0.879	0.879
4	5	0.998	0.884	0.798	0.798	0.798	0.798
4	6	0.998	0.867	0.857	0.857	0.857	0.857
4	7	0.998	0.910	0.895	0.895	0.895	0.895
4	8	0.997	0.864	0.849	0.849	0.849	0.849
4	9	0.997	0.884	0.880	0.880	0.880	0.880
4	10	0.998	0.883	0.882	0.882	0.882	0.882
5	6	0.999	0.881	0.887	0.887	0.887	0.887
5	7	0.999	0.913	0.844	0.844	0.844	0.844
5	8	0.998	0.897	0.884	0.884	0.884	0.884
5	9	0.998	0.919	0.870	0.870	0.870	0.870
5	10	0.998	0.912	0.885	0.885	0.885	0.885
6	7	0.999	0.868	0.868	0.868	0.868	0.868
6	8	0.998	0.901	0.891	0.891	0.891	0.891
6	9	0.998	0.894	0.907	0.907	0.907	0.907
6	10	0.999	0.899	0.912	0.912	0.912	0.912
7	8	0.998	0.897	0.815	0.815	0.815	0.815
7	9	0.999	0.920	0.895	0.895	0.895	0.895
7	10	0.998	0.901	0.908	0.907	0.908	0.908
8	9	0.998	0.901	0.863	0.863	0.863	0.863
8	10	0.997	0.927	0.869	0.869	0.869	0.869
9	10	0.997	0.900	0.938	0.938	0.938	0.938
Average		0.997	0.900	0.870	0.870	0.870	0.870

Auxiliary Information:

- Bob Orthmeyer observed the runs.
- Used an existing chalk line from previous vendor, reapplied chalk line in spots. Operators used an outrigger wheel on right side of device for balance. Using two operators.
- The crew did 13 runs on 10/20. The device froze up many times until the crew gave up. The chalk line also faded often due to rain. Messed with firmware to try to sort out the problem. On 10/22, the crew performed 4 more runs in the morning until UMTRI took over the site. The crew returned in the afternoon for 10 more runs. Used the old firmware.

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 10/23/2009, 16:57 – 18:50

Device: SurPro 3000

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 1 inch

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.976	0.969
Long (elev.)	0.967	0.958
Medium (elev.)	0.976	0.974
Short (elev.)	0.952	0.845
Long (slope)	0.969	0.963
Medium (slope)	0.975	0.963
Short (slope)	0.896	0.204

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.79 to -0.81 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
2	17:10	17:17	77.9	1.2	486.25	-0.79
3	17:20	17:27	78.8	2.3	486.25	-0.79
4	17:30	17:37	79.3	2.9	486.17	-0.81
5	17:40	17:47	78.8	2.2	486.17	-0.81
6	17:49	17:56	77.2	0.2	486.25	-0.79
7	17:59	18:04	78.0	1.2	486.17	-0.81
8	18:12	18:18	77.5	0.6	486.17	-0.81
9	18:21	18:28	79.2	2.8	486.17	-0.81
10	18:38	18:44	77.2	0.2	486.17	-0.81
11	18:47	—	78.8	2.2	486.25	-0.79

Notes:

- Section length is 490.119 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.971	0.973	0.979	0.843	0.843	0.843	0.843
3	0.959	0.983	0.971	0.866	0.866	0.866	0.866
4	0.957	0.980	0.963	0.839	0.839	0.839	0.839
5	0.968	0.937	0.977	0.841	0.841	0.841	0.841
6	0.980	0.934	0.984	0.845	0.845	0.845	0.845
7	0.971	0.967	0.977	0.823	0.823	0.823	0.823
8	0.978	0.949	0.985	0.856	0.856	0.856	0.856
9	0.957	0.954	0.967	0.858	0.858	0.858	0.858
10	0.971	0.932	0.958	0.856	0.856	0.856	0.856
11	0.974	0.969	0.976	0.826	0.826	0.826	0.826
Ave.	0.969	0.958	0.974	0.845	0.845	0.845	0.845

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.967	0.960	0.196	0.196	0.196	0.196
3	0.983	0.967	0.210	0.210	0.210	0.210
4	0.989	0.951	0.202	0.202	0.202	0.202
5	0.946	0.964	0.206	0.206	0.206	0.206
6	0.945	0.972	0.210	0.210	0.210	0.210
7	0.976	0.969	0.204	0.204	0.204	0.204
8	0.949	0.968	0.207	0.207	0.207	0.206
9	0.963	0.947	0.205	0.205	0.205	0.205
10	0.933	0.960	0.204	0.203	0.203	0.203
11	0.979	0.972	0.198	0.198	0.198	0.198
Ave.	0.963	0.963	0.204	0.204	0.204	0.204

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
2	3	0.976	0.971	0.973	0.949	0.949	0.949
2	4	0.975	0.968	0.969	0.972	0.972	0.972
2	5	0.981	0.967	0.982	0.965	0.965	0.965
2	6	0.984	0.961	0.993	0.964	0.964	0.964
2	7	0.990	0.992	0.987	0.955	0.955	0.955
2	8	0.984	0.977	0.988	0.972	0.972	0.972
2	9	0.975	0.980	0.975	0.963	0.963	0.963
2	10	0.969	0.958	0.960	0.948	0.948	0.948
2	11	0.982	0.990	0.983	0.947	0.947	0.947
3	4	0.983	0.995	0.984	0.941	0.941	0.941
3	5	0.975	0.941	0.966	0.930	0.930	0.930
3	6	0.972	0.935	0.976	0.940	0.940	0.940
3	7	0.975	0.966	0.979	0.928	0.928	0.928
3	8	0.972	0.951	0.977	0.947	0.947	0.947
3	9	0.985	0.953	0.985	0.947	0.947	0.947
3	10	0.956	0.933	0.972	0.944	0.944	0.944
3	11	0.968	0.962	0.966	0.918	0.918	0.918
4	5	0.975	0.937	0.962	0.969	0.969	0.969
4	6	0.970	0.933	0.973	0.953	0.953	0.953
4	7	0.972	0.962	0.974	0.960	0.960	0.960
4	8	0.970	0.949	0.973	0.957	0.957	0.957
4	9	0.982	0.949	0.982	0.949	0.949	0.949
4	10	0.958	0.931	0.984	0.945	0.945	0.945
4	11	0.968	0.957	0.963	0.953	0.953	0.953
5	6	0.977	0.987	0.983	0.957	0.958	0.958
5	7	0.979	0.971	0.976	0.954	0.954	0.954
5	8	0.979	0.985	0.983	0.959	0.959	0.959
5	9	0.976	0.984	0.966	0.958	0.958	0.958
5	10	0.965	0.985	0.956	0.948	0.948	0.948
5	11	0.977	0.965	0.988	0.960	0.960	0.960
6	7	0.985	0.965	0.988	0.936	0.936	0.936
6	8	0.988	0.981	0.991	0.975	0.975	0.975
6	9	0.969	0.978	0.976	0.976	0.976	0.976
6	10	0.977	0.993	0.961	0.959	0.959	0.959
6	11	0.984	0.956	0.984	0.946	0.946	0.946
7	8	0.985	0.981	0.987	0.946	0.946	0.946
7	9	0.974	0.984	0.981	0.936	0.936	0.936
7	10	0.970	0.963	0.965	0.926	0.926	0.926
7	11	0.984	0.989	0.978	0.963	0.963	0.963
8	9	0.973	0.995	0.979	0.975	0.975	0.975
8	10	0.976	0.980	0.963	0.960	0.960	0.960
8	11	0.984	0.969	0.982	0.945	0.945	0.945
9	10	0.960	0.976	0.976	0.970	0.970	0.970
9	11	0.970	0.976	0.969	0.942	0.942	0.942
10	11	0.971	0.955	0.957	0.935	0.935	0.935
Average		0.976	0.967	0.976	0.952	0.952	0.952

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	3	0.960	0.983	0.869	0.869	0.869	0.869
2	4	0.974	0.975	0.889	0.889	0.889	0.889
2	5	0.979	0.983	0.895	0.895	0.895	0.895
2	6	0.977	0.984	0.855	0.855	0.855	0.855
2	7	0.986	0.982	0.890	0.890	0.890	0.890
2	8	0.979	0.984	0.906	0.906	0.906	0.906
2	9	0.995	0.972	0.913	0.913	0.913	0.913
2	10	0.961	0.979	0.856	0.856	0.856	0.856
2	11	0.974	0.969	0.892	0.892	0.892	0.892
3	4	0.985	0.969	0.922	0.923	0.922	0.922
3	5	0.943	0.978	0.883	0.884	0.883	0.883
3	6	0.941	0.986	0.880	0.880	0.880	0.880
3	7	0.969	0.981	0.909	0.910	0.909	0.909
3	8	0.943	0.985	0.897	0.897	0.897	0.897
3	9	0.957	0.968	0.861	0.861	0.861	0.861
3	10	0.925	0.974	0.884	0.884	0.884	0.884
3	11	0.972	0.969	0.890	0.890	0.890	0.890
4	5	0.956	0.972	0.896	0.896	0.896	0.896
4	6	0.955	0.971	0.899	0.899	0.899	0.899
4	7	0.983	0.966	0.919	0.919	0.919	0.919
4	8	0.958	0.972	0.911	0.910	0.911	0.911
4	9	0.971	0.983	0.880	0.880	0.880	0.880
4	10	0.941	0.978	0.900	0.900	0.900	0.900
4	11	0.986	0.957	0.895	0.895	0.895	0.895
5	6	0.988	0.979	0.895	0.895	0.895	0.895
5	7	0.968	0.975	0.899	0.899	0.899	0.899
5	8	0.991	0.983	0.933	0.932	0.933	0.933
5	9	0.981	0.969	0.909	0.908	0.909	0.909
5	10	0.974	0.979	0.896	0.896	0.896	0.896
5	11	0.960	0.967	0.919	0.919	0.919	0.919
6	7	0.965	0.988	0.878	0.878	0.878	0.878
6	8	0.994	0.984	0.898	0.898	0.898	0.898
6	9	0.978	0.967	0.889	0.889	0.889	0.889
6	10	0.982	0.973	0.891	0.891	0.891	0.891
6	11	0.955	0.976	0.895	0.895	0.895	0.895
7	8	0.968	0.981	0.902	0.902	0.902	0.902
7	9	0.984	0.964	0.866	0.866	0.866	0.866
7	10	0.951	0.971	0.895	0.895	0.895	0.895
7	11	0.986	0.976	0.899	0.899	0.899	0.899
8	9	0.981	0.973	0.916	0.916	0.916	0.916
8	10	0.981	0.979	0.900	0.900	0.900	0.900
8	11	0.956	0.970	0.924	0.925	0.924	0.924
9	10	0.965	0.978	0.893	0.892	0.893	0.893
9	11	0.973	0.955	0.913	0.913	0.913	0.913
10	11	0.941	0.963	0.910	0.910	0.910	0.910
Average		0.969	0.975	0.896	0.896	0.896	0.896

Auxiliary Information:

- Steve Karamihas observed the runs.
- The weather was cold, and ranged from steady to heavy rain.
- Loop closure was not performed.
- Operators began start-up procedures at 16:50 PM.
- Operators tried to place a chalk line, but the pavement was far too wet. Instead, they applied guide marks with a grease pencil and followed it using a laser guide on an outrigger (in runs 2-3). Run 1 was done without the laser. The operators asked not to include it because of poor lateral tracking. (This run was done by Erwin. Paul did the rest.)
- Run 8 was restarted due to poor lateral tracking.
- After run 8, the operators switched to using a head lamp (on Paul's forehead, pointed at the stripe) to help guide the device.
- During run 9, the sun had completely set.
- Run 10 included a false start because of darkness.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining
Date: 10/22/2009, 11:48 – 14:36
Device: SurPro 3000
Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung
Recording Interval: 1 inch
Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.987	0.975
Long (elev.)	0.987	0.824
Medium (elev.)	0.984	0.929
Short (elev.)	0.937	0.606
Long (slope)	0.995	0.975
Medium (slope)	0.983	0.976
Short (slope)	0.853	0.062

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -1.02 to -0.97 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Length (ft)	Percent Error
1	11:48	12:03	71.6	493.17	-1.00
2	13:04	12:19	72.5	493.25	-0.99
3	13:21	12:37	72.0	493.25	-0.99
4	13:40	12:55	72.2	493.25	-0.99
5	13:56	13:12	71.6	493.25	-0.99
6	13:14	13:28	72.2	493.33	-0.97
7	13:31	13:47	72.5	493.17	-1.00
8	13:48	14:02	72.8	493.33	-0.97
9	14:03	14:20	72.8	493.17	-1.00
10	14:21	14:36	71.9	493.08	-1.02

Notes:

- Section length is 498.175 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The benchmark profile only covered 164.7 ft. Accuracy scores for the IRI waveband and the long waveband do not represent expected performance over a longer segment of road.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.984	0.844	0.936	0.601
2	0.975	0.804	0.926	0.612
3	0.974	0.836	0.933	0.602
4	0.963	0.843	0.915	0.612
5	0.987	0.827	0.948	0.590
6	0.982	0.803	0.939	0.604
7	0.974	0.821	0.935	0.607
8	0.967	0.794	0.904	0.607
9	0.977	0.820	0.931	0.592
10	0.967	0.847	0.923	0.630
Ave.	0.975	0.824	0.929	0.606

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.984	0.966	0.050
2	0.965	0.986	0.065
3	0.980	0.986	0.063
4	0.976	0.974	0.056
5	0.979	0.964	0.052
6	0.970	0.974	0.072
7	0.978	0.984	0.062
8	0.962	0.973	0.054
9	0.976	0.981	0.065
10	0.979	0.970	0.078
Ave.	0.975	0.976	0.062

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.981	0.994	0.992	0.934
1	3	0.991	0.999	0.980	0.979
1	4	0.980	0.989	0.988	0.883
1	5	0.993	0.991	0.989	0.957
1	6	0.988	0.993	0.985	0.926
1	7	0.981	0.991	0.989	0.972
1	8	0.978	0.974	0.976	0.967
1	9	0.979	0.991	0.989	0.933
1	10	0.988	0.988	0.984	0.912
2	3	0.984	0.994	0.981	0.937
2	4	0.993	0.994	0.992	0.930
2	5	0.983	0.985	0.990	0.924
2	6	0.988	0.998	0.988	0.958
2	7	0.993	0.986	0.991	0.951
2	8	0.991	0.969	0.976	0.949
2	9	0.993	0.996	0.991	0.939
2	10	0.986	0.993	0.987	0.937
3	4	0.984	0.989	0.983	0.889
3	5	0.991	0.991	0.984	0.959
3	6	0.991	0.994	0.988	0.930
3	7	0.984	0.991	0.982	0.978
3	8	0.980	0.973	0.963	0.969
3	9	0.982	0.991	0.978	0.950
3	10	0.991	0.988	0.987	0.907
4	5	0.982	0.981	0.990	0.872
4	6	0.988	0.993	0.990	0.946
4	7	0.993	0.982	0.993	0.908
4	8	0.989	0.964	0.973	0.918
4	9	0.992	0.998	0.987	0.918
4	10	0.987	0.998	0.991	0.958
5	6	0.989	0.986	0.988	0.907
5	7	0.983	0.998	0.991	0.956
5	8	0.979	0.981	0.972	0.956
5	9	0.979	0.983	0.984	0.947
5	10	0.990	0.980	0.989	0.881
6	7	0.987	0.987	0.989	0.949
6	8	0.983	0.970	0.969	0.952
6	9	0.985	0.995	0.983	0.948
6	10	0.993	0.992	0.994	0.937
7	8	0.990	0.981	0.974	0.986
7	9	0.991	0.983	0.988	0.966
7	10	0.986	0.980	0.989	0.920
8	9	0.993	0.966	0.980	0.968
8	10	0.981	0.963	0.969	0.924
9	10	0.983	0.997	0.982	0.898
Average		0.987	0.987	0.984	0.937

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.996	0.973	0.843
1	3	0.995	0.989	0.930
1	4	0.991	0.976	0.732
1	5	0.997	0.989	0.906
1	6	0.990	0.983	0.778
1	7	0.995	0.972	0.943
1	8	0.996	0.971	0.890
1	9	0.999	0.974	0.835
1	10	0.991	0.981	0.771
2	3	0.998	0.978	0.862
2	4	0.997	0.989	0.805
2	5	0.998	0.978	0.852
2	6	0.996	0.984	0.825
2	7	0.998	0.992	0.868
2	8	0.990	0.989	0.890
2	9	0.998	0.992	0.889
2	10	0.996	0.985	0.813
3	4	0.998	0.979	0.765
3	5	0.999	0.990	0.936
3	6	0.997	0.987	0.804
3	7	0.999	0.975	0.943
3	8	0.989	0.973	0.917
3	9	0.997	0.978	0.883
3	10	0.997	0.985	0.786
4	5	0.996	0.979	0.753
4	6	0.999	0.987	0.926
4	7	0.998	0.988	0.787
4	8	0.985	0.985	0.825
4	9	0.993	0.991	0.831
4	10	0.999	0.988	0.908
5	6	0.995	0.986	0.786
5	7	0.998	0.976	0.941
5	8	0.991	0.975	0.903
5	9	0.998	0.976	0.894
5	10	0.995	0.985	0.759
6	7	0.998	0.982	0.824
6	8	0.984	0.979	0.856
6	9	0.993	0.984	0.854
6	10	0.999	0.992	0.903
7	8	0.988	0.990	0.937
7	9	0.997	0.991	0.894
7	10	0.998	0.982	0.793
8	9	0.994	0.988	0.928
8	10	0.984	0.979	0.822
9	10	0.992	0.984	0.791
Average		0.995	0.983	0.853

Auxiliary Information:

- Bob Orthmeyer observed the runs.
- Cloudy, 40 F, light breeze.
- Loop closure was performed on all runs.
- MnDOT swept the debris from site at 11:00 AM.
- Operators arrived at 11:30 and applied a chalk line 52 1/16 inch from fog line. Loose leaves still blowing across site occasionally.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 10/20/2009, 12:34 – 21:10

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.981	0.857
Long (elev.)	0.980	0.971
Medium (elev.)	0.983	0.921
Short (elev.)	0.914	0.307
Long (slope)	0.986	0.963
Medium (slope)	0.979	0.806
Short (slope)	0.810	0.033

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.96 to -1.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	12:34	13:06	82.8	-8.4	1218.6	-1.05
3	13:53	14:33	80.3	-11.8	1219.0	-1.02
4	14:37	15:15	80.8	-11.2	1218.8	-1.04
5	15:19	15:58	81.3	-10.5	1219.0	-1.02
6	16:06	16:42	80.1	-12.1	1218.8	-1.04
7	16:47	17:25	81.3	-10.5	1219.2	-1.01
8	17:29	18:09	80.4	-11.7	1218.9	-1.03
10	18:55	19:35	80.5	-11.5	1219.7	-0.97
11	19:40	20:18	81.2	-10.6	1219.8	-0.96
12	20:29	21:10	79.0	-13.6	1219.1	-1.01

Notes:

- Section length is 1231.588 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.882	0.989	0.941	0.333	0.311	0.311	0.306
3	0.854	0.989	0.918	0.315	0.296	0.296	0.292
4	0.854	0.968	0.920	0.326	0.297	0.296	0.301
5	0.861	0.974	0.914	0.338	0.313	0.313	0.314
6	0.852	0.958	0.920	0.315	0.292	0.292	0.291
7	0.862	0.984	0.922	0.328	0.308	0.308	0.304
8	0.851	0.967	0.921	0.323	0.302	0.301	0.303
10	0.852	0.939	0.916	0.325	0.301	0.301	0.300
11	0.862	0.976	0.929	0.343	0.320	0.319	0.321
12	0.841	0.966	0.907	0.299	0.276	0.276	0.273
Ave.	0.857	0.971	0.921	0.325	0.302	0.301	0.300

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.978	0.831	0.035	0.036	0.036	0.033
3	0.970	0.803	0.033	0.032	0.032	0.030
4	0.961	0.803	0.034	0.032	0.032	0.030
5	0.967	0.807	0.038	0.036	0.036	0.033
6	0.957	0.800	0.034	0.032	0.032	0.029
7	0.973	0.808	0.035	0.033	0.033	0.031
8	0.960	0.799	0.036	0.034	0.034	0.031
10	0.946	0.804	0.033	0.032	0.031	0.029
11	0.966	0.812	0.039	0.037	0.037	0.035
12	0.951	0.792	0.031	0.029	0.029	0.026
Ave.	0.963	0.806	0.035	0.033	0.033	0.031

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	3	0.961	0.998	0.968	0.835	0.835	0.835
1	4	0.962	0.978	0.972	0.895	0.893	0.893
1	5	0.968	0.982	0.964	0.868	0.868	0.866
1	6	0.959	0.969	0.972	0.844	0.843	0.843
1	7	0.969	0.992	0.972	0.870	0.869	0.869
1	8	0.957	0.976	0.972	0.840	0.845	0.845
1	10	0.958	0.948	0.966	0.881	0.884	0.884
1	11	0.968	0.984	0.978	0.898	0.903	0.903
1	12	0.948	0.975	0.957	0.819	0.819	0.824
3	4	0.994	0.978	0.992	0.912	0.927	0.927
3	5	0.986	0.983	0.992	0.915	0.919	0.919
3	6	0.993	0.968	0.992	0.965	0.965	0.963
3	7	0.985	0.991	0.987	0.922	0.923	0.923
3	8	0.992	0.976	0.990	0.961	0.957	0.957
3	10	0.993	0.947	0.993	0.914	0.919	0.919
3	11	0.982	0.985	0.978	0.867	0.863	0.863
3	12	0.982	0.975	0.985	0.928	0.930	0.930
4	5	0.987	0.994	0.988	0.964	0.960	0.960
4	6	0.992	0.989	0.996	0.930	0.937	0.937
4	7	0.986	0.984	0.992	0.963	0.964	0.964
4	8	0.990	0.995	0.994	0.932	0.945	0.945
4	10	0.991	0.969	0.990	0.956	0.953	0.953
4	11	0.984	0.990	0.983	0.919	0.908	0.908
4	12	0.980	0.996	0.981	0.903	0.912	0.912
5	6	0.986	0.984	0.990	0.930	0.927	0.927
5	7	0.994	0.989	0.985	0.967	0.967	0.968
5	8	0.983	0.992	0.986	0.928	0.932	0.940
5	10	0.985	0.964	0.990	0.959	0.956	0.956
5	11	0.990	0.995	0.975	0.921	0.922	0.922
5	12	0.974	0.991	0.988	0.895	0.893	0.893
6	7	0.984	0.973	0.993	0.942	0.943	0.943
6	8	0.993	0.985	0.994	0.972	0.969	0.969
6	10	0.992	0.977	0.990	0.930	0.933	0.933
6	11	0.981	0.980	0.983	0.890	0.885	0.885
6	12	0.984	0.990	0.982	0.946	0.949	0.949
7	8	0.982	0.981	0.994	0.938	0.943	0.943
7	10	0.983	0.953	0.986	0.965	0.967	0.967
7	11	0.992	0.990	0.986	0.917	0.915	0.912
7	12	0.973	0.980	0.978	0.905	0.908	0.908
8	10	0.990	0.965	0.987	0.927	0.941	0.941
8	11	0.979	0.989	0.984	0.882	0.882	0.882
8	12	0.985	0.993	0.979	0.943	0.941	0.941
10	11	0.981	0.961	0.976	0.919	0.915	0.915
10	12	0.980	0.969	0.981	0.897	0.898	0.898
11	12	0.970	0.987	0.968	0.850	0.846	0.846
Average		0.981	0.980	0.983	0.914	0.915	0.913

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	3	0.989	0.955	0.625	0.625	0.625	0.615
1	4	0.981	0.956	0.691	0.686	0.686	0.679
1	5	0.984	0.960	0.668	0.644	0.644	0.636
1	6	0.977	0.953	0.622	0.622	0.621	0.605
1	7	0.991	0.960	0.640	0.640	0.640	0.633
1	8	0.978	0.951	0.625	0.623	0.621	0.617
1	10	0.964	0.957	0.678	0.670	0.669	0.660
1	11	0.984	0.964	0.731	0.734	0.732	0.727
1	12	0.970	0.945	0.605	0.605	0.605	0.587
3	4	0.991	0.991	0.884	0.880	0.880	0.898
3	5	0.995	0.986	0.805	0.801	0.801	0.803
3	6	0.986	0.992	0.932	0.926	0.925	0.918
3	7	0.994	0.986	0.872	0.859	0.859	0.858
3	8	0.988	0.990	0.909	0.899	0.899	0.904
3	10	0.973	0.986	0.855	0.857	0.857	0.856
3	11	0.994	0.978	0.758	0.746	0.746	0.745
3	12	0.979	0.983	0.856	0.848	0.846	0.839
4	5	0.994	0.987	0.856	0.852	0.852	0.852
4	6	0.994	0.990	0.903	0.896	0.895	0.894
4	7	0.987	0.987	0.911	0.896	0.896	0.895
4	8	0.997	0.988	0.930	0.933	0.933	0.934
4	10	0.982	0.988	0.886	0.883	0.883	0.882
4	11	0.992	0.979	0.802	0.786	0.786	0.784
4	12	0.988	0.981	0.868	0.859	0.859	0.858
5	6	0.989	0.986	0.825	0.817	0.817	0.814
5	7	0.992	0.993	0.880	0.888	0.888	0.887
5	8	0.991	0.983	0.853	0.857	0.857	0.856
5	10	0.977	0.990	0.856	0.845	0.845	0.842
5	11	0.997	0.983	0.847	0.833	0.833	0.831
5	12	0.983	0.977	0.782	0.769	0.768	0.766
6	7	0.982	0.986	0.884	0.869	0.869	0.866
6	8	0.994	0.992	0.927	0.913	0.913	0.914
6	10	0.985	0.986	0.860	0.853	0.853	0.857
6	11	0.987	0.977	0.784	0.767	0.767	0.764
6	12	0.991	0.986	0.912	0.909	0.908	0.905
7	8	0.984	0.984	0.910	0.906	0.906	0.902
7	10	0.969	0.989	0.910	0.922	0.922	0.921
7	11	0.991	0.985	0.803	0.798	0.798	0.795
7	12	0.976	0.977	0.837	0.831	0.829	0.818
8	10	0.981	0.984	0.884	0.893	0.893	0.898
8	11	0.990	0.975	0.782	0.771	0.771	0.769
8	12	0.987	0.986	0.879	0.870	0.870	0.863
10	11	0.977	0.980	0.819	0.801	0.801	0.800
10	12	0.991	0.977	0.821	0.810	0.810	0.808
11	12	0.980	0.969	0.731	0.712	0.712	0.709
Average		0.986	0.979	0.815	0.809	0.809	0.806

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was cloudy, cold, and windy . The pavement was dry.
- All runs included loop closure.
- Placed a fresh chalk line.
- Performed vertical calibration in the shop before measuring the section. This took only 4 minutes. This was done to account for the lower temperatures (35 degrees F versus 55 degrees F two days earlier), although it was done inside the shop (65 degrees F).
- Used a hardware store laser pointed at the chalk line to help with lateral guidance.
- Run 2 was discarded because the operator noticed a wobbling DMI wheel. The operator knew something was wrong in real time before noticing the problem with the wheel.
- Changed the laptop battery between runs 6 and 7.
- Run 9 was discarded as the trace did not match the other traces when viewed in ProVal. The operators said the trace had a big dip in the last 7 feet of the run. The operator thought he may have pushed a little sideways on the handle and cause the device to lift up off the ground.
- Changed the laptop battery between runs 10 and 11.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 10/21/2009, 11:56 – 18:15

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.904	0.856
Long (elev.)	0.950	0.987
Medium (elev.)	0.874	0.828
Short (elev.)	0.893	0.217
Long (slope)	0.944	0.974
Medium (slope)	0.865	0.679
Short (slope)	0.845	0.024

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.68 to -0.76 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
4	11:56	12:23	103.7	-12.4	492.8	-0.68
5	12:25	12:57	105.1	-10.9	492.7	-0.70
7	13:25	13:50	104.7	-11.3	492.8	-0.68
8	13:51	14:16	101.5	-14.9	492.6	-0.72
9	14:19	14:45	99.7	-16.9	492.2	-0.80
11	15:21	15:47	103.4	-12.7	492.5	-0.74
12	15:51	16:17	101.6	-14.7	492.5	-0.74
13	16:25	16:51	103.1	-13.0	492.4	-0.76
15	17:21	17:46	98.6	-18.2	492.5	-0.74
16	17:50	18:15	103.3	-12.8	492.3	-0.78

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	0.888	0.998	0.876	0.209	0.209	0.209	0.209
5	0.862	0.993	0.776	0.156	0.156	0.156	0.156
7	0.882	0.997	0.857	0.206	0.204	0.204	0.204
8	0.844	0.967	0.862	0.203	0.203	0.203	0.203
9	0.869	0.990	0.878	0.213	0.212	0.212	0.212
11	0.860	0.995	0.834	0.281	0.281	0.281	0.281
12	0.816	0.964	0.795	0.223	0.223	0.223	0.223
13	0.838	0.991	0.798	0.226	0.225	0.225	0.225
15	0.833	0.995	0.830	0.229	0.228	0.228	0.228
16	0.865	0.976	0.778	0.231	0.231	0.231	0.231
Ave.	0.856	0.987	0.828	0.218	0.217	0.217	0.217

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	0.991	0.702	0.024	0.024	0.024	0.024
5	0.959	0.620	0.018	0.018	0.018	0.018
7	0.984	0.699	0.021	0.021	0.021	0.021
8	0.966	0.687	0.022	0.022	0.022	0.022
9	0.987	0.706	0.024	0.024	0.024	0.024
11	0.970	0.704	0.031	0.031	0.031	0.031
12	0.959	0.629	0.025	0.025	0.025	0.025
13	0.983	0.652	0.025	0.025	0.025	0.025
15	0.964	0.701	0.025	0.025	0.025	0.025
16	0.977	0.689	0.025	0.025	0.025	0.025
Ave.	0.974	0.679	0.024	0.024	0.024	0.024

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
4	5	0.938	0.888	0.919	0.914	0.921	0.921
4	7	0.934	0.954	0.921	0.868	0.872	0.872
4	8	0.884	0.976	0.837	0.867	0.870	0.870
4	9	0.871	0.937	0.806	0.785	0.790	0.790
4	11	0.934	0.979	0.943	0.839	0.844	0.844
4	12	0.919	0.973	0.902	0.864	0.868	0.868
4	13	0.921	0.935	0.883	0.863	0.872	0.872
4	15	0.888	0.954	0.861	0.805	0.815	0.815
4	16	0.927	0.900	0.914	0.803	0.815	0.815
5	7	0.919	0.923	0.891	0.882	0.879	0.879
5	8	0.862	0.902	0.822	0.897	0.892	0.892
5	9	0.868	0.926	0.839	0.817	0.814	0.814
5	11	0.919	0.884	0.920	0.860	0.856	0.856
5	12	0.897	0.900	0.904	0.887	0.885	0.885
5	13	0.898	0.924	0.841	0.865	0.867	0.867
5	15	0.861	0.918	0.848	0.831	0.833	0.833
5	16	0.912	0.971	0.906	0.821	0.825	0.825
7	8	0.869	0.969	0.825	0.938	0.940	0.940
7	9	0.877	0.988	0.817	0.876	0.878	0.878
7	11	0.929	0.957	0.926	0.927	0.928	0.929
7	12	0.911	0.977	0.896	0.944	0.943	0.944
7	13	0.905	0.981	0.845	0.928	0.936	0.936
7	15	0.865	0.989	0.834	0.883	0.888	0.888
7	16	0.914	0.941	0.885	0.877	0.884	0.885
8	9	0.908	0.961	0.866	0.868	0.870	0.870
8	11	0.897	0.981	0.858	0.930	0.933	0.933
8	12	0.907	0.986	0.859	0.956	0.957	0.957
8	13	0.890	0.952	0.874	0.934	0.943	0.943
8	15	0.949	0.970	0.917	0.897	0.904	0.904
8	16	0.886	0.914	0.851	0.883	0.892	0.892
9	11	0.901	0.952	0.844	0.907	0.907	0.907
9	12	0.918	0.964	0.864	0.883	0.883	0.884
9	13	0.898	0.987	0.865	0.874	0.869	0.869
9	15	0.902	0.985	0.851	0.919	0.915	0.915
9	16	0.885	0.947	0.836	0.925	0.920	0.920
11	12	0.942	0.976	0.927	0.951	0.953	0.953
11	13	0.932	0.944	0.881	0.942	0.937	0.937
11	15	0.889	0.961	0.863	0.921	0.928	0.928
11	16	0.932	0.906	0.906	0.917	0.926	0.926
12	13	0.929	0.961	0.890	0.959	0.963	0.963
12	15	0.905	0.974	0.869	0.917	0.923	0.923
12	16	0.921	0.918	0.911	0.908	0.915	0.915
13	15	0.890	0.978	0.882	0.904	0.906	0.906
13	16	0.914	0.944	0.875	0.906	0.909	0.909
15	16	0.882	0.936	0.875	0.937	0.936	0.936
Average		0.904	0.950	0.874	0.891	0.893	0.893

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
4	5	0.949	0.890	0.821	0.831	0.831	0.831
4	7	0.967	0.889	0.792	0.792	0.792	0.792
4	8	0.920	0.868	0.765	0.767	0.767	0.767
4	9	0.931	0.837	0.657	0.664	0.664	0.664
4	11	0.959	0.910	0.774	0.780	0.780	0.780
4	12	0.960	0.898	0.779	0.781	0.781	0.781
4	13	0.952	0.904	0.815	0.827	0.827	0.827
4	15	0.946	0.860	0.741	0.751	0.751	0.751
4	16	0.944	0.898	0.698	0.707	0.707	0.707
5	7	0.965	0.872	0.847	0.841	0.841	0.841
5	8	0.901	0.806	0.858	0.853	0.853	0.853
5	9	0.918	0.816	0.757	0.755	0.755	0.755
5	11	0.938	0.874	0.832	0.829	0.829	0.829
5	12	0.927	0.850	0.846	0.842	0.842	0.842
5	13	0.922	0.834	0.859	0.860	0.860	0.860
5	15	0.917	0.806	0.812	0.812	0.812	0.812
5	16	0.969	0.845	0.781	0.782	0.782	0.782
7	8	0.914	0.839	0.903	0.902	0.902	0.902
7	9	0.941	0.832	0.810	0.820	0.820	0.820
7	11	0.962	0.897	0.918	0.924	0.924	0.924
7	12	0.957	0.874	0.913	0.914	0.914	0.914
7	13	0.944	0.864	0.889	0.882	0.882	0.882
7	15	0.934	0.822	0.871	0.881	0.881	0.881
7	16	0.958	0.862	0.823	0.832	0.832	0.832
8	9	0.952	0.849	0.813	0.821	0.821	0.821
8	11	0.945	0.861	0.910	0.916	0.916	0.916
8	12	0.947	0.869	0.937	0.937	0.937	0.937
8	13	0.920	0.881	0.890	0.885	0.885	0.885
8	15	0.963	0.896	0.915	0.923	0.923	0.923
8	16	0.893	0.883	0.862	0.871	0.871	0.871
9	11	0.963	0.861	0.842	0.843	0.843	0.843
9	12	0.968	0.870	0.828	0.833	0.833	0.833
9	13	0.946	0.862	0.768	0.766	0.767	0.767
9	15	0.974	0.817	0.834	0.834	0.834	0.834
9	16	0.912	0.841	0.874	0.873	0.873	0.873
11	12	0.982	0.905	0.949	0.950	0.950	0.950
11	13	0.970	0.892	0.899	0.895	0.895	0.895
11	15	0.964	0.842	0.899	0.901	0.901	0.901
11	16	0.936	0.866	0.864	0.868	0.868	0.868
12	13	0.966	0.902	0.908	0.903	0.903	0.903
12	15	0.968	0.853	0.915	0.922	0.922	0.922
12	16	0.924	0.893	0.873	0.881	0.881	0.881
13	15	0.951	0.851	0.873	0.873	0.873	0.873
13	16	0.915	0.894	0.834	0.833	0.834	0.834
15	16	0.910	0.876	0.894	0.897	0.897	0.897
Average		0.944	0.865	0.843	0.846	0.846	0.846

Auxiliary Information:

- Bruce Wasill observed the runs.

- This section was measured during steady light rain.
- The chalk line remaining from the previous day was barely visible, but the operators did not feel it was necessary to remark the section.
- All runs included loop closure.
- The crew completed one run. They moved off the track during the second run and voided the data because the distance did not seem correct. The third run included obvious errors including poor longitudinal distance measurement and a lack of loop closure (e.g., 6.5 ft error).
- The crew decided to try and recalibrate and if they were still having problems to head to the shop area and take the cover off the unit and see if they could find anything wrong. At 9:30 they found that the GPS unit had been turned on by accident. They suspected that the GPS was trying to integrate the GPS data into the distance measurement. They turned off the GPS and collected data on the Transverse Tined Section and got a correct distance and similar IRI to runs taken on Tuesday. At 9:28 they started a calibration run going backward on the DMI section. The calibration checked. Since the failure to collect data was due to an inadvertent operator/equipment error they were permitted to void the first 3 runs and 10 new runs collected.
- Rain increased to steady light rain after run 4.
- The laptop battery died during run 6, and the run was voided. The crew took a break for lunch.
- Rain decreased to light sprinkles after run 7.
- The computer failed to record data for run 10. (The data file could not be located.)
- Rain stopped after run 10.
- After run 12, a new laptop battery was installed.
- After run 12, light sprinkles resumed.
- The computer did not record run 14.
- Some of the problems encountered on this section ceased when the GPS unit on the computer was turned off.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 10/20/2009, 19:03 – 21:43

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.894	0.856
Long (elev.)	0.981	0.987
Medium (elev.)	0.777	0.828
Short (elev.)	0.609	0.217
Long (slope)	0.963	0.974
Medium (slope)	0.773	0.679
Short (slope)	0.571	0.024

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.91 to -0.97 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
3	19:03	19:16	53.0	-4.1	457.1	-0.97
4	19:17	19:31	54.0	-2.2	457.1	-0.97
5	19:33	19:46	53.0	-4.2	457.2	-0.95
6	19:52	20:05	52.3	-5.5	457.1	-0.97
7	20:07	20:25	53.5	-3.1	457.4	-0.91
8	20:27	20:41	53.7	-2.8	457.3	-0.93
9	20:42	20:57	53.0	-4.1	457.3	-0.93
10	20:58	21:11	53.2	-3.8	457.4	-0.91
11	21:13	21:27	52.3	-5.5	457.3	-0.93
12	21:29	21:43	53.5	-3.0	457.4	-0.91

Notes:

- Section length is 461.591 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
3	0.888	0.998	0.876	0.209	0.209	0.209	0.209
4	0.862	0.993	0.776	0.156	0.156	0.156	0.156
5	0.882	0.997	0.857	0.206	0.204	0.204	0.204
6	0.844	0.967	0.862	0.203	0.203	0.203	0.203
7	0.869	0.990	0.878	0.213	0.212	0.212	0.212
8	0.860	0.995	0.834	0.281	0.281	0.281	0.281
9	0.816	0.964	0.795	0.223	0.223	0.223	0.223
10	0.838	0.991	0.798	0.226	0.225	0.225	0.225
11	0.833	0.995	0.830	0.229	0.228	0.228	0.228
12	0.865	0.976	0.778	0.231	0.231	0.231	0.231
Ave.	0.856	0.987	0.828	0.218	0.217	0.217	0.217

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
3	0.991	0.702	0.024	0.024	0.024	0.024
4	0.959	0.620	0.018	0.018	0.018	0.018
5	0.984	0.699	0.021	0.021	0.021	0.021
6	0.966	0.687	0.022	0.022	0.022	0.022
7	0.987	0.706	0.024	0.024	0.024	0.024
8	0.970	0.704	0.031	0.031	0.031	0.031
9	0.959	0.629	0.025	0.025	0.025	0.025
10	0.983	0.652	0.025	0.025	0.025	0.025
11	0.964	0.701	0.025	0.025	0.025	0.025
12	0.977	0.689	0.025	0.025	0.025	0.025
Ave.	0.974	0.679	0.024	0.024	0.024	0.024

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
3	4	0.929	0.990	0.819	0.625	0.626	0.625
3	5	0.927	0.994	0.869	0.736	0.734	0.736
3	6	0.907	0.970	0.890	0.493	0.493	0.493
3	7	0.926	0.991	0.854	0.804	0.804	0.804
3	8	0.901	0.993	0.767	0.504	0.503	0.504
3	9	0.878	0.967	0.788	0.636	0.636	0.636
3	10	0.891	0.991	0.795	0.697	0.697	0.697
3	11	0.888	0.992	0.810	0.687	0.686	0.687
3	12	0.891	0.978	0.773	0.619	0.619	0.619
4	5	0.952	0.997	0.865	0.708	0.708	0.708
4	6	0.935	0.956	0.840	0.529	0.528	0.529
4	7	0.939	0.977	0.779	0.648	0.647	0.648
4	8	0.904	0.989	0.684	0.404	0.403	0.404
4	9	0.892	0.952	0.725	0.581	0.581	0.581
4	10	0.888	0.978	0.681	0.513	0.512	0.513
4	11	0.890	0.991	0.704	0.644	0.644	0.644
4	12	0.882	0.963	0.681	0.373	0.373	0.373
5	6	0.927	0.960	0.871	0.554	0.554	0.554
5	7	0.930	0.981	0.828	0.782	0.782	0.782
5	8	0.905	0.991	0.722	0.581	0.580	0.581
5	9	0.885	0.955	0.742	0.733	0.733	0.733
5	10	0.888	0.981	0.741	0.645	0.645	0.645
5	11	0.870	0.991	0.726	0.786	0.786	0.786
5	12	0.890	0.967	0.710	0.602	0.602	0.602
6	7	0.909	0.985	0.836	0.525	0.525	0.525
6	8	0.893	0.969	0.798	0.558	0.558	0.558
6	9	0.865	0.994	0.792	0.543	0.543	0.543
6	10	0.879	0.984	0.806	0.446	0.446	0.435
6	11	0.868	0.966	0.785	0.587	0.587	0.587
6	12	0.894	0.991	0.780	0.528	0.528	0.528
7	8	0.914	0.991	0.814	0.527	0.527	0.527
7	9	0.888	0.983	0.773	0.643	0.643	0.643
7	10	0.912	0.998	0.794	0.652	0.651	0.652
7	11	0.910	0.989	0.806	0.753	0.753	0.753
7	12	0.875	0.992	0.768	0.571	0.571	0.571
8	9	0.875	0.966	0.780	0.525	0.525	0.525
8	10	0.883	0.992	0.775	0.534	0.533	0.534
8	11	0.886	0.996	0.783	0.647	0.647	0.647
8	12	0.859	0.976	0.734	0.508	0.509	0.508
9	10	0.892	0.980	0.790	0.642	0.642	0.642
9	11	0.858	0.961	0.734	0.738	0.737	0.738
9	12	0.850	0.988	0.711	0.694	0.694	0.694
10	11	0.922	0.991	0.827	0.691	0.690	0.691
10	12	0.851	0.989	0.727	0.631	0.631	0.631
11	12	0.830	0.975	0.700	0.593	0.593	0.593
Average		0.894	0.981	0.777	0.609	0.609	0.609

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
3	4	0.962	0.786	0.587	0.588	0.587	0.587
3	5	0.979	0.875	0.661	0.661	0.661	0.661
3	6	0.960	0.845	0.452	0.439	0.440	0.440
3	7	0.989	0.873	0.752	0.752	0.752	0.752
3	8	0.971	0.771	0.520	0.520	0.520	0.520
3	9	0.953	0.776	0.616	0.615	0.616	0.616
3	10	0.981	0.815	0.692	0.692	0.692	0.692
3	11	0.966	0.831	0.693	0.693	0.693	0.693
3	12	0.975	0.775	0.655	0.654	0.655	0.655
4	5	0.980	0.820	0.718	0.719	0.718	0.718
4	6	0.936	0.785	0.483	0.483	0.483	0.483
4	7	0.965	0.779	0.591	0.591	0.591	0.591
4	8	0.972	0.674	0.435	0.434	0.435	0.435
4	9	0.919	0.706	0.552	0.552	0.552	0.491
4	10	0.953	0.726	0.466	0.465	0.466	0.466
4	11	0.965	0.719	0.666	0.667	0.666	0.666
4	12	0.949	0.683	0.474	0.473	0.474	0.446
5	6	0.955	0.835	0.489	0.489	0.489	0.489
5	7	0.982	0.853	0.665	0.664	0.665	0.665
5	8	0.979	0.750	0.591	0.590	0.591	0.591
5	9	0.935	0.771	0.619	0.619	0.619	0.619
5	10	0.974	0.783	0.469	0.468	0.468	0.468
5	11	0.972	0.759	0.774	0.774	0.774	0.774
5	12	0.966	0.761	0.484	0.483	0.484	0.482
6	7	0.963	0.812	0.412	0.411	0.412	0.412
6	8	0.947	0.769	0.528	0.527	0.527	0.527
6	9	0.971	0.768	0.544	0.544	0.544	0.544
6	10	0.959	0.779	0.447	0.371	0.405	0.405
6	11	0.937	0.807	0.506	0.505	0.506	0.506
6	12	0.965	0.780	0.522	0.522	0.527	0.522
7	8	0.980	0.772	0.512	0.511	0.512	0.512
7	9	0.949	0.752	0.565	0.565	0.565	0.565
7	10	0.988	0.782	0.547	0.547	0.547	0.547
7	11	0.980	0.793	0.671	0.670	0.671	0.671
7	12	0.978	0.756	0.545	0.544	0.545	0.545
8	9	0.936	0.745	0.539	0.539	0.539	0.539
8	10	0.970	0.743	0.527	0.527	0.527	0.527
8	11	0.979	0.790	0.653	0.652	0.653	0.653
8	12	0.961	0.725	0.523	0.523	0.523	0.523
9	10	0.947	0.735	0.596	0.596	0.596	0.596
9	11	0.922	0.739	0.595	0.595	0.596	0.595
9	12	0.946	0.725	0.718	0.718	0.718	0.718
10	11	0.977	0.796	0.571	0.571	0.571	0.571
10	12	0.972	0.711	0.644	0.644	0.644	0.644
11	12	0.953	0.734	0.492	0.491	0.493	0.492
Average		0.963	0.773	0.572	0.570	0.571	0.569

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was mostly cloudy, cold, and windy with a few light sprinkles in the early evening.
- Used a chalk line.
- All runs included loop closure.
- Rain had stopped as data collection began. The pavement surface was damp throughout data collection.
- All data collection occurred in the darkness. A car followed the device (slightly to the left) to provide light and make the chalk line more visible.
- Operators noted that the first two runs did not match the other eight runs when the data was viewed in ProVAL. They had slowed the pace at which they were collecting data after the first few runs, so they decided to collect two more runs at the slower pace and discard the first two.

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 10/23/2009, 12:52 – 15:45

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.908	0.868
Long (elev.)	0.948	0.953
Medium (elev.)	0.928	0.896
Short (elev.)	0.765	0.431
Long (slope)	0.940	0.949
Medium (slope)	0.917	0.839
Short (slope)	0.701	0.044

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.96 to -1.00 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	12:52	—	69.9	-10.2	485.2	-1.00
2	13:08	13:29	70.1	-9.9	485.2	-1.00
3	13:41	13:59	68.2	-13.0	485.3	-0.98
4	14:06	14:28	71.9	-7.1	485.3	-0.98
5	14:30	14:49	70.8	-8.8	485.4	-0.96
6	14:52	15:08	70.3	-9.6	485.4	-0.96
7	15:09	15:26	72.5	-6.2	485.3	-0.98
8	15:27	15:45	74.3	-3.7	485.4	-0.96

Notes:

- Section length is 490.119 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.870	0.964	0.896	0.433	0.433	0.433	0.433
2	0.876	0.978	0.916	0.427	0.427	0.427	0.427
3	0.837	0.954	0.867	0.466	0.466	0.466	0.466
4	0.880	0.956	0.914	0.408	0.408	0.408	0.408
5	0.864	0.939	0.902	0.464	0.464	0.464	0.464
6	0.855	0.921	0.892	0.428	0.428	0.428	0.428
7	0.878	0.947	0.919	0.417	0.417	0.417	0.417
8	0.884	0.965	0.863	0.455	0.455	0.455	0.455
Ave.	0.868	0.953	0.896	0.437	0.437	0.437	0.413

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.952	0.837	0.044	0.044	0.044	0.044
2	0.980	0.839	0.044	0.044	0.044	0.044
3	0.922	0.815	0.049	0.049	0.049	0.049
4	0.968	0.845	0.042	0.042	0.042	0.042
5	0.936	0.856	0.044	0.044	0.044	0.044
6	0.907	0.839	0.044	0.044	0.044	0.044
7	0.967	0.834	0.041	0.041	0.041	0.041
8	0.960	0.850	0.046	0.046	0.046	0.046
Ave.	0.949	0.839	0.044	0.044	0.044	0.042

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.983	0.963	0.975	0.950	0.950	0.950
1	3	0.958	0.988	0.958	0.877	0.877	0.877
1	4	0.965	0.947	0.952	0.908	0.908	0.908
1	5	0.959	0.937	0.949	0.859	0.859	0.859
1	6	0.958	0.961	0.946	0.888	0.888	0.888
1	7	0.929	0.937	0.912	0.784	0.784	0.784
1	8	0.809	0.974	0.910	0.501	0.501	0.501
2	3	0.949	0.956	0.940	0.860	0.860	0.860
2	4	0.970	0.983	0.970	0.906	0.906	0.906
2	5	0.965	0.963	0.967	0.846	0.846	0.846
2	6	0.955	0.921	0.963	0.864	0.864	0.864
2	7	0.932	0.962	0.923	0.756	0.756	0.756
2	8	0.810	0.961	0.925	0.479	0.479	0.479
3	4	0.928	0.944	0.914	0.820	0.819	0.820
3	5	0.926	0.927	0.915	0.934	0.934	0.934
3	6	0.929	0.964	0.913	0.879	0.879	0.879
3	7	0.900	0.930	0.888	0.842	0.842	0.841
3	8	0.781	0.959	0.877	0.536	0.536	0.536
4	5	0.963	0.971	0.959	0.806	0.806	0.806
4	6	0.942	0.913	0.947	0.853	0.853	0.853
4	7	0.938	0.962	0.928	0.758	0.758	0.758
4	8	0.815	0.940	0.910	0.486	0.486	0.486
5	6	0.933	0.909	0.936	0.857	0.857	0.857
5	7	0.929	0.965	0.924	0.826	0.826	0.826
5	8	0.804	0.938	0.919	0.534	0.534	0.534
6	7	0.905	0.901	0.883	0.824	0.824	0.824
6	8	0.772	0.935	0.902	0.517	0.517	0.517
7	8	0.805	0.933	0.887	0.460	0.460	0.460
Average		0.908	0.948	0.928	0.765	0.765	0.765

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.969	0.984	0.905	0.905	0.905	0.905
1	3	0.962	0.969	0.849	0.849	0.849	0.849
1	4	0.952	0.959	0.873	0.873	0.873	0.873
1	5	0.977	0.923	0.819	0.819	0.819	0.819
1	6	0.950	0.930	0.772	0.772	0.772	0.772
1	7	0.936	0.919	0.644	0.643	0.644	0.644
1	8	0.934	0.861	0.468	0.468	0.383	0.468
2	3	0.937	0.962	0.822	0.822	0.822	0.822
2	4	0.981	0.963	0.841	0.841	0.841	0.841
2	5	0.958	0.924	0.823	0.823	0.823	0.823
2	6	0.920	0.935	0.754	0.754	0.754	0.754
2	7	0.959	0.917	0.626	0.626	0.626	0.626
2	8	0.958	0.870	0.450	0.450	0.450	0.450
3	4	0.923	0.932	0.792	0.792	0.792	0.792
3	5	0.942	0.902	0.897	0.897	0.897	0.897
3	6	0.970	0.913	0.859	0.859	0.859	0.859
3	7	0.909	0.904	0.706	0.705	0.706	0.706
3	8	0.894	0.843	0.486	0.486	0.486	0.486
4	5	0.950	0.930	0.783	0.783	0.783	0.783
4	6	0.914	0.945	0.742	0.742	0.742	0.742
4	7	0.952	0.928	0.630	0.630	0.630	0.630
4	8	0.946	0.862	0.378	0.378	0.378	0.378
5	6	0.937	0.918	0.840	0.840	0.840	0.840
5	7	0.921	0.931	0.682	0.682	0.682	0.682
5	8	0.925	0.900	0.496	0.496	0.496	0.496
6	7	0.888	0.911	0.707	0.707	0.707	0.707
6	8	0.891	0.875	0.531	0.531	0.531	0.531
7	8	0.964	0.879	0.476	0.476	0.476	0.476
Average		0.940	0.917	0.702	0.702	0.699	0.702

Auxiliary Information:

- Steve Karamihas observed the runs.
- The weather was varied from steady rain to driving rain.
- Used the provided paint line.
- In runs 1-3, used a laser pointed at the line as a guide. After that, gave up on it and taped a stick top the device with a piece of tape hanging over the paint line.
- Voided the first attempt at run 3 due to a dead battery on the laser guide.
- In many runs the operator pushed forward slowly only a few feet, then pulled the device back and started again.
- Before providing data, the operator plotted all 8 runs on the device laptop. Run 1 did not look like the others, so only runs 2-8 were provided. After some time in their vehicle, the crew returned to provide run 1. (The poor agreement was due to an error in file selection, and the plot was showing run 1 from another section.)

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 10/20/2009, 16:01 – 18:08

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.965	0.848
Long (elev.)	0.936	0.910
Medium (elev.)	0.946	0.869
Short (elev.)	0.964	0.413
Long (slope)	0.945	0.915
Medium (slope)	0.968	0.805
Short (slope)	0.959	0.039

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.80 to -0.86 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
2	16:14	16:25	110.5	-15.9	164.9	-0.86
3	16:26	16:37	112.1	-14.2	164.9	-0.86
4	16:39	16:48	109.2	-17.3	165.0	-0.80
5	16:49	16:59	116.4	-10.0	165.0	-0.80
6	17:01	17:11	114.2	-12.1	165.0	-0.80
7	17:12	17:22	114.0	-12.3	165.0	-0.80
8	17:23	17:34	113.3	-13.0	165.0	-0.80
9	17:36	17:46	112.5	-13.8	165.0	-0.80
10	17:47	17:57	111.0	-15.4	165.0	-0.80
11	17:58	18:08	112.0	-14.3	164.9	-0.86

Notes:

- Section length is 166.326 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
2	0.832	0.873	0.836	0.424	0.424
3	0.834	0.912	0.835	0.424	0.425
4	0.835	0.918	0.912	0.406	0.406
5	0.881	0.994	0.896	0.411	0.411
6	0.860	0.863	0.881	0.422	0.422
7	0.862	0.955	0.891	0.410	0.410
8	0.857	0.966	0.887	0.406	0.406
9	0.836	0.868	0.834	0.414	0.414
10	0.834	0.859	0.865	0.401	0.401
11	0.846	0.895	0.850	0.416	0.416
Ave.	0.848	0.910	0.869	0.413	0.414

Run	Cross Correlation to Benchmark Profile, Slope			
	Long	Medium	Short, Seg. 1	Short, Seg. 2
2	0.878	0.801	0.039	0.039
3	0.890	0.794	0.040	0.040
4	0.898	0.818	0.038	0.038
5	0.986	0.805	0.039	0.039
6	0.906	0.823	0.039	0.039
7	0.958	0.811	0.038	0.038
8	0.967	0.803	0.038	0.038
9	0.879	0.795	0.039	0.039
10	0.873	0.802	0.038	0.038
11	0.914	0.799	0.039	0.039
Ave.	0.915	0.805	0.039	0.039

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation				
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
2	3	0.985	0.970	0.984	0.988	0.988
2	4	0.988	0.958	0.904	0.959	0.959
2	5	0.938	0.873	0.920	0.958	0.958
2	6	0.952	0.979	0.934	0.983	0.983
2	7	0.955	0.918	0.922	0.967	0.967
2	8	0.961	0.902	0.928	0.943	0.943
2	9	0.982	0.996	0.982	0.972	0.972
2	10	0.974	0.964	0.950	0.928	0.928
2	11	0.983	0.977	0.980	0.968	0.968
3	4	0.982	0.995	0.902	0.957	0.957
3	5	0.943	0.903	0.917	0.956	0.956
3	6	0.955	0.948	0.928	0.989	0.989
3	7	0.962	0.944	0.923	0.963	0.963
3	8	0.967	0.924	0.930	0.938	0.938
3	9	0.987	0.965	0.977	0.965	0.965
3	10	0.968	0.941	0.958	0.924	0.924
3	11	0.990	0.977	0.977	0.965	0.965
4	5	0.937	0.909	0.971	0.988	0.988
4	6	0.947	0.935	0.957	0.949	0.949
4	7	0.957	0.953	0.974	0.983	0.983
4	8	0.961	0.934	0.966	0.970	0.970
4	9	0.978	0.951	0.896	0.980	0.980
4	10	0.975	0.926	0.926	0.958	0.958
4	11	0.983	0.963	0.921	0.982	0.982
5	6	0.976	0.860	0.966	0.946	0.946
5	7	0.975	0.955	0.981	0.979	0.979
5	8	0.970	0.962	0.975	0.976	0.976
5	9	0.945	0.871	0.921	0.983	0.983
5	10	0.924	0.858	0.929	0.962	0.962
5	11	0.950	0.889	0.931	0.985	0.985
6	7	0.981	0.902	0.971	0.958	0.958
6	8	0.977	0.884	0.982	0.929	0.929
6	9	0.956	0.980	0.930	0.960	0.960
6	10	0.933	0.988	0.946	0.919	0.919
6	11	0.957	0.962	0.943	0.956	0.956
7	8	0.986	0.982	0.978	0.964	0.964
7	9	0.957	0.910	0.912	0.990	0.990
7	10	0.942	0.892	0.932	0.952	0.952
7	11	0.966	0.934	0.934	0.992	0.992
8	9	0.966	0.892	0.924	0.965	0.965
8	10	0.946	0.874	0.938	0.974	0.974
8	11	0.973	0.918	0.946	0.967	0.967
9	10	0.964	0.965	0.957	0.949	0.949
9	11	0.988	0.970	0.973	0.990	0.990
10	11	0.972	0.954	0.971	0.954	0.954
Average		0.965	0.936	0.946	0.964	0.964

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
2	3	0.992	0.983	0.976	0.976
2	4	0.974	0.966	0.949	0.949
2	5	0.877	0.986	0.959	0.959
2	6	0.968	0.950	0.970	0.970
2	7	0.917	0.964	0.951	0.951
2	8	0.907	0.981	0.946	0.946
2	9	0.995	0.984	0.973	0.973
2	10	0.983	0.972	0.931	0.931
2	11	0.961	0.982	0.963	0.963
3	4	0.982	0.958	0.946	0.946
3	5	0.883	0.981	0.949	0.949
3	6	0.973	0.942	0.984	0.984
3	7	0.922	0.965	0.937	0.937
3	8	0.913	0.977	0.933	0.933
3	9	0.993	0.981	0.958	0.958
3	10	0.982	0.976	0.922	0.921
3	11	0.969	0.982	0.952	0.952
4	5	0.892	0.967	0.980	0.980
4	6	0.987	0.957	0.932	0.932
4	7	0.936	0.984	0.982	0.982
4	8	0.927	0.974	0.978	0.978
4	9	0.972	0.958	0.968	0.968
4	10	0.961	0.961	0.965	0.965
4	11	0.980	0.962	0.976	0.976
5	6	0.903	0.944	0.936	0.936
5	7	0.958	0.967	0.977	0.977
5	8	0.966	0.982	0.979	0.979
5	9	0.878	0.981	0.981	0.981
5	10	0.868	0.978	0.966	0.966
5	11	0.911	0.983	0.988	0.988
6	7	0.944	0.960	0.929	0.929
6	8	0.934	0.951	0.917	0.917
6	9	0.970	0.940	0.952	0.951
6	10	0.955	0.938	0.916	0.916
6	11	0.990	0.939	0.941	0.941
7	8	0.989	0.971	0.981	0.981
7	9	0.913	0.952	0.968	0.968
7	10	0.903	0.958	0.967	0.967
7	11	0.950	0.961	0.978	0.978
8	9	0.905	0.972	0.964	0.964
8	10	0.896	0.967	0.971	0.970
8	11	0.943	0.977	0.973	0.973
9	10	0.980	0.974	0.950	0.950
9	11	0.963	0.977	0.981	0.981
10	11	0.955	0.982	0.961	0.961
Average		0.945	0.968	0.959	0.959

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was mostly cloudy, cold, and windy with a few light sprinkles in the early evening.
- Used a chalk line.
- All runs included loop closure.
- Light rain started between runs 2 and 3.
- Encountered a rock during run 1. Completed the run but elected not to submit it.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 10/20/2009, 09:59 – 15:00

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: No

Data were already low-pass filtered. The cut-off appears to be > 2 ft.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.949	0.893
Long (elev.)	0.967	0.780
Medium (elev.)	0.945	0.936
Short (elev.)	0.904	0.287
Long (slope)	0.955	0.922
Medium (slope)	0.959	0.875
Short (slope)	0.812	0.012

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.95 to -0.98 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Length (ft)	Percent Error
1	09:59	10:28	67.9	533.5	-0.95
2	10:32	11:04	66.8	533.3	-0.98
3	11:09	11:38	70.3	533.4	-0.96
4	11:47	12:16	66.6	533.4	-0.96
5	12:19	12:46	69.5	533.4	-0.96
6	12:48	13:15	70.0	533.5	-0.95
7	13:20	13:48	66.8	533.5	-0.95
8	14:06	14:31	67.4	533.4	-0.96
9	14:33	14:58	69.2	533.5	-0.95
10	15:00	15:28	65.9	533.4	-0.96

Notes:

- Section length is 538.596 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The benchmark profile only covered 164.7 ft. Accuracy scores for the IRI waveband and the long waveband do not represent expected performance over a longer segment of road.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.902	0.726	0.963	0.276
2	0.886	0.809	0.955	0.291
3	0.929	0.717	0.881	0.299
4	0.913	0.817	0.894	0.276
5	0.915	0.756	0.917	0.295
6	0.904	0.786	0.944	0.287
7	0.853	0.742	0.941	0.291
8	0.869	0.882	0.953	0.283
9	0.881	0.741	0.948	0.294
10	0.874	0.823	0.964	0.280
Ave.	0.893	0.780	0.936	0.287

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.938	0.870	0.011
2	0.979	0.853	0.013
3	0.847	0.907	0.012
4	0.956	0.902	0.010
5	0.913	0.904	0.012
6	0.947	0.869	0.012
7	0.919	0.852	0.012
8	0.890	0.880	0.011
9	0.901	0.859	0.013
10	0.935	0.857	0.011
Ave.	0.922	0.875	0.012

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.971	0.989	0.978	0.895
1	3	0.954	0.993	0.922	0.874
1	4	0.958	0.961	0.960	0.931
1	5	0.936	0.956	0.914	0.861
1	6	0.949	0.983	0.947	0.865
1	7	0.966	0.977	0.946	0.897
1	8	0.975	0.971	0.934	0.880
1	9	0.958	0.971	0.961	0.864
1	10	0.950	0.947	0.963	0.876
2	3	0.943	0.985	0.916	0.935
2	4	0.970	0.964	0.952	0.916
2	5	0.928	0.960	0.914	0.892
2	6	0.941	0.979	0.941	0.909
2	7	0.980	0.978	0.949	0.933
2	8	0.973	0.977	0.931	0.914
2	9	0.945	0.975	0.958	0.911
2	10	0.963	0.948	0.960	0.915
3	4	0.932	0.960	0.929	0.895
3	5	0.965	0.950	0.953	0.908
3	6	0.977	0.980	0.935	0.930
3	7	0.938	0.976	0.956	0.928
3	8	0.948	0.968	0.964	0.917
3	9	0.969	0.967	0.935	0.915
3	10	0.927	0.947	0.925	0.900
4	5	0.910	0.982	0.913	0.884
4	6	0.930	0.949	0.954	0.880
4	7	0.975	0.971	0.954	0.921
4	8	0.960	0.979	0.936	0.894
4	9	0.931	0.962	0.964	0.880
4	10	0.967	0.979	0.962	0.893
5	6	0.963	0.946	0.941	0.906
5	7	0.924	0.960	0.950	0.941
5	8	0.923	0.970	0.955	0.888
5	9	0.952	0.960	0.922	0.906
5	10	0.905	0.968	0.920	0.881
6	7	0.938	0.964	0.960	0.930
6	8	0.943	0.962	0.942	0.914
6	9	0.964	0.963	0.958	0.901
6	10	0.924	0.937	0.958	0.885
7	8	0.963	0.980	0.965	0.932
7	9	0.937	0.982	0.958	0.923
7	10	0.968	0.958	0.951	0.915
8	9	0.952	0.981	0.948	0.913
8	10	0.953	0.964	0.939	0.933
9	10	0.914	0.946	0.949	0.912
Average		0.949	0.967	0.945	0.904

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.988	0.983	0.777
1	3	0.971	0.944	0.837
1	4	0.948	0.959	0.876
1	5	0.975	0.927	0.780
1	6	0.969	0.951	0.762
1	7	0.972	0.969	0.841
1	8	0.984	0.961	0.817
1	9	0.960	0.976	0.771
1	10	0.950	0.979	0.798
2	3	0.957	0.947	0.887
2	4	0.955	0.957	0.789
2	5	0.965	0.932	0.774
2	6	0.958	0.954	0.805
2	7	0.979	0.971	0.798
2	8	0.986	0.960	0.774
2	9	0.950	0.977	0.835
2	10	0.957	0.977	0.771
3	4	0.923	0.964	0.823
3	5	0.968	0.966	0.809
3	6	0.986	0.965	0.835
3	7	0.945	0.960	0.856
3	8	0.958	0.968	0.837
3	9	0.979	0.946	0.832
3	10	0.929	0.941	0.819
4	5	0.915	0.945	0.795
4	6	0.920	0.972	0.717
4	7	0.967	0.974	0.862
4	8	0.950	0.975	0.822
4	9	0.908	0.961	0.767
4	10	0.978	0.952	0.808
5	6	0.972	0.951	0.823
5	7	0.948	0.945	0.881
5	8	0.954	0.951	0.801
5	9	0.959	0.928	0.820
5	10	0.923	0.927	0.768
6	7	0.943	0.969	0.809
6	8	0.958	0.975	0.799
6	9	0.979	0.954	0.817
6	10	0.926	0.950	0.748
7	8	0.968	0.973	0.850
7	9	0.934	0.967	0.830
7	10	0.973	0.965	0.826
8	9	0.952	0.962	0.805
8	10	0.953	0.959	0.867
9	10	0.903	0.965	0.809
Average		0.955	0.959	0.812

Auxiliary Information:

- Bruce Wasill observed the runs.
- The weather was mostly cloudy, cold, and windy with a few light sprinkles in the early evening.
- Marked the center line.
- Performed DMI calibration over 300 ft of pavement.
- The device encountered a small rock during run 1, and the operators decided to void the run. Later after seeing the other runs and comparing them in ProVAL they decided that the run was OK and submitted it with the rest without making an 11th run.
- Conversion of data files to ppf took 10-15 minutes.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt
Date: 10/22/2009
Device: VPTL Terrain measurement system
Operator(s): Virginia Tech, Heather, Ma and Robert
Recording Interval: 25 mm
Use Moving Average: Yes
No low-pass filtering evident.
Up-Sampling: For comparison to the benchmark profile measurement, data were up-sampled to an interval of 5.08 mm.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.979	0.873
Long (elev.)	0.866	0.922
Medium (elev.)	0.795	0.766
Short (elev.)	0.690	0.249
Long (slope)	0.821	0.873
Medium (slope)	0.787	0.774
Short (slope)	0.499	0.022

Result for Longitudinal Distance:

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	82.5	-8.2	1231.22	-0.03
2	83.8	-6.6	1231.22	-0.03
3	83.4	-7.1	1231.22	-0.03
4	83.6	-6.9	1231.22	-0.03
5	83.0	-7.6	1231.22	-0.03
6	83.5	-7.1	1231.22	-0.03
7	83.4	-7.1	1231.22	-0.03
8	83.6	-6.9	1231.22	-0.03
9	82.6	-8.0	1231.22	-0.03
10	83.9	-6.6	1231.22	-0.03

Notes:

- Section length is 1231.588 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Run 3 included a very sharp drop-off in the last few samples. With run 3 eliminated, the Results for Profile change to:

Waveband	Repeatability Score	Accuracy Score
IRI	0.981	0.879
Long (elev.)	0.998	0.985
Medium (elev.)	0.991	0.849
Short (elev.)	0.691	0.250
Long (slope)	0.999	0.950
Medium (slope)	0.981	0.859
Short (slope)	0.497	0.022

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.876	0.983	0.850	0.256	0.251	0.248	0.237
2	0.879	0.985	0.850	0.259	0.249	0.247	0.237
3	0.823	0.356	0.016	0.250	0.242	0.240	0.228
4	0.882	0.985	0.850	0.260	0.255	0.248	0.240
5	0.880	0.984	0.850	0.261	0.256	0.248	0.241
6	0.877	0.985	0.848	0.277	0.267	0.262	0.258
7	0.884	0.984	0.854	0.258	0.246	0.246	0.237
8	0.879	0.986	0.852	0.257	0.245	0.243	0.235
9	0.873	0.988	0.841	0.251	0.244	0.236	0.230
10	0.879	0.984	0.845	0.262	0.252	0.245	0.240
Ave.	0.873	0.922	0.766	0.259	0.251	0.246	0.238

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.950	0.855	0.023	0.024	0.024	0.025
2	0.950	0.860	0.023	0.021	0.021	0.021
3	0.181	0.008	0.021	0.021	0.021	0.021
4	0.951	0.864	0.021	0.019	0.019	0.019
5	0.950	0.861	0.021	0.020	0.020	0.021
6	0.949	0.859	0.020	0.030	0.030	0.030
7	0.950	0.864	0.026	0.020	0.020	0.020
8	0.952	0.857	0.022	0.020	0.020	0.020
9	0.951	0.849	0.022	0.023	0.023	0.022
10	0.949	0.860	0.022	0.021	0.021	0.021
Ave.	0.873	0.774	0.022	0.022	0.022	0.022

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	
1	2	0.985	0.998	0.993	0.727	0.719	0.719	0.720
1	3	0.947	0.370	0.011	0.712	0.698	0.698	0.698
1	4	0.985	0.998	0.995	0.724	0.718	0.718	0.718
1	5	0.990	0.999	0.995	0.663	0.658	0.658	0.650
1	6	0.988	0.998	0.994	0.702	0.695	0.695	0.695
1	7	0.983	1.000	0.992	0.676	0.668	0.668	0.666
1	8	0.988	0.998	0.993	0.718	0.710	0.710	0.710
1	9	0.991	0.994	0.990	0.655	0.652	0.652	0.648
1	10	0.988	0.999	0.990	0.695	0.682	0.682	0.681
2	3	0.948	0.372	0.010	0.693	0.689	0.689	0.685
2	4	0.990	0.999	0.996	0.742	0.741	0.741	0.737
2	5	0.985	0.999	0.990	0.669	0.662	0.662	0.659
2	6	0.991	1.000	0.994	0.745	0.740	0.740	0.737
2	7	0.983	0.999	0.991	0.657	0.653	0.653	0.650
2	8	0.990	0.999	0.996	0.728	0.726	0.726	0.722
2	9	0.980	0.996	0.986	0.631	0.629	0.629	0.626
2	10	0.991	1.000	0.989	0.713	0.707	0.707	0.703
3	4	0.949	0.326	0.012	0.701	0.694	0.694	0.689
3	5	0.951	0.323	0.013	0.678	0.674	0.674	0.663
3	6	0.943	0.326	0.012	0.683	0.676	0.676	0.671
3	7	0.952	0.322	0.012	0.695	0.688	0.688	0.684
3	8	0.946	0.325	0.012	0.711	0.702	0.702	0.697
3	9	0.943	0.333	0.008	0.670	0.667	0.667	0.663
3	10	0.947	0.325	0.011	0.711	0.699	0.699	0.693
4	5	0.985	0.998	0.992	0.676	0.667	0.667	0.665
4	6	0.987	1.000	0.994	0.750	0.744	0.744	0.740
4	7	0.986	0.998	0.991	0.704	0.698	0.698	0.696
4	8	0.989	1.000	0.996	0.754	0.746	0.746	0.744
4	9	0.980	0.996	0.988	0.662	0.656	0.656	0.655
4	10	0.989	0.999	0.990	0.755	0.749	0.749	0.747
5	6	0.985	0.999	0.994	0.685	0.678	0.678	0.676
5	7	0.985	1.000	0.990	0.715	0.712	0.712	0.712
5	8	0.987	0.998	0.991	0.666	0.665	0.665	0.662
5	9	0.987	0.995	0.991	0.688	0.676	0.676	0.673
5	10	0.988	0.999	0.990	0.705	0.702	0.702	0.699
6	7	0.980	0.998	0.988	0.672	0.663	0.663	0.660
6	8	0.992	1.000	0.993	0.740	0.739	0.739	0.735
6	9	0.984	0.996	0.989	0.661	0.659	0.659	0.657
6	10	0.991	0.999	0.992	0.724	0.720	0.720	0.717
7	8	0.983	0.998	0.992	0.664	0.659	0.659	0.656
7	9	0.982	0.994	0.986	0.685	0.679	0.679	0.676
7	10	0.982	0.999	0.984	0.673	0.668	0.668	0.665
8	9	0.985	0.997	0.987	0.618	0.622	0.622	0.618
8	10	0.992	0.999	0.989	0.742	0.734	0.734	0.730
9	10	0.984	0.995	0.991	0.651	0.654	0.654	0.651
Average		0.979	0.866	0.795	0.695	0.690	0.690	0.687

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	1.000	0.977	0.555	0.552	0.552	0.553
1	3	0.101	0.008	0.551	0.536	0.536	0.535
1	4	0.999	0.977	0.527	0.530	0.530	0.533
1	5	1.000	0.984	0.450	0.443	0.443	0.442
1	6	1.000	0.980	0.467	0.464	0.464	0.467
1	7	1.000	0.978	0.516	0.514	0.514	0.518
1	8	0.998	0.985	0.550	0.554	0.554	0.556
1	9	0.998	0.985	0.472	0.469	0.469	0.466
1	10	1.000	0.982	0.516	0.512	0.512	0.513
2	3	0.101	0.008	0.503	0.498	0.498	0.497
2	4	1.000	0.986	0.557	0.566	0.566	0.567
2	5	1.000	0.979	0.474	0.469	0.469	0.472
2	6	0.999	0.989	0.562	0.562	0.562	0.563
2	7	1.000	0.979	0.443	0.449	0.449	0.452
2	8	0.998	0.983	0.505	0.508	0.508	0.507
2	9	0.999	0.974	0.418	0.419	0.419	0.420
2	10	0.999	0.987	0.506	0.506	0.506	0.506
3	4	0.102	0.008	0.513	0.514	0.514	0.516
3	5	0.102	0.008	0.504	0.496	0.496	0.495
3	6	0.102	0.008	0.417	0.418	0.418	0.419
3	7	0.101	0.008	0.532	0.535	0.535	0.534
3	8	0.102	0.008	0.518	0.522	0.522	0.521
3	9	0.185	0.011	0.500	0.497	0.497	0.498
3	10	0.102	0.008	0.541	0.537	0.537	0.536
4	5	1.000	0.978	0.472	0.473	0.473	0.478
4	6	0.999	0.983	0.551	0.554	0.554	0.552
4	7	0.999	0.984	0.525	0.528	0.528	0.534
4	8	0.999	0.981	0.561	0.559	0.559	0.560
4	9	0.999	0.974	0.506	0.511	0.511	0.514
4	10	0.999	0.984	0.585	0.589	0.589	0.594
5	6	0.999	0.981	0.432	0.429	0.429	0.432
5	7	1.000	0.981	0.513	0.515	0.515	0.514
5	8	0.998	0.980	0.465	0.467	0.467	0.470
5	9	0.998	0.982	0.481	0.475	0.475	0.474
5	10	0.999	0.983	0.527	0.524	0.524	0.527
6	7	1.000	0.976	0.436	0.428	0.428	0.433
6	8	0.998	0.987	0.500	0.493	0.493	0.495
6	9	0.998	0.978	0.434	0.430	0.430	0.433
6	10	1.000	0.990	0.498	0.487	0.487	0.492
7	8	0.998	0.976	0.487	0.484	0.484	0.487
7	9	0.998	0.978	0.483	0.486	0.486	0.487
7	10	1.000	0.977	0.483	0.477	0.477	0.480
8	9	0.999	0.981	0.408	0.411	0.411	0.412
8	10	0.998	0.988	0.538	0.531	0.531	0.530
9	10	0.998	0.980	0.490	0.487	0.487	0.488
Average		0.821	0.787	0.499	0.498	0.498	0.499

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 10/21/2009

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech, Heather, Ma and Robert

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.807	0.651
Long (elev.)	0.968	0.777
Medium (elev.)	0.780	0.563
Short (elev.)	0.443	0.173
Long (slope)	0.965	0.656
Medium (slope)	0.802	0.634
Short (slope)	0.210	0.042

Result for Longitudinal Distance:

Error in longitudinal distance was -0.07 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	85.4	-27.3	496.18	-0.07
2	85.2	-27.4	496.18	-0.07
3	85.0	-27.6	496.18	-0.07
4	83.6	-28.9	496.18	-0.07
5	84.7	-27.9	496.18	-0.07
6	83.8	-28.7	496.18	-0.07
7	84.8	-27.8	496.18	-0.07
8	84.9	-27.7	496.18	-0.07
9	86.2	-26.6	496.18	-0.07
10	83.6	-28.8	496.18	-0.07

Notes:

- Section length is 496.182 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.630	0.764	0.547	0.197	0.203	0.205	0.202
2	0.662	0.774	0.554	0.200	0.207	0.207	0.207
3	0.613	0.795	0.570	0.200	0.201	0.202	0.140
4	0.746	0.767	0.576	0.098	0.097	0.101	0.100
5	0.604	0.793	0.560	0.182	0.188	0.188	0.120
6	0.742	0.770	0.579	0.128	0.131	0.131	0.099
7	0.618	0.756	0.562	0.148	0.151	0.151	0.151
8	0.647	0.777	0.568	0.188	0.193	0.193	0.193
9	0.616	0.797	0.562	0.222	0.230	0.230	0.230
10	0.634	0.776	0.551	0.169	0.181	0.181	0.181
Ave.	0.651	0.777	0.563	0.173	0.178	0.179	0.162

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.644	0.637	0.037	0.036	0.036	0.036
2	0.656	0.631	0.056	0.060	0.060	0.060
3	0.651	0.611	0.044	0.039	0.039	0.039
4	0.681	0.662	0.043	0.047	0.047	0.047
5	0.651	0.612	0.030	0.043	0.043	0.043
6	0.683	0.662	0.035	0.040	0.040	0.035
7	0.645	0.643	0.044	0.043	0.043	0.043
8	0.658	0.632	0.041	0.031	0.031	0.031
9	0.644	0.629	0.043	0.042	0.041	0.041
10	0.648	0.619	0.031	0.046	0.046	0.046
Ave.	0.656	0.634	0.041	0.043	0.043	0.042

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.840	0.983	0.857	0.387	0.384	0.384
1	3	0.609	0.944	0.647	0.202	0.249	0.249
1	4	0.850	0.965	0.643	0.374	0.376	0.376
1	5	0.666	0.952	0.709	0.244	0.294	0.294
1	6	0.840	0.968	0.660	0.333	0.321	0.321
1	7	0.817	0.992	0.853	0.532	0.532	0.532
1	8	0.846	0.988	0.883	0.383	0.379	0.379
1	9	0.587	0.935	0.652	0.212	0.265	0.269
1	10	0.847	0.986	0.898	0.363	0.360	0.362
2	3	0.758	0.965	0.794	0.444	0.442	0.442
2	4	0.973	0.992	0.794	0.613	0.612	0.612
2	5	0.827	0.970	0.836	0.444	0.443	0.443
2	6	0.980	0.994	0.810	0.605	0.604	0.604
2	7	0.692	0.961	0.734	0.185	0.300	0.300
2	8	0.973	0.999	0.975	0.594	0.597	0.597
2	9	0.733	0.957	0.782	0.443	0.439	0.439
2	10	0.971	0.999	0.957	0.606	0.607	0.608
3	4	0.747	0.948	0.759	0.440	0.435	0.447
3	5	0.922	0.998	0.937	0.735	0.737	0.737
3	6	0.759	0.951	0.775	0.420	0.416	0.416
3	7	0.614	0.916	0.579	0.194	0.085	0.099
3	8	0.752	0.966	0.804	0.442	0.441	0.441
3	9	0.963	0.997	0.982	0.755	0.760	0.760
3	10	0.751	0.968	0.787	0.452	0.451	0.451
4	5	0.817	0.951	0.714	0.446	0.446	0.449
4	6	0.982	1.000	0.983	0.665	0.667	0.667
4	7	0.698	0.942	0.571	0.170	0.164	0.266
4	8	0.978	0.986	0.747	0.668	0.677	0.677
4	9	0.724	0.940	0.753	0.429	0.427	0.436
4	10	0.984	0.986	0.744	0.675	0.679	0.679
5	6	0.828	0.955	0.739	0.430	0.426	0.435
5	7	0.621	0.926	0.622	0.123	0.159	0.159
5	8	0.820	0.971	0.854	0.446	0.446	0.446
5	9	0.896	0.993	0.931	0.757	0.760	0.760
5	10	0.820	0.973	0.837	0.465	0.463	0.463
6	7	0.688	0.945	0.584	0.191	0.216	0.216
6	8	0.982	0.989	0.774	0.637	0.641	0.641
6	9	0.735	0.944	0.765	0.428	0.415	0.429
6	10	0.976	0.989	0.761	0.619	0.621	0.621
7	8	0.706	0.968	0.769	0.294	0.282	0.282
7	9	0.587	0.904	0.575	0.151	0.154	0.154
7	10	0.697	0.966	0.736	0.290	0.282	0.268
8	9	0.730	0.957	0.797	0.433	0.430	0.430
8	10	0.979	1.000	0.966	0.684	0.687	0.687
9	10	0.730	0.959	0.781	0.437	0.434	0.434
Average		0.807	0.968	0.780	0.441	0.445	0.448
							0.440

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.974	0.847	0.144	0.145	0.145	0.145
1	3	0.962	0.732	0.244	0.250	0.257	0.257
1	4	0.925	0.707	0.103	0.105	0.105	0.105
1	5	0.968	0.770	0.249	0.248	0.248	0.248
1	6	0.923	0.728	0.079	0.075	0.075	0.075
1	7	0.988	0.855	0.316	0.316	0.316	0.316
1	8	0.979	0.871	0.068	0.091	0.091	0.091
1	9	0.965	0.719	0.228	0.209	0.261	0.261
1	10	0.988	0.886	0.125	0.123	0.123	0.123
2	3	0.982	0.837	0.158	0.154	0.154	0.154
2	4	0.964	0.842	0.250	0.255	0.255	0.255
2	5	0.982	0.863	0.164	0.167	0.167	0.167
2	6	0.962	0.863	0.286	0.288	0.288	0.288
2	7	0.955	0.730	0.149	0.157	0.157	0.157
2	8	0.997	0.949	0.206	0.210	0.210	0.210
2	9	0.980	0.813	0.098	0.099	0.099	0.099
2	10	0.994	0.941	0.285	0.292	0.292	0.292
3	4	0.947	0.734	0.150	0.151	0.151	0.151
3	5	0.998	0.962	0.416	0.421	0.421	0.421
3	6	0.951	0.752	0.178	0.175	0.175	0.175
3	7	0.935	0.626	0.144	0.126	0.179	0.179
3	8	0.986	0.836	0.112	0.107	0.107	0.107
3	9	0.999	0.973	0.387	0.393	0.393	0.393
3	10	0.985	0.824	0.206	0.215	0.211	0.211
4	5	0.943	0.729	0.134	0.144	0.144	0.144
4	6	0.999	0.982	0.377	0.378	0.378	0.378
4	7	0.904	0.599	0.076	0.133	0.152	0.078
4	8	0.959	0.816	0.375	0.380	0.380	0.380
4	9	0.944	0.734	0.085	0.087	0.087	0.087
4	10	0.946	0.792	0.413	0.418	0.418	0.418
5	6	0.943	0.725	0.186	0.194	0.194	0.194
5	7	0.943	0.644	0.089	0.073	0.096	0.096
5	8	0.988	0.865	0.160	0.161	0.161	0.161
5	9	0.998	0.947	0.477	0.483	0.483	0.483
5	10	0.986	0.854	0.208	0.210	0.210	0.210
6	7	0.899	0.609	0.085	0.080	0.087	0.087
6	8	0.958	0.835	0.308	0.311	0.311	0.311
6	9	0.948	0.750	0.156	0.161	0.157	0.157
6	10	0.945	0.811	0.327	0.333	0.333	0.333
7	8	0.961	0.760	0.081	0.084	0.107	0.107
7	9	0.927	0.643	0.130	0.123	0.161	0.161
7	10	0.958	0.745	0.157	0.160	0.160	0.160
8	9	0.984	0.820	0.108	0.123	0.111	0.111
8	10	0.997	0.968	0.402	0.411	0.411	0.411
9	10	0.984	0.808	0.199	0.199	0.199	0.199
Average		0.965	0.802	0.206	0.209	0.214	0.212

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 10/21/2009

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech, Heather, Ma and Robert

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.986	0.930
Long (elev.)	0.999	0.931
Medium (elev.)	0.988	0.894
Short (elev.)	0.871	0.690
Long (slope)	0.999	0.931
Medium (slope)	0.983	0.928
Short (slope)	0.570	0.087

Result for Longitudinal Distance:

Error in longitudinal distance was -0.19 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	122.3	-4.5	166.01	-0.19
2	122.5	-4.3	166.01	-0.19
3	122.2	-4.6	166.01	-0.19
4	122.2	-4.6	166.01	-0.19
5	122.4	-4.4	166.01	-0.19
6	123.5	-3.5	166.01	-0.19
7	122.9	-4.0	166.01	-0.19
8	122.8	-4.1	166.01	-0.19
9	121.7	-4.9	166.01	-0.19
10	121.5	-5.1	166.01	-0.19

Notes:

- Section length is 166.326 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation				
	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.934	0.930	0.897	0.694	0.694
2	0.929	0.930	0.892	0.693	0.693
3	0.921	0.930	0.898	0.704	0.704
4	0.931	0.933	0.884	0.679	0.679
5	0.936	0.928	0.905	0.687	0.687
6	0.937	0.930	0.899	0.707	0.707
7	0.936	0.931	0.897	0.672	0.672
8	0.929	0.932	0.892	0.690	0.690
9	0.932	0.935	0.894	0.685	0.684
10	0.919	0.933	0.885	0.694	0.694
Ave.	0.930	0.931	0.894	0.690	0.690

Run	Cross Correlation to Benchmark Profile, Slope			
	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	0.932	0.928	0.098	0.098
2	0.928	0.926	0.084	0.084
3	0.934	0.919	0.099	0.099
4	0.933	0.926	0.078	0.078
5	0.931	0.939	0.097	0.088
6	0.929	0.936	0.090	0.090
7	0.931	0.936	0.076	0.076
8	0.930	0.923	0.089	0.089
9	0.933	0.930	0.081	0.081
10	0.931	0.914	0.084	0.084
Ave.	0.931	0.928	0.088	0.087

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation				
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.992	1.000	0.991	0.844	0.844
1	3	0.975	1.000	0.993	0.927	0.927
1	4	0.993	0.999	0.982	0.835	0.835
1	5	0.994	1.000	0.989	0.921	0.921
1	6	0.987	1.000	0.991	0.829	0.829
1	7	0.993	1.000	0.994	0.903	0.903
1	8	0.991	1.000	0.993	0.858	0.858
1	9	0.995	0.998	0.996	0.912	0.913
1	10	0.980	0.999	0.984	0.851	0.851
2	3	0.977	1.000	0.992	0.840	0.840
2	4	0.995	0.999	0.989	0.905	0.905
2	5	0.989	1.000	0.982	0.855	0.855
2	6	0.987	1.000	0.987	0.878	0.878
2	7	0.989	1.000	0.988	0.848	0.848
2	8	0.996	1.000	0.996	0.921	0.921
2	9	0.994	0.998	0.992	0.854	0.854
2	10	0.984	0.999	0.991	0.869	0.869
3	4	0.977	0.999	0.984	0.825	0.825
3	5	0.971	1.000	0.983	0.904	0.904
3	6	0.966	1.000	0.986	0.831	0.831
3	7	0.971	1.000	0.988	0.879	0.879
3	8	0.978	1.000	0.994	0.850	0.850
3	9	0.976	0.998	0.994	0.884	0.884
3	10	0.991	0.999	0.986	0.848	0.848
4	5	0.990	0.999	0.974	0.848	0.848
4	6	0.986	0.999	0.978	0.872	0.872
4	7	0.990	0.999	0.980	0.855	0.855
4	8	0.996	1.000	0.988	0.910	0.910
4	9	0.994	1.000	0.984	0.858	0.858
4	10	0.983	1.000	0.996	0.859	0.859
5	6	0.992	1.000	0.994	0.834	0.834
5	7	0.998	1.000	0.992	0.917	0.917
5	8	0.988	0.999	0.984	0.855	0.855
5	9	0.993	0.997	0.988	0.924	0.924
5	10	0.977	0.999	0.976	0.861	0.860
6	7	0.992	1.000	0.995	0.849	0.849
6	8	0.987	1.000	0.990	0.915	0.915
6	9	0.987	0.999	0.990	0.838	0.838
6	10	0.973	1.000	0.980	0.863	0.863
7	8	0.988	1.000	0.991	0.862	0.862
7	9	0.992	0.998	0.993	0.922	0.922
7	10	0.978	1.000	0.982	0.866	0.866
8	9	0.991	0.999	0.994	0.870	0.870
8	10	0.984	1.000	0.989	0.882	0.882
9	10	0.981	1.000	0.986	0.865	0.865
Average		0.986	0.999	0.988	0.871	0.871

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		Long	Medium	Short, Seg. 1	Short, Seg. 2
1	2	0.999	0.992	0.476	0.476
1	3	1.000	0.977	0.768	0.768
1	4	1.000	0.993	0.470	0.470
1	5	1.000	0.984	0.689	0.689
1	6	0.999	0.980	0.486	0.486
1	7	1.000	0.984	0.633	0.633
1	8	1.000	0.989	0.518	0.518
1	9	1.000	0.991	0.707	0.707
1	10	1.000	0.981	0.485	0.486
2	3	0.997	0.976	0.500	0.500
2	4	0.998	0.994	0.674	0.674
2	5	0.999	0.982	0.486	0.486
2	6	1.000	0.984	0.587	0.587
2	7	0.999	0.983	0.494	0.494
2	8	1.000	0.992	0.679	0.679
2	9	0.998	0.991	0.534	0.534
2	10	0.999	0.983	0.488	0.488
3	4	1.000	0.977	0.503	0.503
3	5	0.999	0.964	0.690	0.690
3	6	0.998	0.962	0.472	0.472
3	7	0.999	0.965	0.607	0.607
3	8	0.999	0.981	0.505	0.505
3	9	1.000	0.973	0.653	0.653
3	10	0.999	0.990	0.445	0.445
4	5	1.000	0.982	0.498	0.498
4	6	0.999	0.981	0.627	0.627
4	7	1.000	0.983	0.524	0.524
4	8	1.000	0.993	0.703	0.703
4	9	1.000	0.989	0.545	0.545
4	10	1.000	0.983	0.534	0.534
5	6	1.000	0.994	0.483	0.483
5	7	1.000	0.997	0.660	0.660
5	8	1.000	0.977	0.487	0.487
5	9	1.000	0.988	0.736	0.736
5	10	1.000	0.970	0.492	0.492
6	7	1.000	0.994	0.568	0.568
6	8	1.000	0.981	0.742	0.742
6	9	0.999	0.984	0.526	0.526
6	10	1.000	0.970	0.491	0.491
7	8	1.000	0.978	0.561	0.561
7	9	1.000	0.988	0.708	0.708
7	10	1.000	0.972	0.549	0.549
8	9	0.999	0.984	0.586	0.586
8	10	1.000	0.987	0.554	0.554
9	10	0.999	0.978	0.545	0.545
Average		0.999	0.983	0.570	0.570

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 10/21/2009

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech, Heather, Ma and Robert

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.783	0.531
Long (elev.)	0.982	0.841
Medium (elev.)	0.845	0.708
Short (elev.)	0.537	0.019
Long (slope)	0.980	0.930
Medium (slope)	0.733	0.507
Short (slope)	0.458	0.010

Result for Longitudinal Distance:

Error in longitudinal distance was -0.08 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)	Percent Error
1	74.3	497.79	-0.08
2	71.2	497.79	-0.08
3	72.2	497.79	-0.08
4	70.8	497.79	-0.08
5	72.0	497.79	-0.08
7	77.4	497.79	-0.08
8	70.9	497.79	-0.08
9	77.1	497.79	-0.08
10	72.6	497.79	-0.08
11	75.4	497.79	-0.08

Notes:

- Section length is 498.175 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The benchmark profile only covered 164.7 ft. Accuracy scores for the IRI waveband and the long waveband do not represent expected performance over a longer segment of road.
- Run 6 included a deep narrow dip that did not appear in the others. With run 6 eliminated, the Results for Profile change to:

Waveband	Repeatability Score	Accuracy Score
IRI	0.865	0.553
Long (elev.)	0.989	0.840
Medium (elev.)	0.926	0.735
Short (elev.)	0.587	0.019
Long (slope)	0.989	0.941
Medium (slope)	0.829	0.532
Short (slope)	0.514	0.010

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.490	0.835	0.722	0.015
2	0.679	0.860	0.815	0.024
3	0.659	0.841	0.814	0.018
4	0.667	0.868	0.773	0.025
5	0.613	0.833	0.802	0.017
6	0.327	0.843	0.468	0.016
7	0.630	0.851	0.779	0.023
8	0.308	0.805	0.569	0.012
9	0.564	0.860	0.748	0.023
10	0.371	0.810	0.594	0.015
Ave.	0.531	0.841	0.708	0.019

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.950	0.465	0.008
2	0.961	0.664	0.012
3	0.954	0.645	0.013
4	0.960	0.640	0.010
5	0.939	0.599	0.011
6	0.836	0.274	0.011
7	0.947	0.607	0.014
8	0.896	0.289	0.008
9	0.958	0.539	0.010
10	0.900	0.343	0.006
Ave.	0.930	0.507	0.010

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.851	0.985	0.936	0.511
1	3	0.935	1.000	0.970	0.849
1	4	0.844	0.980	0.945	0.446
1	5	0.943	0.993	0.967	0.922
1	6	0.443	0.965	0.495	0.179
1	7	0.859	0.984	0.937	0.523
1	8	0.858	0.998	0.914	0.697
1	9	0.892	0.985	0.947	0.585
1	10	0.856	0.987	0.893	0.674
2	3	0.893	0.985	0.952	0.541
2	4	0.955	0.994	0.972	0.456
2	5	0.890	0.978	0.947	0.492
2	6	0.477	0.953	0.549	0.476
2	7	0.958	0.999	0.983	0.541
2	8	0.732	0.987	0.856	0.397
2	9	0.947	0.999	0.969	0.846
2	10	0.822	0.997	0.890	0.669
3	4	0.883	0.980	0.941	0.477
3	5	0.977	0.993	0.987	0.846
3	6	0.443	0.967	0.518	0.300
3	7	0.879	0.984	0.939	0.426
3	8	0.798	0.997	0.884	0.612
3	9	0.878	0.985	0.932	0.636
3	10	0.802	0.987	0.871	0.541
4	5	0.883	0.973	0.936	0.440
4	6	0.445	0.946	0.530	0.443
4	7	0.926	0.995	0.969	0.566
4	8	0.710	0.981	0.852	0.365
4	9	0.922	0.995	0.968	0.707
4	10	0.783	0.991	0.878	0.520
5	6	0.435	0.970	0.505	0.286
5	7	0.889	0.977	0.934	0.502
5	8	0.810	0.990	0.884	0.689
5	9	0.891	0.978	0.929	0.586
5	10	0.808	0.980	0.869	0.587
6	7	0.457	0.952	0.527	0.436
6	8	0.462	0.961	0.491	0.179
6	9	0.476	0.951	0.543	0.399
6	10	0.453	0.952	0.506	0.302
7	8	0.749	0.986	0.863	0.407
7	9	0.955	0.999	0.970	0.799
7	10	0.844	0.997	0.899	0.637
8	9	0.774	0.986	0.884	0.457
8	10	0.905	0.989	0.966	0.478
9	10	0.856	0.997	0.913	0.721
Average		0.783	0.982	0.845	0.537

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.986	0.809	0.464
1	3	0.999	0.908	0.715
1	4	0.984	0.810	0.460
1	5	0.992	0.916	0.778
1	6	0.951	0.343	0.182
1	7	0.986	0.824	0.311
1	8	0.993	0.825	0.463
1	9	0.991	0.870	0.383
1	10	0.994	0.809	0.683
2	3	0.986	0.867	0.363
2	4	0.999	0.946	0.679
2	5	0.978	0.864	0.479
2	6	0.939	0.372	0.325
2	7	0.999	0.937	0.766
2	8	0.979	0.672	0.388
2	9	0.997	0.925	0.699
2	10	0.991	0.771	0.516
3	4	0.984	0.864	0.430
3	5	0.993	0.973	0.765
3	6	0.955	0.326	0.254
3	7	0.985	0.825	0.360
3	8	0.993	0.746	0.476
3	9	0.990	0.831	0.575
3	10	0.993	0.737	0.457
4	5	0.976	0.865	0.302
4	6	0.934	0.325	0.258
4	7	0.998	0.902	0.711
4	8	0.976	0.651	0.310
4	9	0.995	0.901	0.688
4	10	0.989	0.727	0.312
5	6	0.955	0.315	0.240
5	7	0.977	0.835	0.310
5	8	0.998	0.758	0.603
5	9	0.982	0.842	0.604
5	10	0.985	0.743	0.514
6	7	0.938	0.350	0.284
6	8	0.950	0.373	0.142
6	9	0.943	0.379	0.151
6	10	0.942	0.355	0.242
7	8	0.978	0.699	0.241
7	9	0.996	0.942	0.688
7	10	0.991	0.802	0.464
8	9	0.983	0.732	0.467
8	10	0.988	0.894	0.506
9	10	0.996	0.818	0.580
Average		0.980	0.733	0.458

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Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2010-Sept-14, 08:00 - 14:05

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.979
Long (elev.)	0.990
Medium (elev.)	0.985
Short (elev.)	0.770
Long (slope)	0.991
Medium (slope)	0.975
Short (slope)	0.485

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	96.4	1111.73
2	96.8	1111.73
3	96.7	1111.73
Comb.	95.4	1111.73

Repeatability:

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.979	0.988	0.975	0.517	0.508	0.508	0.482
1	3	0.984	0.998	0.978	0.511	0.503	0.503	0.480
2	3	0.975	0.987	0.971	0.465	0.455	0.455	0.430
Average		0.979	0.991	0.975	0.498	0.489	0.489	0.464

		Cross Correlation by Waveband, Elevation					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.995	0.989	0.817	0.800	0.800	0.770
1	3	0.990	0.982	0.828	0.804	0.804	0.775
2	3	0.985	0.983	0.749	0.708	0.708	0.681
Average		0.990	0.985	0.798	0.771	0.771	0.742

Notes:

- Section length is 1111.41 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2010-Sept-13, 08:57 - 11:52

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.991
Long (elev.)	0.996
Medium (elev.)	0.995
Short (elev.)	0.969
Long (slope)	0.999
Medium (slope)	0.977
Short (slope)	0.655

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	95.0	504.47
2	95.0	504.47
Comb.	96.2	504.47

Notes:

- Section length is 504.81 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Segment 6 in run 3 was missing data.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 2010-Sept-14, 13:54 - 16:19

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.978
Long (elev.)	0.998
Medium (elev.)	0.980
Short (elev.)	0.759
Long (slope)	0.999
Medium (slope)	0.959
Short (slope)	0.355

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	60.3	433.72
2	60.4	433.72
3	60.4	433.72
Comb.	60.5	433.72

Repeatability:

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.981	0.999	0.966	0.346	0.346	0.346	0.346
1	3	0.978	1.000	0.956	0.356	0.356	0.356	0.356
2	3	0.975	0.999	0.954	0.363	0.363	0.363	0.363
Average		0.978	0.999	0.959	0.355	0.355	0.355	0.355

		Cross Correlation by Waveband, Elevation					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	1.000	0.985	0.729	0.740	0.734	0.740
1	3	0.998	0.979	0.773	0.784	0.784	0.784
2	3	0.997	0.976	0.753	0.763	0.763	0.763
Average		0.998	0.980	0.752	0.763	0.760	0.763

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 2010-Sept-16, 09:45 - 11:45

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.994
Long (elev.)	0.990
Medium (elev.)	0.996
Short (elev.)	0.881
Long (slope)	0.997
Medium (slope)	0.992
Short (slope)	0.615

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	82.0	499.32
2	82.4	499.32
3	82.2	499.32
Comb.	82.7	499.32

Repeatability:

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.994	0.997	0.992	0.594	0.594	0.594	0.594
1	3	0.993	0.997	0.993	0.651	0.651	0.651	0.651
2	3	0.994	0.996	0.992	0.599	0.599	0.599	0.599
Average		0.994	0.997	0.992	0.615	0.615	0.615	0.615

		Cross Correlation by Waveband, Elevation					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.986	0.995	0.866	0.866	0.866	0.866
1	3	0.986	0.995	0.889	0.889	0.889	0.889
2	3	0.998	0.998	0.889	0.889	0.889	0.889
Average		0.990	0.996	0.881	0.881	0.881	0.881

Notes:

- Section length is 499.65 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the repeat measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2010-sept-14, 17:06 - 17:38

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Scott Bogard

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.978
Long (elev.)	0.996
Medium (elev.)	0.980
Short (elev.)	0.961
Long (slope)	0.996
Medium (slope)	0.973
Short (slope)	0.611

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	127.4	167.22
2	128.1	167.22
3	123.9	167.22
Comb.	127.4	167.22

Repeatability:

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		IRI	Long	Medium	Short
1	2	0.993	0.994	0.993	0.606
1	3	0.970	0.999	0.964	0.613
2	3	0.972	0.996	0.961	0.613
Average		0.978	0.996	0.973	0.611

Run 1	Run 2	Cross Correlation by Waveband, Elevation		
		Long	Medium	Short
1	2	0.993	0.987	0.956
1	3	0.999	0.980	0.969
2	3	0.996	0.971	0.957
Average		0.996	0.980	0.961

Notes:

- Section length is 167.48 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2010-Sept-13, 14:03 - 17:11

Device: Benchmark Profiler

Operator(s): UMTRI, Chris Winkler, Steve Karamihas

Recording Interval: 5.08 mm

Use Moving Average: Yes

The official profiles used for comparison were decimated to an interval of 5.08 mm after application of a low-pass bridging filter with a base length of 76.2 mm.

Results for Profile:

Waveband	Repeatability Score
IRI	0.971
Long (elev.)	0.986
Medium (elev.)	0.978
Short (elev.)	0.832
Long (slope)	0.992
Medium (slope)	0.965
Short (slope)	0.659

Run Log, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	77.1	528.17
2	75.7	528.17
3	76.5	528.17
Comb.	76.7	528.17

Repeatability:

		Cross Correlation by Waveband, Elevation						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.962	0.987	0.955	0.711	0.711	0.711	0.711
1	3	0.978	0.998	0.965	0.638	0.636	0.636	0.636
2	3	0.975	0.990	0.976	0.633	0.631	0.631	0.631
Average		0.971	0.992	0.965	0.661	0.659	0.659	0.659

		Cross Correlation by Waveband, Slope					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.979	0.984	0.833	0.827	0.827	0.827
1	3	0.992	0.972	0.838	0.828	0.828	0.828
2	3	0.986	0.979	0.840	0.837	0.837	0.837
Average		0.986	0.978	0.837	0.831	0.831	0.831

Notes:

- Section length is 538.54 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All repeat measurements use a single laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2010-Sept-16, 11:37 – 14:40

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.900	0.730
Long (elev.)	0.986	0.986
Medium (elev.)	0.932	0.861
Short (elev.)	0.400	0.145
Long (slope)	0.985	0.985
Medium (slope)	0.896	0.688
Short (slope)	0.200	0.052

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.09 to -0.01 percent.

Run Log, DMI Results:

Run	Start Time	End Time	Start Time	End Time
1	11:37	11:47	13:33	13:45
2	11:52	12:02	13:49	13:58
3	12:06	12:16	14:02	14:11
4	12:20	12:29	14:16	14:25
5	12:33	12:43	14:30	14:40

The section was run in two segments, with 5 runs on each segment before proceeding to the next.

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	116.2	21.8	1110.416	-0.09
2	112.4	17.8	1111.25	-0.01
3	114.7	20.3	1111.041	-0.03
4	113.7	19.2	1111.041	-0.03
5	116.9	22.5	1110.833	-0.05

Notes:

- Section length is 1111.41 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.705	0.986	0.668	0.042	0.042	0.041	0.044
2	0.731	0.988	0.689	0.048	0.044	0.055	0.040
3	0.741	0.982	0.690	0.066	0.065	0.060	0.055
4	0.749	0.983	0.707	0.060	0.057	0.057	0.051
5	0.725	0.985	0.685	0.048	0.042	0.065	0.064
Ave.	0.730	0.985	0.688	0.053	0.050	0.056	0.051

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.989	0.860	0.137	0.097	0.109	0.094
2	0.986	0.881	0.138	0.114	0.113	0.099
3	0.979	0.844	0.179	0.165	0.154	0.123
4	0.983	0.878	0.212	0.200	0.188	0.162
5	0.991	0.842	0.174	0.151	0.155	0.139
Ave.	0.986	0.861	0.168	0.145	0.144	0.124

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.902	0.982	0.902	0.265	0.273	0.273
1	3	0.913	0.976	0.915	0.241	0.184	0.184
1	4	0.871	0.994	0.872	0.121	0.167	0.167
1	5	0.884	0.992	0.880	0.200	0.203	0.203
2	3	0.896	0.993	0.899	0.216	0.218	0.218
2	4	0.925	0.981	0.915	0.185	0.192	0.192
2	5	0.893	0.980	0.885	0.182	0.179	0.213
3	4	0.909	0.979	0.899	0.174	0.171	0.171
3	5	0.891	0.979	0.894	0.228	0.231	0.231
4	5	0.919	0.994	0.902	0.164	0.176	0.154
Average		0.900	0.985	0.896	0.198	0.199	0.201

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.981	0.940	0.598	0.602	0.602	0.604
1	3	0.972	0.934	0.428	0.396	0.396	0.399
1	4	0.978	0.941	0.227	0.253	0.250	0.250
1	5	0.985	0.921	0.385	0.402	0.402	0.409
2	3	0.990	0.915	0.358	0.363	0.363	0.366
2	4	0.996	0.957	0.280	0.296	0.296	0.305
2	5	0.993	0.909	0.547	0.553	0.553	0.553
3	4	0.993	0.925	0.399	0.369	0.369	0.373
3	5	0.986	0.950	0.353	0.386	0.385	0.378
4	5	0.991	0.929	0.404	0.381	0.382	0.372
Average		0.986	0.932	0.398	0.400	0.400	0.401

Auxiliary Information:

- Dan Huddleson observed most of the testing. John Hall observed the end of run 5 on the second segment.
- Used a chalk line left by another crew.
- The section was run in three segments. Five runs were performed on each segment before moving to the next segment. The border between segments was marked with chalk.
- The test set-up for each segment included two tripod-mounted spinning lasers placed along the edge of the section. One was placed at the quarter point, and the other at a point three quarters of the way long the segment. The device traversed half of the segment with the first laser operating and the second laser covered. The operator stopped at the half-way point, and continued after another operator uncovered the second laser and covered the first laser.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2010-Sept-16, 07:27 – 08:42

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.879	0.764
Long (elev.)	0.997	0.985
Medium (elev.)	0.921	0.873
Short (elev.)	0.483	0.150
Long (slope)	0.996	0.992
Medium (slope)	0.860	0.664
Short (slope)	0.305	0.125

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.08 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	07:27	07:39	101.7	5.8	504.99	0.04
2	07:44	07:56	106.0	10.3	505.208	0.08
3	08:01	08:12	102.2	6.3	505.208	0.08
4	08:15	08:27	106.9	11.1	505.208	0.08
5	08:31	08:42	100.7	4.7	505.208	0.08

Notes:

- Section length is 504.81 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.774	0.990	0.674	0.156	0.151	0.151	0.151
2	0.755	0.994	0.654	0.058	0.042	0.043	0.042
3	0.763	0.991	0.664	0.144	0.143	0.143	0.143
4	0.758	0.994	0.657	0.064	0.179	0.180	0.179
5	0.772	0.991	0.675	0.136	0.133	0.131	0.131
Ave.	0.764	0.992	0.664	0.111	0.130	0.129	0.129

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.984	0.846	0.190	0.182	0.182	0.182
2	0.979	0.894	0.084	0.091	0.091	0.138
3	0.989	0.874	0.081	0.083	0.128	0.127
4	0.988	0.905	0.219	0.217	0.219	0.218
5	0.987	0.845	0.145	0.139	0.140	0.141
Ave.	0.985	0.873	0.144	0.142	0.152	0.161

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.861	0.995	0.841	0.331	0.318	0.318	0.318
1	3	0.891	0.998	0.867	0.233	0.223	0.223	0.223
1	4	0.881	0.995	0.849	0.353	0.341	0.341	0.341
1	5	0.890	0.997	0.865	0.296	0.287	0.292	0.287
2	3	0.904	0.995	0.880	0.246	0.240	0.240	0.240
2	4	0.890	0.998	0.869	0.331	0.326	0.326	0.326
2	5	0.875	0.995	0.866	0.343	0.339	0.345	0.345
3	4	0.838	0.994	0.833	0.246	0.242	0.242	0.242
3	5	0.929	0.998	0.908	0.444	0.447	0.446	0.447
4	5	0.828	0.994	0.818	0.275	0.271	0.271	0.271
Average		0.879	0.996	0.860	0.310	0.303	0.304	0.304

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.923	0.353	0.348	0.348	0.348
1	3	0.999	0.931	0.464	0.464	0.464	0.464
1	4	0.999	0.908	0.470	0.459	0.459	0.459
1	5	0.999	0.923	0.530	0.525	0.527	0.527
2	3	0.993	0.952	0.553	0.553	0.553	0.553
2	4	0.995	0.926	0.490	0.492	0.492	0.492
2	5	0.995	0.913	0.571	0.579	0.579	0.579
3	4	0.999	0.918	0.302	0.300	0.302	0.300
3	5	0.999	0.934	0.737	0.738	0.738	0.738
4	5	0.999	0.880	0.363	0.368	0.367	0.368
Average		0.997	0.921	0.483	0.483	0.483	0.483

Auxiliary Information:

- Dan Huddleson observed the testing.
- Used a chalk line left by another crew.
- The test set-up included two tripod-mounted spinning lasers placed along the edge of the section. One was placed at the quarter point, and the other at a point three quarters of the way long the section. The device traversed half of the section with the first laser operating and the second laser covered. The operator stopped at the half-way point, and continued after another operator uncovered the second laser and covered the first laser.
- During run 4, a minivan passed between the tripods and the device. The operator confirmed (using the on-board display) that the run was not compromised.
- Attempted to measure this section on 15-Sept starting at 10:17, but stopped during the first run because of rain.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 2010-Sept-16, 09:49 – 10:50

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.767	0.591
Long (elev.)	0.989	0.993
Medium (elev.)	0.817	0.633
Short (elev.)	0.468	0.096
Long (slope)	0.988	0.984
Medium (slope)	0.737	0.429
Short (slope)	0.235	0.099

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.07 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	09:49	09:59	74.3	22.8	433.958	-0.02
2	10:02	10:12	73.6	21.7	433.749	-0.07
3	10:16	10:25	76.4	26.3	433.958	-0.02
4	10:28	10:38	73.7	21.8	433.958	-0.02
5	10:41	10:50	72.7	20.2	434.16	0.03

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.522	0.978	0.391	0.124	0.124	0.124	0.124
2	0.627	0.978	0.449	0.091	0.091	0.091	0.091
3	0.571	0.987	0.417	0.112	0.111	0.111	0.111
4	0.598	0.992	0.431	0.065	0.086	0.086	0.086
5	0.638	0.986	0.459	0.087	0.087	0.087	0.087
Ave.	0.591	0.984	0.429	0.096	0.100	0.100	0.100

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.992	0.576	0.077	0.096	0.096	0.095
2	0.992	0.642	0.105	0.106	0.102	0.105
3	0.984	0.631	0.101	0.112	0.111	0.110
4	0.999	0.666	0.060	0.082	0.082	0.082
5	0.996	0.652	0.153	0.077	0.094	0.075
Ave.	0.993	0.633	0.099	0.095	0.097	0.093

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.694	0.988	0.713	0.248	0.244	0.250	0.244
1	3	0.732	0.985	0.731	0.268	0.268	0.268	0.268
1	4	0.805	0.987	0.779	0.299	0.166	0.299	0.299
1	5	0.683	0.988	0.703	0.288	0.288	0.288	0.288
2	3	0.834	0.978	0.769	0.248	0.227	0.227	0.248
2	4	0.759	0.989	0.692	0.241	0.241	0.241	0.241
2	5	0.837	0.994	0.747	0.234	0.234	0.234	0.249
3	4	0.717	0.987	0.678	0.189	0.189	0.189	0.189
3	5	0.773	0.988	0.733	0.158	0.157	0.158	0.158
4	5	0.835	0.995	0.825	0.221	0.221	0.221	0.221
Average		0.767	0.988	0.737	0.239	0.224	0.238	0.241

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.986	0.848	0.374	0.351	0.351	0.351
1	3	0.992	0.817	0.447	0.412	0.412	0.422
1	4	0.993	0.819	0.540	0.548	0.548	0.548
1	5	0.991	0.760	0.454	0.444	0.444	0.444
2	3	0.973	0.818	0.548	0.540	0.537	0.537
2	4	0.995	0.822	0.411	0.399	0.399	0.399
2	5	0.998	0.808	0.559	0.559	0.559	0.559
3	4	0.983	0.784	0.428	0.396	0.396	0.405
3	5	0.979	0.838	0.517	0.500	0.499	0.501
4	5	0.999	0.859	0.504	0.487	0.487	0.487
Average		0.989	0.817	0.478	0.464	0.463	0.465

Auxiliary Information:

- Dan Huddleson observed the testing.
- Used a chalk line left by another crew.
- The test set-up included two tripod-mounted spinning lasers placed along the edge of the section. One was placed at the quarter point, and the other at a point three quarters of the way long the section. The device traversed half of the section with the first laser operating and the second laser covered. The operator stopped at the half-way point, and continued after another operator uncovered the second laser and covered the first laser.

Benchmark Test Evaluation Report

Test Section: US 10 E.B. near Junction City, WI

Longitudinal Tining

Date: 2010-Sept-17, 12:04 – 13:11

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.873	0.828
Long (elev.)	0.955	0.855
Medium (elev.)	0.953	0.952
Short (elev.)	0.473	0.079
Long (slope)	0.967	0.946
Medium (slope)	0.882	0.861
Short (slope)	0.244	0.074

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.01 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	12:04	12:17	85.1	2.9	499.791	0.03
2	12:21	12:31	89.5	8.2	499.583	-0.01
3	12:34	12:43	89.6	8.4	499.791	0.03
4	12:49	12:59	86.1	4.1	499.791	0.03
5	13:03	13:11	83.0	0.4	499.791	0.03

Notes:

- Section length is 499.65 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.862	0.942	0.885	0.059	0.065	0.059	0.059
2	0.827	0.974	0.873	0.099	0.099	0.099	0.099
3	0.768	0.939	0.786	0.055	0.055	0.055	0.055
4	0.839	0.940	0.868	0.097	0.097	0.097	0.097
5	0.847	0.936	0.893	0.053	0.053	0.053	0.070
Ave.	0.828	0.946	0.861	0.073	0.074	0.073	0.076

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.855	0.967	0.100	0.096	0.096	0.096
2	0.884	0.961	0.072	0.072	0.072	0.072
3	0.842	0.927	0.056	0.056	0.056	0.056
4	0.852	0.960	0.088	0.088	0.088	0.088
5	0.843	0.945	0.084	0.084	0.084	0.084
Ave.	0.855	0.952	0.080	0.079	0.079	0.079

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.846	0.963	0.889	0.210	0.212	0.210	0.212
1	3	0.831	0.950	0.843	0.271	0.271	0.271	0.271
1	4	0.847	0.989	0.878	0.230	0.149	0.149	0.149
1	5	0.869	0.984	0.897	0.254	0.254	0.254	0.254
2	3	0.892	0.974	0.877	0.237	0.239	0.221	0.221
2	4	0.919	0.961	0.922	0.285	0.285	0.285	0.285
2	5	0.891	0.961	0.900	0.222	0.222	0.222	0.222
3	4	0.881	0.950	0.880	0.239	0.239	0.221	0.206
3	5	0.832	0.947	0.827	0.303	0.303	0.304	0.302
4	5	0.920	0.993	0.910	0.264	0.266	0.265	0.266
Average		0.873	0.967	0.882	0.252	0.244	0.240	0.239

		Cross Correlation by Waveband, Elevation					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.961	0.960	0.409	0.419	0.409	0.419
1	3	0.917	0.944	0.501	0.501	0.501	0.501
1	4	0.988	0.975	0.417	0.416	0.416	0.417
1	5	0.982	0.963	0.385	0.385	0.385	0.385
2	3	0.938	0.957	0.566	0.566	0.566	0.566
2	4	0.962	0.955	0.550	0.549	0.550	0.550
2	5	0.963	0.943	0.483	0.483	0.483	0.483
3	4	0.924	0.949	0.468	0.468	0.468	0.468
3	5	0.919	0.919	0.396	0.396	0.396	0.396
4	5	0.992	0.966	0.555	0.555	0.555	0.555
Average		0.955	0.953	0.473	0.474	0.473	0.474

Auxiliary Information:

- Steve Karamihas observed the testing.
- The weather was cool and breezy. The pavement was slightly damp from an earlier rain storm, but nearly completely dry by the end of the last run.
- Used the provided paint line.
- The test set-up included two tripod-mounted spinning lasers placed along the edge of the section. One was placed at the quarter point, and the other at a point three quarters of the way long the section. The device traversed half of the section with the first laser operating and the second laser covered. The operator stopped at the half-way point, and continued after another operator uncovered the second laser and covered the first laser.
- During run 1, the operators stopped for a brief conversation with the monitors during the tripod exchange.
- The wind was stronger during run 3 than in the other runs.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2010-Sept-15, 14:37 – 15:06

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.919	0.904
Long (elev.)	0.982	0.971
Medium (elev.)	0.949	0.941
Short (elev.)	0.519	0.405
Long (slope)	0.993	0.982
Medium (slope)	0.905	0.881
Short (slope)	0.272	0.157

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.01 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	14:37	14:42	126.3	-0.9	167.5	0.01
2	14:46	14:50	132.9	4.3	167.5	0.01
3	14:51	14:54	130.3	2.3	167.5	0.01
4	14:56	14:59	124.7	-2.2	167.5	0.01
5	15:02	15:06	125.6	-1.5	167.5	0.01

Notes:

- Section length is 167.48 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Slope			
	IRI	Long	Medium	Short
1	0.891	0.978	0.874	0.175
2	0.919	0.987	0.877	0.147
3	0.917	0.981	0.897	0.134
4	0.888	0.982	0.875	0.144
5	0.907	0.982	0.883	0.187
Ave.	0.904	0.982	0.881	0.157

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation		
	Long	Medium	Short
1	0.956	0.938	0.416
2	0.989	0.968	0.425
3	0.953	0.927	0.378
4	0.977	0.929	0.407
5	0.980	0.945	0.400
Ave.	0.971	0.941	0.405

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		IRI	Long	Medium	Short
1	2	0.907	0.988	0.887	0.212
1	3	0.943	0.998	0.946	0.213
1	4	0.936	0.995	0.931	0.478
1	5	0.930	0.986	0.900	0.335
2	3	0.934	0.992	0.907	0.253
2	4	0.884	0.995	0.871	0.267
2	5	0.932	0.998	0.915	0.315
3	4	0.921	0.998	0.918	0.184
3	5	0.913	0.990	0.890	0.232
4	5	0.895	0.994	0.890	0.230
Average		0.919	0.993	0.905	0.272

Run 1	Run 2	Cross Correlation by Waveband, Elevation		
		Long	Medium	Short
1	2	0.968	0.955	0.482
1	3	0.998	0.962	0.413
1	4	0.983	0.957	0.743
1	5	0.971	0.948	0.514
2	3	0.968	0.943	0.640
2	4	0.993	0.937	0.456
2	5	0.996	0.971	0.638
3	4	0.979	0.967	0.413
3	5	0.966	0.916	0.446
4	5	0.994	0.932	0.442
Average		0.982	0.949	0.519

Auxiliary Information:

- John Koch observed the testing.
- Used a chalk line left by another crew.
- Conducted the runs using a single tripod set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2010-Sept-15, 08:27 – 09:58

Device: APR Consultants, Auto Rod & Level

Operator(s): APR Consultants, Mike and Dan Freeman

Recording Interval: 0.2083 ft

Use Moving Average: Yes

No low-pass filtering was apparent.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.868	0.587
Long (elev.)	0.969	0.970
Medium (elev.)	0.923	0.717
Short (elev.)	0.482	0.087
Long (slope)	0.984	0.968
Medium (slope)	0.871	0.490
Short (slope)	0.267	0.088

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.08 to -0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:27	08:42	95.04	23.9	538.12	-0.08
2	08:47	09:00	91.9	19.8	538.33	-0.04
3	09:06	09:20	91.5	19.3	538.3	-0.04
4	09:24	09:37	93.8	22.3	538.33	-0.04
5	09:42	09:57	92.5	20.6	538.33	-0.04

Notes:

- Section length is 538.54 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.565	0.952	0.463	0.051	0.053	0.053	0.053
2	0.575	0.985	0.489	0.065	0.061	0.061	0.061
3	0.600	0.977	0.503	0.120	0.121	0.121	0.121
4	0.591	0.963	0.491	0.098	0.096	0.096	0.096
5	0.604	0.965	0.506	0.108	0.108	0.107	0.108
Ave.	0.587	0.968	0.490	0.088	0.088	0.088	0.088

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.935	0.678	0.096	0.095	0.095	0.095
2	0.980	0.717	0.078	0.048	0.049	0.048
3	0.987	0.712	0.104	0.100	0.100	0.100
4	0.971	0.730	0.050	0.063	0.063	0.063
5	0.975	0.745	0.125	0.120	0.120	0.120
Ave.	0.970	0.717	0.091	0.085	0.085	0.085

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope						
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.802	0.969	0.815	0.260	0.264	0.264	0.264
1	3	0.880	0.973	0.862	0.280	0.271	0.271	0.271
1	4	0.835	0.993	0.851	0.220	0.214	0.214	0.214
1	5	0.912	0.990	0.889	0.348	0.341	0.341	0.341
2	3	0.830	0.993	0.857	0.278	0.273	0.273	0.273
2	4	0.936	0.977	0.919	0.464	0.472	0.471	0.472
2	5	0.857	0.980	0.872	0.164	0.164	0.164	0.164
3	4	0.846	0.983	0.865	0.244	0.239	0.239	0.239
3	5	0.908	0.987	0.910	0.182	0.184	0.184	0.184
4	5	0.873	0.995	0.876	0.246	0.245	0.245	0.245
Average		0.868	0.984	0.871	0.269	0.267	0.267	0.267

		Cross Correlation by Waveband, Elevation					
Run 1	Run 2	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.954	0.914	0.464	0.458	0.323	0.385
1	3	0.932	0.928	0.508	0.497	0.498	0.497
1	4	0.962	0.917	0.455	0.443	0.443	0.443
1	5	0.958	0.921	0.642	0.636	0.636	0.636
2	3	0.978	0.919	0.417	0.417	0.474	0.417
2	4	0.988	0.941	0.747	0.751	0.750	0.751
2	5	0.992	0.921	0.356	0.297	0.297	0.410
3	4	0.968	0.915	0.437	0.438	0.438	0.438
3	5	0.973	0.918	0.477	0.467	0.467	0.467
4	5	0.992	0.939	0.439	0.311	0.425	0.434
Average		0.969	0.923	0.494	0.471	0.475	0.488

Auxiliary Information:

- John Koch observed the testing.
- Used a chalk line left by another crew.
- The test set-up included two tripod-mounted spinning lasers placed along the edge of the section. One was placed at the quarter point, and the other at a point three quarters of the way long the section. The device traversed half of the section with the first laser operating and the second laser covered. The operator stopped at the half-way point, and continued after another operator uncovered the second laser and covered the first laser.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2010-Sept-16, 08:32 – 11:24

Device: SurPro 3000+

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.997	0.980
Long (elev.)	0.998	0.996
Medium (elev.)	0.996	0.978
Short (elev.)	0.972	0.801
Long (slope)	1.000	0.993
Medium (slope)	0.996	0.960
Short (slope)	0.922	0.235

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.09 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	08:32	09:03	95.3	-0.1	339.000	0.07
2	09:06	09:23	95.2	-0.2	339.074	0.09
3	09:30	09:45	95.4	0.0	338.975	0.06
4	09:51	10:05	95.3	-0.1	338.850	0.03
6	11:07	11:24	95.2	-0.2	338.825	0.02

Notes:

- Section length is 1111.41 ft, measured by a steel tape and corrected for temperature.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- All length values derived from submitted data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.984	0.994	0.967	0.250	0.239	0.239	0.198
2	0.979	0.994	0.957	0.264	0.247	0.247	0.213
3	0.977	0.993	0.960	0.251	0.235	0.234	0.198
4	0.979	0.993	0.958	0.261	0.244	0.244	0.213
6	0.981	0.992	0.959	0.247	0.233	0.233	0.203
Ave.	0.980	0.993	0.960	0.254	0.240	0.239	0.205

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.997	0.982	0.819	0.800	0.800	0.774
2	0.998	0.976	0.844	0.789	0.828	0.800
3	0.993	0.978	0.810	0.794	0.794	0.770
4	0.996	0.975	0.824	0.808	0.807	0.783
6	0.995	0.980	0.812	0.799	0.798	0.775
Ave.	0.996	0.978	0.822	0.798	0.806	0.780

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.995	1.000	0.994	0.905	0.896	0.896	0.889
1	3	0.996	1.000	0.995	0.933	0.926	0.926	0.915
1	4	0.997	1.000	0.995	0.924	0.917	0.917	0.907
1	6	0.996	0.999	0.994	0.966	0.954	0.954	0.946
2	3	0.996	1.000	0.995	0.907	0.898	0.902	0.899
2	4	0.998	1.000	0.999	0.957	0.958	0.958	0.953
2	6	0.999	0.999	0.998	0.901	0.900	0.900	0.897
3	4	0.998	1.000	0.996	0.920	0.911	0.911	0.909
3	6	0.996	1.000	0.995	0.953	0.939	0.939	0.939
4	6	0.998	1.000	0.998	0.920	0.920	0.920	0.913
Average		0.997	1.000	0.996	0.929	0.922	0.922	0.917

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.999	0.995	0.962	0.959	0.958	0.957
1	3	0.996	0.997	0.973	0.976	0.976	0.974
1	4	0.999	0.993	0.986	0.978	0.978	0.977
1	6	0.998	0.998	0.988	0.988	0.988	0.986
2	3	0.995	0.997	0.955	0.957	0.957	0.959
2	4	0.998	0.998	0.974	0.975	0.975	0.975
2	6	0.997	0.996	0.955	0.958	0.957	0.959
3	4	0.997	0.995	0.974	0.972	0.972	0.974
3	6	0.998	0.998	0.984	0.978	0.978	0.978
4	6	0.999	0.995	0.976	0.977	0.977	0.976
Average		0.998	0.996	0.973	0.972	0.971	0.971

Auxiliary Information:

- John Hall observed the runs.
- Loop closure was performed on run 1, but not the others.
- Operators placed a chalk line.
- The first attempt at run 2 was aborted after 50 ft, because the operator (Paul) bumped the device with his foot.
- Run 5 was rejected by the operator because the longitudinal distance was not consistent with the others. Plots of the run revealed corrupted data about 350 ft from the start of the run.
- Run 6 was performed after a brief break.
- The first attempt at run 6 was aborted after 20 ft, because the operator (Ewing) bumped the device.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2010-Sept-14, 14:55 – 16:46

Device: SurPro 3000+

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.994	0.985
Long (elev.)	0.999	0.991
Medium (elev.)	0.990	0.987
Short (elev.)	0.963	0.698
Long (slope)	0.999	0.998
Medium (slope)	0.991	0.972
Short (slope)	0.905	0.045

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 1.19 to 1.27 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
2	15:08	15:24	94.8	-1.4	155.74	1.22
3	15:26	15:43	95.6	-0.6	155.675	1.18
4	15:46	16:01	95.8	-0.4	155.75	1.22
5	16:03	16:19	95.4	-0.8	155.70	1.19
6	16:20	16:37	95.8	-0.3	155.825	1.27

Notes:

- Section length is 504.81 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.988	0.999	0.972	0.026	0.033	0.033	0.033
3	0.986	0.998	0.966	0.047	0.124	0.124	0.124
4	0.983	0.997	0.978	0.024	0.032	0.032	0.032
5	0.986	0.999	0.972	0.030	0.033	0.033	0.033
6	0.982	0.998	0.974	0.021	0.029	0.029	0.029
Ave.	0.985	0.998	0.972	0.030	0.050	0.050	0.050

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
	2	0.990	0.990	0.691	0.688	0.688
3	0.993	0.985	0.680	0.677	0.677	0.677
4	0.987	0.984	0.716	0.715	0.715	0.715
5	0.993	0.986	0.703	0.702	0.702	0.702
6	0.990	0.992	0.706	0.704	0.704	0.704
Ave.	0.991	0.987	0.699	0.697	0.697	0.697

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	3	0.996	0.999	0.991	0.848	0.846	0.846	0.846
2	4	0.991	0.999	0.990	0.933	0.933	0.933	0.933
2	5	0.996	0.999	0.996	0.948	0.950	0.950	0.950
2	6	0.992	0.999	0.993	0.934	0.934	0.934	0.934
3	4	0.994	1.000	0.985	0.824	0.823	0.823	0.823
3	5	0.997	0.999	0.991	0.865	0.866	0.866	0.866
3	6	0.994	0.999	0.988	0.848	0.845	0.845	0.845
4	5	0.993	0.999	0.991	0.936	0.935	0.935	0.935
4	6	0.997	0.999	0.994	0.963	0.964	0.964	0.964
5	6	0.993	0.999	0.994	0.952	0.950	0.950	0.950
Average		0.994	0.999	0.991	0.905	0.905	0.905	0.905

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	3	1.000	0.993	0.959	0.960	0.960	0.960
2	4	0.999	0.985	0.958	0.958	0.958	0.958
2	5	0.999	0.994	0.981	0.981	0.981	0.981
2	6	1.000	0.997	0.970	0.969	0.969	0.969
3	4	0.998	0.981	0.929	0.929	0.929	0.929
3	5	1.000	0.997	0.953	0.954	0.954	0.954
3	6	0.999	0.992	0.945	0.945	0.945	0.945
4	5	0.998	0.981	0.971	0.970	0.970	0.970
4	6	0.999	0.987	0.976	0.977	0.977	0.977
5	6	0.999	0.992	0.985	0.984	0.984	0.984
Average		0.999	0.990	0.963	0.963	0.963	0.963

Auxiliary Information:

- John Hall observed the testing.
- Operators placed a chalk line over the existing chalk line.
- All runs included loop closure.
- Run 1 was never completed, but no reason was given.
- At the end of run 4, the operator pushed the wrong button, and was not sure that the run was captured. (It was.)
- The operator performed a 7th run, but seemed to have difficulty at the end of the the section. The run was scrapped, and no return measurement was conducted.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 2010-Sept-14, 17:50 – 18:35
Device: SurPro 3000+
Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung
Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.981	0.879
Long (elev.)	1.000	0.997
Medium (elev.)	0.949	0.755
Short (elev.)	0.947	0.525
Long (slope)	1.000	0.999
Medium (slope)	0.945	0.732
Short (slope)	0.792	0.084

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.21 to 0.34 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	17:50	17:56	55.1	-9.0	132.575	0.21
2	18:00	18:06	54.9	-9.2	132.700	0.31
3	18:09	18:15	54.4	-10.1	132.575	0.21
4	18:19	18:25	53.9	-10.8	132.750	0.34
5	18:28	18:35	53.4	-11.6	132.750	0.34

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.896	0.999	0.767	0.098	0.098	0.098	0.098
2	0.892	0.999	0.762	0.068	0.068	0.068	0.068
3	0.879	0.999	0.732	0.096	0.096	0.096	0.096
4	0.874	0.999	0.715	0.068	0.068	0.068	0.068
5	0.856	0.999	0.683	0.089	0.089	0.089	0.089
Ave.	0.879	0.999	0.732	0.084	0.084	0.084	0.084

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.998	0.790	0.520	0.538	0.537	0.537
2	0.997	0.784	0.513	0.527	0.526	0.526
3	0.997	0.755	0.519	0.538	0.537	0.537
4	0.997	0.737	0.512	0.527	0.526	0.525
5	0.998	0.711	0.507	0.519	0.518	0.517
Ave.	0.997	0.755	0.514	0.530	0.529	0.528

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.993	1.000	0.985	0.719	0.719	0.719	0.719
1	3	0.982	1.000	0.952	0.935	0.935	0.935	0.935
1	4	0.979	1.000	0.934	0.700	0.700	0.700	0.700
1	5	0.962	1.000	0.898	0.800	0.800	0.800	0.800
2	3	0.987	1.000	0.960	0.689	0.689	0.689	0.689
2	4	0.985	1.000	0.943	0.941	0.941	0.941	0.941
2	5	0.967	1.000	0.906	0.844	0.844	0.844	0.844
3	4	0.994	1.000	0.974	0.696	0.696	0.696	0.696
3	5	0.977	1.000	0.936	0.778	0.778	0.778	0.778
4	5	0.981	1.000	0.957	0.817	0.817	0.817	0.817
Average		0.981	1.000	0.945	0.792	0.792	0.792	0.792

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	1.000	0.986	0.947	0.946	0.946	0.946
1	3	1.000	0.957	0.970	0.968	0.968	0.968
1	4	1.000	0.936	0.947	0.948	0.948	0.948
1	5	1.000	0.906	0.927	0.925	0.925	0.925
2	3	1.000	0.966	0.924	0.921	0.921	0.921
2	4	1.000	0.945	0.971	0.969	0.969	0.969
2	5	1.000	0.915	0.977	0.976	0.977	0.977
3	4	1.000	0.974	0.947	0.947	0.947	0.947
3	5	1.000	0.943	0.909	0.906	0.906	0.906
4	5	1.000	0.967	0.961	0.958	0.958	0.958
Average		1.000	0.949	0.948	0.947	0.947	0.947

Auxiliary Information:

- John Hall observed the runs.
- Loop closure was not performed.
- Operators placed a chalk line.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding
Date: 2010-Sept-16, 13:17 – 14:05
Device: SurPro 3000+
Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung
Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.993	0.902
Long (elev.)	1.000	0.999
Medium (elev.)	0.978	0.802
Short (elev.)	0.969	0.540
Long (slope)	1.000	0.999
Medium (slope)	0.980	0.787
Short (slope)	0.921	0.075

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.17 to 0.25 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
6	13:17	13:23	55.5	-8.3	132.525	0.17
7	13:27	13:34	55.8	-7.7	132.575	0.21
8	13:38	13:44	55.4	-8.5	132.550	0.19
9	13:48	13:55	55.5	-8.2	132.625	0.25
10	13:58	14:05	56.0	-7.4	132.550	0.19

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
6	0.897	0.999	0.772	0.072	0.072	0.072	0.072
7	0.902	0.999	0.788	0.075	0.075	0.075	0.075
8	0.900	0.999	0.785	0.075	0.075	0.075	0.075
9	0.902	0.999	0.787	0.079	0.079	0.079	0.079
10	0.910	0.999	0.802	0.064	0.073	0.073	0.073
Ave.	0.902	0.999	0.787	0.073	0.075	0.075	0.075

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
6	0.999	0.784	0.527	0.549	0.548	0.548
7	0.998	0.796	0.526	0.543	0.542	0.542
8	1.000	0.800	0.529	0.549	0.548	0.548
9	0.999	0.803	0.520	0.539	0.538	0.538
10	1.000	0.825	0.528	0.548	0.547	0.547
Ave.	0.999	0.802	0.526	0.546	0.545	0.544

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
6	7	0.995	1.000	0.974	0.886	0.886	0.886	0.886
6	7	0.997	1.000	0.983	0.926	0.926	0.926	0.926
6	7	0.996	1.000	0.981	0.914	0.914	0.914	0.914
6	7	0.988	1.000	0.964	0.945	0.945	0.945	0.945
7	8	0.996	1.000	0.985	0.908	0.908	0.908	0.908
7	8	0.996	1.000	0.988	0.931	0.931	0.931	0.931
7	8	0.990	1.000	0.982	0.896	0.896	0.896	0.896
8	9	0.997	1.000	0.993	0.920	0.920	0.920	0.920
8	9	0.989	1.000	0.977	0.949	0.949	0.949	0.949
9	10	0.988	1.000	0.976	0.932	0.932	0.932	0.932
Average		0.993	1.000	0.980	0.921	0.921	0.921	0.921

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
6	7	1.000	0.978	0.948	0.946	0.946	0.946
6	7	1.000	0.980	0.975	0.976	0.976	0.976
6	7	1.000	0.976	0.959	0.959	0.960	0.960
6	7	1.000	0.953	0.983	0.984	0.984	0.984
7	8	1.000	0.993	0.955	0.952	0.952	0.952
7	8	1.000	0.994	0.986	0.989	0.989	0.989
7	8	1.000	0.968	0.966	0.962	0.962	0.962
8	9	1.000	0.993	0.963	0.962	0.962	0.962
8	9	1.000	0.970	0.983	0.984	0.984	0.984
9	10	1.000	0.972	0.971	0.970	0.970	0.970
Average		1.000	0.978	0.969	0.969	0.969	0.969

Auxiliary Information:

- John Hall observed the runs.
- Loop closure was not performed.
- Operators placed a chalk line.
- The operators performed a mock run before the 5 runs that were recorded to “climatize the machine”.

Benchmark Test Evaluation Report

Test Section: US 10 was -0.08 run 113e the set of 5 .B. near Junction City, WI

Longitudinal Tining

Date: 2010-Sept-17, 13:45 – 14:40

Device: SurPro 3000+

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.997	0.949
Long (elev.)	0.996	0.054
Medium (elev.)	0.997	0.941
Short (elev.)	0.968	0.648
Long (slope)	0.998	0.953
Medium (slope)	0.997	0.934
Short (slope)	0.945	0.190

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.08 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	13:45	14:00	79.1	-4.3	152.175	-0.08
2	14:02	14:09	79.1	-4.4	152.175	-0.08
3	14:13	14:20	79.1	-4.3	152.175	-0.08
4	14:22	14:30	79.1	-4.3	152.175	-0.08
5	14:34	14:40	79.3	-4.1	152.175	-0.08

Notes:

- Section length is 499.65 ft, measured by a steel tape and corrected for temperature.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.947	0.953	0.931	0.185	0.185	0.185	0.185
2	0.949	0.955	0.935	0.187	0.187	0.187	0.187
3	0.947	0.951	0.933	0.191	0.191	0.191	0.191
4	0.949	0.954	0.935	0.190	0.190	0.190	0.190
5	0.951	0.951	0.936	0.197	0.197	0.197	0.197
Ave.	0.949	0.953	0.934	0.190	0.190	0.190	0.190

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.957	0.938	0.648	0.648	0.648	0.648
2	0.954	0.943	0.639	0.639	0.639	0.639
3	0.957	0.939	0.655	0.655	0.655	0.655
4	0.952	0.942	0.641	0.641	0.641	0.641
5	0.952	0.941	0.657	0.657	0.657	0.657
Ave.	0.954	0.941	0.648	0.648	0.648	0.648

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.998	0.996	0.959	0.959	0.959	0.959
1	3	0.999	0.998	0.999	0.962	0.962	0.962	0.962
1	4	0.996	0.999	0.996	0.952	0.952	0.952	0.952
1	5	0.996	0.998	0.995	0.920	0.920	0.920	0.920
2	3	0.997	0.997	0.997	0.949	0.949	0.949	0.949
2	4	0.998	0.999	0.998	0.952	0.952	0.952	0.952
2	5	0.998	0.997	0.998	0.913	0.913	0.913	0.913
3	4	0.996	0.997	0.997	0.953	0.953	0.953	0.953
3	5	0.996	1.000	0.996	0.947	0.947	0.947	0.947
4	5	0.998	0.997	0.997	0.943	0.943	0.943	0.943
Average		0.997	0.998	0.997	0.945	0.945	0.945	0.945

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.996	0.995	0.979	0.979	0.979	0.979
1	3	0.999	0.999	0.992	0.992	0.992	0.992
1	4	0.994	0.996	0.960	0.960	0.960	0.960
1	5	0.994	0.997	0.956	0.956	0.956	0.956
2	3	0.997	0.996	0.980	0.980	0.980	0.980
2	4	0.997	0.999	0.980	0.980	0.980	0.980
2	5	0.997	0.998	0.947	0.947	0.947	0.947
3	4	0.994	0.996	0.968	0.968	0.968	0.968
3	5	0.995	0.998	0.963	0.963	0.963	0.963
4	5	1.000	0.998	0.952	0.952	0.952	0.952
Average		0.996	0.997	0.968	0.968	0.968	0.968

Auxiliary Information:

- Steve Karamihas observed the runs.
- Loop closure was performed on run 1, but not the others.
- Operators placed a chalk line.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2010-Sept-15, 09:57 – 10:33

Device: SurPro 3000+

Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung

Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.997	0.964
Long (elev.)	1.000	0.990
Medium (elev.)	0.991	0.956
Short (elev.)	0.991	0.765
Long (slope)	0.999	0.985
Medium (slope)	0.996	0.948
Short (slope)	0.952	0.100

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.89 to 0.97 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	09:57	10:03	122.4	-3.9	51.541	0.97
2	10:05	10:13	122.6	-3.8	51.528	0.94
3	10:15	10:23	123.0	-3.5	51.5	0.89
4	10:24	10:28	122.3	-4.0	51.5	0.89
5	10:29	10:33	122.5	-3.8	51.5	0.89

Notes:

- Section length is 167.48 ft, measured by a steel tape and corrected for temperature.
- Runs 1 through 3 include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Slope			
	IRI	Long	Medium	Short
1	0.961	0.982	0.946	0.101
2	0.964	0.985	0.947	0.099
3	0.967	0.988	0.946	0.102
4	0.962	0.984	0.953	0.099
5	0.965	0.989	0.949	0.100
Ave.	0.964	0.985	0.948	0.100

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation		
	Long	Medium	Short
1	0.989	0.952	0.766
2	0.991	0.951	0.762
3	0.990	0.951	0.764
4	0.989	0.967	0.763
5	0.989	0.960	0.772
Ave.	0.990	0.956	0.765

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		IRI	Long	Medium	Short
1	2	0.996	1.000	0.999	0.972
1	3	0.994	0.998	0.999	0.964
1	4	0.997	1.000	0.991	0.966
1	5	0.995	0.998	0.997	0.939
2	3	0.997	0.999	0.999	0.951
2	4	0.998	0.999	0.992	0.966
2	5	0.998	0.999	0.997	0.940
3	4	0.996	0.999	0.992	0.958
3	5	0.998	1.000	0.998	0.924
4	5	0.997	0.999	0.994	0.937
Average		0.997	0.999	0.996	0.952

Run 1	Run 2	Cross Correlation by Waveband, Elevation		
		Long	Medium	Short
1	2	1.000	0.998	0.996
1	3	1.000	0.999	0.995
1	4	1.000	0.984	0.995
1	5	1.000	0.992	0.985
2	3	1.000	0.999	0.996
2	4	0.999	0.982	0.997
2	5	1.000	0.990	0.983
3	4	1.000	0.982	0.996
3	5	1.000	0.991	0.984
4	5	1.000	0.991	0.982
Average		1.000	0.991	0.991

Auxiliary Information:

- Steve Karamihas observed the runs.
- Operators placed a chalk line over the existing chalk line.
- Runs 1 through 3 included loop closure.
- Light rain began at 10:24.
- Paul operated the device in runs 1, 3 and 5; Ewing operated the device in runs 2 and 4.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining
Date: 2010-Sept-15, 16:12 – 17:14
Device: SurPro 3000+
Operator(s): EBA Engineering Consultants, Paul Toom and Erwin Kung
Recording Interval: 25 mm

Use Moving Average: No

The layout of the device imposes an analog filter equivalent to a 250-mm moving average.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.997	0.916
Long (elev.)	0.990	0.990
Medium (elev.)	0.987	0.797
Short (elev.)	0.967	0.532
Long (slope)	0.997	0.994
Medium (slope)	0.992	0.818
Short (slope)	0.925	0.094

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.00 to 0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	16:12	16:28	76.8	0.1	164.210	0.04
2	16:31	16:38	76.9	0.3	164.175	0.02
3	16:43	16:50	77.0	0.4	164.175	0.02
4	16:54	17:02	77.0	0.4	164.200	0.03
5	17:07	17:14	76.9	0.2	164.150	0.00

Notes:

- Section length is 538.54 ft, measured by a steel tape and corrected for temperature.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.918	0.997	0.824	0.098	0.098	0.098	0.098
2	0.914	0.989	0.812	0.088	0.088	0.088	0.088
3	0.916	0.994	0.817	0.094	0.094	0.094	0.094
4	0.917	0.998	0.824	0.097	0.097	0.097	0.097
5	0.914	0.994	0.815	0.095	0.095	0.095	0.095
Ave.	0.916	0.994	0.818	0.094	0.094	0.094	0.094

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.998	0.807	0.545	0.537	0.537	0.537
2	0.980	0.788	0.537	0.527	0.527	0.527
3	0.989	0.792	0.536	0.526	0.526	0.526
4	0.998	0.806	0.547	0.538	0.538	0.538
5	0.985	0.790	0.530	0.521	0.521	0.521
Ave.	0.990	0.797	0.539	0.530	0.530	0.530

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.999	0.993	0.991	0.890	0.888	0.888	0.888
1	3	0.998	0.998	0.996	0.932	0.931	0.931	0.931
1	4	0.997	1.000	0.996	0.959	0.959	0.959	0.959
1	5	0.997	0.997	0.990	0.922	0.922	0.922	0.922
2	3	0.998	0.998	0.994	0.936	0.936	0.936	0.936
2	4	0.997	0.992	0.988	0.900	0.898	0.898	0.898
2	5	0.998	0.999	0.996	0.902	0.902	0.902	0.902
3	4	0.998	0.997	0.993	0.944	0.943	0.943	0.943
3	5	0.996	1.000	0.993	0.937	0.938	0.938	0.938
4	5	0.995	0.997	0.988	0.934	0.934	0.934	0.934
Average		0.997	0.997	0.992	0.926	0.925	0.925	0.925

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.981	0.980	0.964	0.962	0.962	0.962
1	3	0.991	0.984	0.968	0.967	0.967	0.967
1	4	1.000	0.998	0.993	0.994	0.994	0.994
1	5	0.987	0.980	0.953	0.951	0.951	0.951
2	3	0.990	0.995	0.987	0.986	0.986	0.986
2	4	0.981	0.979	0.960	0.956	0.956	0.956
2	5	0.994	0.997	0.975	0.973	0.973	0.973
3	4	0.991	0.982	0.968	0.965	0.965	0.965
3	5	0.996	0.994	0.970	0.967	0.967	0.967
4	5	0.987	0.979	0.950	0.947	0.947	0.947
Average		0.990	0.987	0.969	0.967	0.967	0.967

Auxiliary Information:

- John Koch observed the runs.
- Loop closure was performed on run 1, but not the others.
- Operators placed a chalk line over the existing chalk line.
- Light rain began during the return from run 2 and stopped during run 3.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2010-Sept-15, 15:16 – 17:53

2010-Sept-16, 10:36 – 11:03

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.977	0.880
Long (elev.)	0.975	0.980
Medium (elev.)	0.976	0.918
Short (elev.)	0.533	0.427
Long (slope)	0.989	0.990
Medium (slope)	0.972	0.845
Short (slope)	0.159	0.093

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from -0.29 to -0.23 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	15:16	15:41	87.8	-7.9	1108.4	-0.27
2	15:44	16:10	86.8	-9.0	1108.2	-0.29
3	16:14	16:40	86.8	-9.0	1108.2	-0.29
4	16:57	17:22	88.3	-7.5	1108.8	-0.23
6†	10:36	11:03	87.1	-8.7	1108.2	-0.29

† Run 6 performed the next day.

Notes:

- Section length is 1111.41 ft, measured by a steel tape and corrected for temperature.
- All length values reported verbally in the field.
- All times include measurement in the upstream direction for loop closure.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.891	0.998	0.859	0.131	0.114	0.113	0.111
2	0.870	0.983	0.835	0.081	0.084	0.081	0.075
3	0.870	0.981	0.835	0.077	0.083	0.075	0.067
4	0.888	0.997	0.851	0.099	0.090	0.090	0.083
6	0.879	0.991	0.848	0.096	0.102	0.102	0.103
Ave.	0.880	0.990	0.845	0.097	0.094	0.092	0.088

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.996	0.924	0.473	0.443	0.443	0.435
2	0.975	0.906	0.439	0.401	0.401	0.399
3	0.958	0.904	0.426	0.395	0.395	0.392
4	0.974	0.932	0.494	0.456	0.456	0.449
6	0.996	0.926	0.436	0.407	0.397	0.409
Ave.	0.980	0.918	0.454	0.420	0.418	0.417

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.969	0.983	0.961	0.117	0.103	0.103	0.098
1	3	0.974	0.982	0.966	0.120	0.111	0.111	0.108
1	4	0.988	0.996	0.980	0.098	0.123	0.123	0.077
1	6	0.978	0.991	0.976	0.100	0.110	0.110	0.104
2	3	0.981	0.997	0.975	0.257	0.231	0.231	0.227
2	4	0.968	0.985	0.965	0.364	0.330	0.330	0.317
2	6	0.981	0.992	0.973	0.143	0.117	0.103	0.099
3	4	0.973	0.983	0.971	0.192	0.174	0.167	0.165
3	6	0.986	0.990	0.979	0.150	0.141	0.141	0.131
4	6	0.978	0.992	0.981	0.161	0.161	0.161	0.161
Average		0.977	0.989	0.972	0.170	0.160	0.158	0.149

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.972	0.972	0.491	0.392	0.392	0.362
1	3	0.954	0.975	0.511	0.459	0.459	0.430
1	4	0.971	0.979	0.514	0.428	0.425	0.393
1	6	0.996	0.991	0.487	0.424	0.424	0.394
2	3	0.981	0.987	0.680	0.584	0.582	0.571
2	4	0.997	0.963	0.700	0.622	0.621	0.614
2	6	0.972	0.972	0.644	0.543	0.543	0.533
3	4	0.981	0.964	0.652	0.597	0.594	0.584
3	6	0.955	0.973	0.636	0.574	0.564	0.551
4	6	0.970	0.983	0.669	0.570	0.572	0.550
Average		0.975	0.976	0.598	0.519	0.518	0.498

Auxiliary Information:

- Dan Huddleson observed most of the testing. John Hall observed the end of run 5 on the second segment.
- It began to rain during run 3, and the crew delayed a few minutes for the rain to die down.
- Run 5 was performed in driving rain, and was excluded from the analysis. One run was performed the next morning to complete the set of 5 repeats.
- All runs included loop closure.
- Used a chalk line left by another crew.
- Dennis Scott downloaded data to a flash drive after run 2 for on-site analysis.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2010-Sept-16, 11:22 – 16:08

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.940	0.869
Long (elev.)	0.972	0.981
Medium (elev.)	0.953	0.895
Short (elev.)	0.833	0.340
Long (slope)	0.967	0.983
Medium (slope)	0.953	0.838
Short (slope)	0.591	0.013

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.14 to 0.31 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	11:22	11:44	87.6	-8.9	506.1	0.26
2	11:48	12:12	92.0	-4.3	506.4	0.31
3	12:23	12:34	89.5	-7.0	506.3	0.30
4	12:48	13:12	85.2	-11.4	505.8	0.20
6	13:44	14:08	88.6	-7.8	505.5	0.14

Notes:

- Section length is 504.81 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.877	0.990	0.841	0.011	0.011	0.011	0.011
2	0.884	0.966	0.831	0.012	0.012	0.012	0.012
3	0.884	0.992	0.846	0.011	0.011	0.011	0.011
4	0.837	0.973	0.838	0.015	0.016	0.016	0.016
6	0.861	0.993	0.834	0.016	0.017	0.017	0.017
Ave.	0.869	0.983	0.838	0.013	0.014	0.014	0.014

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.990	0.899	0.285	0.282	0.281	0.281
2	0.958	0.896	0.285	0.283	0.283	0.284
3	0.991	0.898	0.358	0.352	0.352	0.352
4	0.984	0.880	0.398	0.392	0.393	0.393
6	0.984	0.901	0.389	0.383	0.384	0.384
Ave.	0.981	0.895	0.343	0.339	0.339	0.339

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.929	0.948	0.946	0.663	0.663	0.663	0.663
1	3	0.960	0.985	0.963	0.604	0.612	0.612	0.612
1	4	0.924	0.977	0.952	0.457	0.460	0.460	0.460
1	6	0.961	0.987	0.951	0.471	0.476	0.476	0.476
2	3	0.950	0.970	0.953	0.606	0.616	0.615	0.615
2	4	0.904	0.931	0.939	0.482	0.485	0.485	0.485
2	6	0.937	0.955	0.950	0.523	0.532	0.532	0.532
3	4	0.931	0.964	0.963	0.682	0.673	0.673	0.673
3	6	0.961	0.988	0.960	0.706	0.699	0.699	0.699
4	6	0.942	0.969	0.955	0.705	0.696	0.696	0.696
Average		0.940	0.967	0.953	0.590	0.591	0.591	0.591

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.963	0.950	0.901	0.901	0.901	0.901
1	3	0.995	0.970	0.822	0.829	0.829	0.829
1	4	0.970	0.940	0.752	0.758	0.758	0.758
1	6	0.990	0.960	0.754	0.757	0.757	0.757
2	3	0.968	0.953	0.838	0.841	0.841	0.841
2	4	0.945	0.930	0.785	0.786	0.786	0.786
2	6	0.958	0.964	0.800	0.800	0.800	0.800
3	4	0.972	0.962	0.882	0.880	0.880	0.880
3	6	0.991	0.958	0.880	0.876	0.876	0.876
4	6	0.967	0.943	0.906	0.904	0.904	0.904
Average		0.972	0.953	0.832	0.833	0.833	0.833

Auxiliary Information:

- John Koch observed the testing.
- Used a chalk line left by another crew.
- All runs included loop closure.
- Dennis Scott downloaded data to a flash drive after run 2 and after run 4 for on-site analysis.
- The device's battery died before the end of run 5.
- This was the second visit to the test section. Seven runs were performed the morning of 14-Sept. No data were provided, and the results prompted a subsequent visit to the distance calibration section for diagnosis and several calls to the device developers. By the end of the day, the crew decided to carry on using the new hardware, but a previous version of the device software.
- In the first visit to this section run 3 was repeated, because it was not saved properly by the device. The visit also included data download after the repeat of run 3 and after run 4 for on-site analysis.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 2010-Sept-16, 08:34 – 09:44

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.958	0.733
Long (elev.)	0.994	0.997
Medium (elev.)	0.897	0.539
Short (elev.)	0.376	0.209
Long (slope)	0.995	0.996
Medium (slope)	0.842	0.473
Short (slope)	0.189	0.035

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.01 to 0.06 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:34	08:44	50.3	-16.9	434.1	0.01
3	08:57	09:08	50.5	-16.4	434.3	0.06
4	09:10	09:20	49.2	-18.7	434.3	0.06
5	09:22	09:32	50.0	-17.3	434.3	0.06
6	09:34	09:44	50.3	-16.8	434.2	0.04

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.719	0.998	0.426	0.062	0.062	0.062	0.062
3	0.729	0.996	0.439	0.029	0.029	0.029	0.029
4	0.726	0.997	0.481	0.026	0.026	0.024	0.026
5	0.743	0.994	0.513	0.037	0.038	0.038	0.037
6	0.737	0.996	0.508	0.023	0.023	0.023	0.023
Ave.	0.731	0.996	0.473	0.035	0.036	0.035	0.035

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	1.000	0.505	0.194	0.190	0.190	0.190
3	0.999	0.500	0.198	0.207	0.207	0.207
4	0.997	0.542	0.191	0.208	0.207	0.207
5	0.992	0.585	0.266	0.270	0.270	0.270
6	0.999	0.565	0.177	0.179	0.179	0.178
Ave.	0.997	0.539	0.205	0.211	0.211	0.211

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	3	0.959	0.995	0.877	0.133	0.133	0.133	0.185
1	4	0.965	0.997	0.839	0.131	0.131	0.131	0.131
1	5	0.962	0.995	0.786	0.454	0.454	0.454	0.454
1	6	0.958	0.996	0.801	0.155	0.155	0.157	0.157
3	4	0.951	0.997	0.858	0.168	0.167	0.168	0.132
3	5	0.960	0.990	0.818	0.217	0.217	0.217	0.217
3	6	0.959	0.995	0.816	0.164	0.164	0.164	0.164
4	5	0.955	0.993	0.860	0.157	0.157	0.157	0.157
4	6	0.958	0.998	0.889	0.164	0.164	0.164	0.164
5	6	0.957	0.993	0.875	0.144	0.127	0.144	0.144
Average		0.958	0.995	0.842	0.189	0.187	0.189	0.190

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	3	0.999	0.932	0.339	0.332	0.332	0.332
1	4	0.997	0.910	0.359	0.366	0.365	0.365
1	5	0.993	0.862	0.318	0.328	0.328	0.327
1	6	0.998	0.880	0.403	0.404	0.404	0.404
3	4	0.996	0.905	0.395	0.407	0.407	0.407
3	5	0.992	0.862	0.443	0.443	0.443	0.443
3	6	0.998	0.869	0.351	0.356	0.356	0.356
4	5	0.984	0.907	0.388	0.401	0.400	0.400
4	6	0.998	0.930	0.387	0.386	0.386	0.386
5	6	0.990	0.917	0.345	0.355	0.355	0.355
Average		0.982	0.698	0.391	0.396	0.395	0.395

Auxiliary Information:

- John Koch observed the runs.
- Used a chalk line.
- All runs included loop closure.
- Dennis Scott downloaded data to a flash drive for on-site analysis after run 1, after run 3 and after run 4.
- The crew performed 6 runs. Dennis asked for exclusion of run 2, because an anomalous upward step appeared near the end of the profile. This was discovered on-site using a custom analysis program.
- This was the second visit to the test section. Four runs were performed the morning of 15-Sept, but the visit was terminated because of rain. John Hall observed these runs. The runs included a data download after run 3, a stop in the middle of run 4 and a repeat of the run. This prompted a “calibration” run after the repeat of run 4. At the end of the calibration run, rain ended the visit.

Benchmark Test Evaluation Report

Test Section: US 10 E.B. near Junction City, WI

Longitudinal Tining

Date: 2010-Sept-17, 08:14 – 10:12

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.991	0.897
Long (elev.)	0.968	0.924
Medium (elev.)	0.991	0.940
Short (elev.)	0.835	0.277
Long (slope)	0.987	0.931
Medium (slope)	0.993	0.904
Short (slope)	0.544	0.034

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.01 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
2	08:28	08:47	75.1	-9.2	499.8	0.03
3	08:56	09:13	75.5	-8.7	499.8	0.03
4	09:15	09:31	75.4	-8.9	499.7	0.01
5	09:33	09:51	75.7	-8.4	499.7	0.01
6	09:55	10:12	75.5	-8.7	499.6	-0.01

Notes:

- Section length is 499.65 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.893	0.923	0.903	0.042	0.049	0.049	0.049
3	0.892	0.924	0.901	0.042	0.042	0.042	0.022
4	0.896	0.939	0.903	0.028	0.028	0.028	0.028
5	0.901	0.931	0.907	0.025	0.025	0.025	0.037
6	0.902	0.937	0.907	0.031	0.031	0.031	0.031
Ave.	0.897	0.931	0.904	0.033	0.035	0.035	0.033

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.912	0.939	0.276	0.268	0.263	0.263
3	0.942	0.934	0.268	0.259	0.256	0.256
4	0.947	0.941	0.284	0.273	0.267	0.267
5	0.913	0.937	0.284	0.276	0.272	0.272
6	0.905	0.947	0.311	0.310	0.308	0.308
Ave.	0.924	0.940	0.285	0.277	0.273	0.273

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	3	0.993	0.993	0.994	0.565	0.565	0.565	0.565
2	4	0.993	0.983	0.995	0.509	0.509	0.509	0.509
2	5	0.989	0.991	0.993	0.528	0.528	0.528	0.528
2	6	0.992	0.982	0.995	0.510	0.511	0.510	0.510
3	4	0.990	0.979	0.992	0.548	0.548	0.548	0.548
3	5	0.988	0.988	0.991	0.578	0.578	0.579	0.579
3	6	0.990	0.979	0.992	0.519	0.519	0.519	0.519
4	5	0.991	0.987	0.993	0.532	0.532	0.532	0.532
4	6	0.994	0.996	0.995	0.514	0.514	0.514	0.514
5	6	0.991	0.988	0.993	0.632	0.632	0.632	0.632
Average		0.991	0.987	0.993	0.543	0.544	0.544	0.544

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	3	0.958	0.990	0.838	0.838	0.838	0.838
2	4	0.960	0.996	0.828	0.828	0.828	0.828
2	5	0.994	0.996	0.818	0.818	0.818	0.818
2	6	0.985	0.991	0.799	0.799	0.799	0.799
3	4	0.990	0.989	0.831	0.831	0.831	0.831
3	5	0.955	0.993	0.855	0.855	0.855	0.855
3	6	0.945	0.984	0.818	0.818	0.818	0.818
4	5	0.957	0.995	0.851	0.851	0.851	0.851
4	6	0.949	0.992	0.838	0.838	0.837	0.837
5	6	0.987	0.989	0.870	0.870	0.870	0.870
Average		0.968	0.991	0.835	0.835	0.835	0.835

Auxiliary Information:

- John Koch observed runs 1-4 and Steve Karamihas observed runs 5 and 6.
- The weather was cool with light sprinkles. By the final run, the surface was wet with some pooling.
- Used the provided paint line.
- All runs included loop closure.
- Dennis Scott downloaded data to a flash drive for on-site analysis after run 2.
- The crew performed 6 runs. At 08:57, Dennis asked for exclusion of run 1, because an anomalous upward step appeared near the end of the profile. This was discovered on-site using a custom analysis program.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2010-Sept-15, 08:50 – 09:35

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.965	0.856
Long (elev.)	0.967	0.976
Medium (elev.)	0.948	0.824
Short (elev.)	0.910	0.334
Long (slope)	0.968	0.949
Medium (slope)	0.972	0.821
Short (slope)	0.678	0.025

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from -0.17 to -0.11 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:50	08:58	111.9	-12.2	167.2	-0.17
2	08:59	09:07	109.7	-13.9	167.3	-0.11
3	09:08	09:12	110.3	-13.5	167.3	-0.11
4	09:18	09:26	107.6	-15.6	167.3	-0.11
5	09:27	09:35	108.1	-15.2	167.3	-0.11

Notes:

- Section length is 167.48 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Slope			
	IRI	Long	Medium	Short
1	0.873	0.969	0.836	0.028
2	0.854	0.946	0.831	0.026
3	0.871	0.985	0.811	0.021
4	0.837	0.917	0.812	0.023
5	0.844	0.930	0.814	0.025
Ave.	0.856	0.949	0.821	0.025

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation		
	Long	Medium	Short
1	0.979	0.853	0.341
2	0.988	0.854	0.317
3	0.957	0.799	0.348
4	0.990	0.791	0.332
5	0.963	0.825	0.331
Ave.	0.976	0.824	0.334

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope			
		IRI	Long	Medium	Short, Seg. 1
1	2	0.975	0.985	0.990	0.710
1	3	0.988	0.981	0.967	0.660
1	4	0.945	0.954	0.955	0.613
1	5	0.962	0.967	0.967	0.667
2	3	0.964	0.959	0.966	0.670
2	4	0.966	0.980	0.957	0.655
2	5	0.984	0.990	0.973	0.744
3	4	0.936	0.932	0.979	0.661
3	5	0.954	0.942	0.985	0.712
4	5	0.976	0.993	0.981	0.685
Average		0.965	0.968	0.972	0.678

Run 1	Run 2	Cross Correlation by Waveband, Elevation		
		Long	Medium	Short, Seg. 1
1	2	0.997	0.983	0.890
1	3	0.939	0.932	0.929
1	4	0.976	0.923	0.888
1	5	0.984	0.967	0.913
2	3	0.947	0.921	0.887
2	4	0.987	0.913	0.923
2	5	0.982	0.958	0.917
3	4	0.974	0.977	0.903
3	5	0.926	0.955	0.924
4	5	0.956	0.948	0.928
Average		0.967	0.948	0.910

Auxiliary Information:

- John Hall observed the runs.
- Placed a chalk line.
- All runs included loop closure.
- Dennis Scott downloaded data to a flash drive between runs 3 and 4 for on-site analysis.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2010-Sept-14, 17:07 – 18:57

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Santiago and Flint

Recording Interval: 1 inch

Use Moving Average: Yes

Data were low-pass filtered with a cut-off near 0.5 ft. The moving average is still necessary.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.986	0.864
Long (elev.)	0.986	0.989
Medium (elev.)	0.977	0.866
Short (elev.)	0.758	0.253
Long (slope)	0.995	0.990
Medium (slope)	0.978	0.809
Short (slope)	0.314	0.019

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.04 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	17:07	17:27	68.0	-11.4	538.3	-0.04
2	17:29	17:51	68.0	-11.4	538.4	-0.03
3	17:52	18:13	67.3	-12.3	538.7	0.03
4	18:16	18:35	68.2	-11.1	538.3	-0.04
5	18:38	18:57	67.6	-11.8	538.4	-0.03

Notes:

- Section length is 538.54 ft, measured by a steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.870	0.990	0.823	0.018	0.018	0.016	0.016
2	0.872	0.995	0.819	0.022	0.021	0.021	0.021
3	0.860	0.995	0.802	0.020	0.019	0.019	0.019
4	0.866	0.992	0.812	0.023	0.022	0.022	0.022
5	0.852	0.981	0.788	0.017	0.017	0.018	0.018
Ave.	0.864	0.990	0.809	0.020	0.019	0.019	0.019

Detailed Accuracy Scores (cont):

Run	Cross Correlation to Benchmark Profile, Elevation					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.995	0.875	0.261	0.257	0.250	0.250
2	0.995	0.882	0.242	0.231	0.231	0.231
3	0.996	0.862	0.244	0.240	0.241	0.241
4	0.988	0.872	0.296	0.284	0.284	0.284
5	0.969	0.841	0.259	0.247	0.246	0.247
Ave.	0.989	0.866	0.260	0.252	0.250	0.250

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Slope						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.995	0.996	0.990	0.219	0.218	0.218	0.218
1	3	0.980	0.997	0.968	0.193	0.247	0.247	0.247
1	4	0.992	0.998	0.988	0.440	0.450	0.447	0.447
1	5	0.982	0.994	0.967	0.318	0.339	0.339	0.339
2	3	0.982	0.999	0.977	0.280	0.286	0.283	0.286
2	4	0.994	0.997	0.989	0.327	0.316	0.316	0.316
2	5	0.983	0.987	0.974	0.218	0.209	0.209	0.209
3	4	0.979	0.997	0.970	0.339	0.341	0.341	0.341
3	5	0.988	0.989	0.984	0.307	0.307	0.307	0.307
4	5	0.984	0.992	0.975	0.449	0.451	0.451	0.451
Average		0.986	0.995	0.978	0.309	0.316	0.316	0.316

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.998	0.992	0.722	0.708	0.708	0.708
1	3	0.999	0.976	0.741	0.741	0.741	0.741
1	4	0.990	0.989	0.847	0.840	0.840	0.840
1	5	0.971	0.965	0.807	0.800	0.800	0.800
2	3	0.997	0.974	0.693	0.690	0.690	0.690
2	4	0.991	0.993	0.755	0.736	0.736	0.729
2	5	0.973	0.962	0.713	0.705	0.705	0.705
3	4	0.990	0.973	0.786	0.778	0.778	0.778
3	5	0.972	0.985	0.750	0.747	0.747	0.747
4	5	0.980	0.966	0.828	0.818	0.818	0.818
Average		0.986	0.977	0.764	0.756	0.756	0.755

Auxiliary Information:

- John Koch observed the runs.
- Used a chalk line.
- All runs included loop closure.
- Dennis Scott downloaded data to a flash drive for on-site analysis after run 3 and after run 4.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 11/12/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.976	0.868
Long (elev.)	0.995	0.774
Medium (elev.)	0.983	0.818
Short (elev.)	0.700	0.419
Long (slope)	0.996	0.847
Medium (slope)	0.970	0.864
Short (slope)	0.235	0.040

Result for Longitudinal Distance:

Error in longitudinal distance was -0.06 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	89.0	-6.7	1110.73	-0.06
2	86.3	-9.5	1110.73	-0.06
3	87.9	-7.9	1110.73	-0.06
4	86.6	-9.2	1110.73	-0.06
5	86.5	-9.4	1110.73	-0.06
6	87.5	-8.3	1110.73	-0.06
7	87.2	-8.6	1110.73	-0.06
8	87.1	-8.7	1110.73	-0.06
9	87.0	-8.8	1110.73	-0.06
10	86.8	-9.0	1110.73	-0.06

Notes:

- Section length is 1111.41 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.884	0.847	0.882	0.042	0.041	0.043	0.044
2	0.863	0.849	0.856	0.049	0.049	0.049	0.044
3	0.878	0.840	0.879	0.032	0.030	0.030	0.044
4	0.864	0.852	0.856	0.030	0.028	0.037	0.037
5	0.861	0.848	0.854	0.048	0.046	0.046	0.043
6	0.876	0.850	0.869	0.045	0.041	0.039	0.027
7	0.866	0.842	0.866	0.043	0.041	0.041	0.025
8	0.868	0.852	0.863	0.047	0.041	0.044	0.042
9	0.862	0.846	0.857	0.045	0.044	0.044	0.042
10	0.862	0.845	0.855	0.029	0.044	0.044	0.024
Ave.	0.868	0.847	0.864	0.041	0.040	0.042	0.037

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.768	0.835	0.460	0.427	0.409	0.371
2	0.780	0.812	0.485	0.452	0.429	0.392
3	0.762	0.829	0.470	0.439	0.423	0.384
4	0.781	0.811	0.455	0.426	0.407	0.370
5	0.764	0.822	0.475	0.446	0.426	0.384
6	0.783	0.815	0.460	0.433	0.413	0.381
7	0.773	0.821	0.446	0.414	0.395	0.359
8	0.783	0.816	0.481	0.453	0.430	0.397
9	0.773	0.814	0.467	0.434	0.416	0.381
10	0.776	0.809	0.402	0.375	0.360	0.323
Ave.	0.774	0.818	0.460	0.430	0.411	0.374

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation						
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	
1	2	0.957	0.993	0.946	0.215	0.094	0.218	0.216
1	3	0.974	0.993	0.971	0.330	0.337	0.337	0.338
1	4	0.960	0.995	0.949	0.233	0.139	0.139	0.139
1	5	0.961	0.999	0.953	0.337	0.342	0.342	0.341
1	6	0.970	0.996	0.958	0.219	0.221	0.221	0.219
1	7	0.970	0.993	0.969	0.282	0.287	0.287	0.285
1	8	0.963	0.996	0.952	0.197	0.203	0.203	0.198
1	9	0.961	0.996	0.954	0.264	0.265	0.265	0.265
1	10	0.958	0.991	0.946	0.214	0.218	0.218	0.216
2	3	0.972	0.998	0.962	0.157	0.157	0.157	0.157
2	4	0.992	0.997	0.990	0.354	0.352	0.352	0.351
2	5	0.986	0.994	0.981	0.226	0.228	0.228	0.226
2	6	0.960	0.997	0.954	0.233	0.238	0.238	0.237
2	7	0.982	0.998	0.972	0.214	0.214	0.214	0.212
2	8	0.989	0.997	0.987	0.323	0.324	0.324	0.325
2	9	0.992	0.997	0.987	0.213	0.211	0.211	0.209
2	10	0.992	0.997	0.992	0.257	0.258	0.258	0.257
3	4	0.975	0.995	0.966	0.211	0.207	0.207	0.207
3	5	0.974	0.993	0.966	0.341	0.347	0.347	0.346
3	6	0.966	0.996	0.964	0.192	0.193	0.193	0.195
3	7	0.983	0.999	0.981	0.235	0.238	0.238	0.236
3	8	0.977	0.995	0.967	0.216	0.221	0.221	0.220
3	9	0.976	0.996	0.968	0.298	0.301	0.301	0.301
3	10	0.973	0.997	0.962	0.119	0.123	0.123	0.122
4	5	0.984	0.996	0.981	0.246	0.253	0.253	0.252
4	6	0.963	1.000	0.957	0.163	0.176	0.176	0.178
4	7	0.985	0.995	0.975	0.266	0.266	0.266	0.264
4	8	0.993	0.999	0.991	0.295	0.304	0.304	0.301
4	9	0.989	0.999	0.988	0.256	0.258	0.258	0.258
4	10	0.992	0.995	0.990	0.290	0.287	0.287	0.284
5	6	0.951	0.996	0.943	0.223	0.222	0.222	0.222
5	7	0.986	0.993	0.979	0.275	0.278	0.278	0.277
5	8	0.981	0.997	0.978	0.224	0.223	0.223	0.221
5	9	0.993	0.997	0.991	0.316	0.314	0.314	0.311
5	10	0.985	0.992	0.981	0.224	0.228	0.228	0.230
6	7	0.960	0.996	0.960	0.239	0.240	0.240	0.105
6	8	0.965	0.999	0.960	0.140	0.211	0.142	0.215
6	9	0.955	0.999	0.949	0.098	0.098	0.098	0.102
6	10	0.960	0.995	0.952	0.174	0.118	0.174	0.172
7	8	0.988	0.995	0.978	0.217	0.217	0.217	0.216
7	9	0.987	0.996	0.980	0.187	0.118	0.118	0.181
7	10	0.983	0.997	0.972	0.254	0.265	0.265	0.265
8	9	0.986	0.999	0.985	0.239	0.238	0.238	0.237
8	10	0.989	0.994	0.987	0.260	0.263	0.263	0.260
9	10	0.990	0.994	0.987	0.192	0.191	0.191	0.191
Average		0.976	0.996	0.970	0.237	0.233	0.236	0.235

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.998	0.964	0.718	0.707	0.705	0.689
1	3	0.994	0.982	0.776	0.760	0.759	0.756
1	4	0.994	0.964	0.704	0.692	0.690	0.681
1	5	0.995	0.976	0.776	0.758	0.758	0.744
1	6	0.990	0.967	0.709	0.687	0.687	0.674
1	7	0.998	0.976	0.767	0.752	0.752	0.743
1	8	0.995	0.969	0.706	0.703	0.700	0.683
1	9	0.998	0.968	0.750	0.726	0.726	0.715
1	10	0.999	0.961	0.647	0.626	0.626	0.617
2	3	0.992	0.976	0.733	0.720	0.720	0.701
2	4	0.996	0.997	0.751	0.739	0.739	0.729
2	5	0.993	0.984	0.733	0.715	0.715	0.701
2	6	0.992	0.982	0.748	0.735	0.735	0.721
2	7	0.999	0.984	0.688	0.679	0.679	0.659
2	8	0.997	0.993	0.790	0.778	0.778	0.768
2	9	0.999	0.994	0.701	0.688	0.688	0.668
2	10	0.999	0.994	0.690	0.673	0.673	0.663
3	4	0.988	0.977	0.688	0.668	0.668	0.667
3	5	0.998	0.987	0.786	0.768	0.767	0.753
3	6	0.984	0.980	0.705	0.678	0.678	0.674
3	7	0.992	0.987	0.727	0.713	0.713	0.702
3	8	0.989	0.981	0.735	0.715	0.715	0.713
3	9	0.992	0.980	0.761	0.743	0.735	0.738
3	10	0.993	0.973	0.631	0.604	0.604	0.603
4	5	0.990	0.984	0.680	0.661	0.661	0.650
4	6	0.996	0.982	0.774	0.765	0.771	0.760
4	7	0.996	0.984	0.704	0.679	0.679	0.683
4	8	0.999	0.993	0.765	0.765	0.765	0.754
4	9	0.996	0.994	0.694	0.674	0.674	0.663
4	10	0.995	0.994	0.734	0.718	0.718	0.703
5	6	0.986	0.986	0.683	0.655	0.655	0.642
5	7	0.993	0.996	0.732	0.717	0.717	0.699
5	8	0.991	0.989	0.721	0.696	0.696	0.685
5	9	0.994	0.989	0.763	0.744	0.744	0.731
5	10	0.995	0.980	0.621	0.594	0.594	0.583
6	7	0.993	0.988	0.708	0.680	0.678	0.680
6	8	0.995	0.987	0.746	0.739	0.739	0.725
6	9	0.993	0.981	0.692	0.662	0.662	0.648
6	10	0.991	0.979	0.697	0.683	0.683	0.670
7	8	0.997	0.989	0.697	0.695	0.694	0.673
7	9	1.000	0.989	0.689	0.667	0.672	0.654
7	10	0.998	0.981	0.634	0.608	0.608	0.613
8	9	0.997	0.992	0.713	0.710	0.710	0.690
8	10	0.996	0.989	0.682	0.672	0.671	0.660
9	10	0.998	0.991	0.631	0.604	0.604	0.592
Average		0.995	0.983	0.715	0.698	0.698	0.687

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 11/12/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.969	0.958
Long (elev.)	0.997	0.985
Medium (elev.)	0.975	0.513
Short (elev.)	0.716	0.511
Long (slope)	0.999	0.972
Medium (slope)	0.961	0.918
Short (slope)	0.428	0.083

Result for Longitudinal Distance:

Error in longitudinal distance was -0.04 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	95.1	-1.1	504.59	-0.04
2	95.6	-0.6	504.59	-0.04
3	94.7	-1.5	504.59	-0.04
4	94.6	-1.6	504.59	-0.04
5	95.1	-1.1	504.59	-0.04
6	95.0	-1.2	504.59	-0.04
7	94.5	-1.7	504.59	-0.04
8	94.1	-2.2	504.59	-0.04
9	94.6	-1.6	504.59	-0.04
10	95.0	-1.2	504.59	-0.04

Notes:

- Section length is 504.81 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.957	0.976	0.907	0.150	0.154	0.154	0.154
2	0.938	0.973	0.891	0.143	0.048	0.048	0.048
3	0.965	0.965	0.932	0.049	0.047	0.138	0.047
4	0.964	0.981	0.902	0.035	0.053	0.053	0.053
5	0.954	0.973	0.911	0.154	0.049	0.049	0.049
6	0.947	0.970	0.946	0.032	0.037	0.060	0.037
7	0.960	0.971	0.928	0.138	0.038	0.038	0.038
8	0.965	0.974	0.923	0.046	0.146	0.146	0.146
9	0.966	0.966	0.920	0.043	0.041	0.041	0.041
10	0.961	0.974	0.916	0.146	0.147	0.147	0.147
Ave.	0.958	0.972	0.918	0.094	0.076	0.087	0.076

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.988	0.934	0.537	0.537	0.537	0.537
2	0.989	0.936	0.510	0.512	0.512	0.512
3	0.975	0.962	0.518	0.514	0.514	0.514
4	0.995	0.936	0.508	0.509	0.509	0.509
5	0.985	0.941	0.526	0.522	0.522	0.522
6	0.983	0.956	0.436	0.432	0.434	0.435
7	0.985	0.965	0.535	0.530	0.530	0.530
8	0.989	0.950	0.511	0.510	0.510	0.510
9	0.979	0.957	0.537	0.532	0.532	0.532
10	0.986	0.944	0.510	0.510	0.510	0.510
Ave.	0.985	0.948	0.513	0.511	0.511	0.511

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.968	1.000	0.961	0.642	0.644	0.644
1	3	0.974	0.998	0.964	0.319	0.330	0.330
1	4	0.975	0.999	0.975	0.582	0.584	0.584
1	5	0.993	0.999	0.990	0.682	0.688	0.688
1	6	0.946	0.998	0.934	0.195	0.197	0.197
1	7	0.975	0.999	0.971	0.465	0.474	0.474
1	8	0.970	0.999	0.958	0.628	0.630	0.630
1	9	0.983	0.998	0.975	0.454	0.460	0.460
1	10	0.987	0.999	0.978	0.595	0.602	0.602
2	3	0.943	0.998	0.929	0.227	0.222	0.222
2	4	0.967	0.999	0.974	0.596	0.596	0.596
2	5	0.973	1.000	0.962	0.520	0.529	0.529
2	6	0.923	0.997	0.910	0.213	0.212	0.212
2	7	0.943	0.999	0.932	0.340	0.344	0.343
2	8	0.967	1.000	0.960	0.601	0.602	0.602
2	9	0.960	0.999	0.950	0.305	0.320	0.320
2	10	0.969	0.999	0.960	0.548	0.561	0.561
3	4	0.970	0.995	0.942	0.226	0.218	0.218
3	5	0.969	0.999	0.965	0.375	0.383	0.383
3	6	0.968	0.999	0.962	0.225	0.238	0.238
3	7	0.991	0.999	0.989	0.600	0.603	0.603
3	8	0.971	0.998	0.959	0.296	0.302	0.302
3	9	0.981	0.999	0.974	0.561	0.564	0.564
3	10	0.971	0.998	0.964	0.391	0.396	0.396
4	5	0.973	0.998	0.975	0.505	0.513	0.513
4	6	0.950	0.996	0.924	0.202	0.202	0.202
4	7	0.969	0.998	0.948	0.301	0.310	0.310
4	8	0.991	0.999	0.974	0.647	0.649	0.649
4	9	0.979	0.996	0.963	0.274	0.284	0.284
4	10	0.982	0.999	0.977	0.507	0.510	0.510
5	6	0.943	0.998	0.936	0.099	0.190	0.190
5	7	0.971	1.000	0.971	0.533	0.531	0.531
5	8	0.968	1.000	0.961	0.579	0.588	0.588
5	9	0.981	0.999	0.979	0.514	0.515	0.515
5	10	0.986	1.000	0.983	0.529	0.539	0.539
6	7	0.969	0.999	0.958	0.206	0.215	0.215
6	8	0.949	0.998	0.937	0.221	0.224	0.224
6	9	0.951	0.999	0.941	0.183	0.191	0.191
6	10	0.947	0.998	0.938	0.231	0.243	0.243
7	8	0.969	0.999	0.961	0.384	0.388	0.388
7	9	0.977	0.999	0.974	0.563	0.565	0.565
7	10	0.969	0.999	0.966	0.453	0.457	0.457
8	9	0.976	0.999	0.967	0.418	0.430	0.430
8	10	0.979	1.000	0.974	0.607	0.611	0.611
9	10	0.987	0.999	0.984	0.456	0.465	0.465
Average		0.969	0.999	0.961	0.422	0.429	0.429

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	1.000	0.988	0.841	0.841	0.841	0.841
1	3	0.991	0.971	0.679	0.679	0.679	0.679
1	4	0.997	0.988	0.804	0.808	0.808	0.808
1	5	0.999	0.990	0.875	0.872	0.872	0.872
1	6	0.998	0.942	0.526	0.518	0.518	0.518
1	7	0.999	0.968	0.783	0.781	0.781	0.781
1	8	1.000	0.976	0.822	0.823	0.823	0.823
1	9	0.995	0.973	0.755	0.754	0.754	0.754
1	10	1.000	0.985	0.805	0.809	0.809	0.809
2	3	0.990	0.968	0.628	0.625	0.625	0.625
2	4	0.998	0.994	0.827	0.829	0.829	0.829
2	5	0.999	0.989	0.816	0.815	0.815	0.815
2	6	0.997	0.941	0.519	0.507	0.507	0.507
2	7	0.999	0.964	0.700	0.703	0.706	0.706
2	8	1.000	0.984	0.815	0.815	0.815	0.815
2	9	0.995	0.973	0.669	0.672	0.672	0.672
2	10	0.999	0.988	0.772	0.775	0.775	0.775
3	4	0.984	0.968	0.618	0.613	0.613	0.613
3	5	0.994	0.977	0.720	0.720	0.720	0.720
3	6	0.996	0.969	0.526	0.524	0.524	0.524
3	7	0.995	0.990	0.824	0.828	0.828	0.828
3	8	0.991	0.982	0.669	0.671	0.671	0.671
3	9	0.999	0.993	0.818	0.818	0.818	0.818
3	10	0.994	0.978	0.721	0.725	0.725	0.725
4	5	0.995	0.988	0.786	0.792	0.792	0.792
4	6	0.992	0.943	0.526	0.518	0.518	0.518
4	7	0.994	0.964	0.671	0.677	0.677	0.677
4	8	0.998	0.984	0.846	0.840	0.840	0.840
4	9	0.989	0.972	0.645	0.650	0.650	0.650
4	10	0.995	0.989	0.781	0.776	0.776	0.776
5	6	0.999	0.949	0.512	0.504	0.504	0.504
5	7	1.000	0.974	0.800	0.799	0.799	0.799
5	8	0.999	0.983	0.822	0.825	0.825	0.825
5	9	0.998	0.981	0.781	0.777	0.777	0.777
5	10	1.000	0.994	0.806	0.811	0.811	0.811
6	7	1.000	0.973	0.529	0.522	0.522	0.522
6	8	0.998	0.955	0.535	0.529	0.529	0.529
6	9	0.999	0.963	0.521	0.518	0.518	0.518
6	10	0.999	0.952	0.519	0.515	0.515	0.515
7	8	0.999	0.976	0.722	0.725	0.725	0.725
7	9	0.998	0.988	0.834	0.835	0.835	0.835
7	10	1.000	0.973	0.758	0.763	0.763	0.763
8	9	0.995	0.985	0.717	0.720	0.720	0.720
8	10	0.999	0.988	0.840	0.840	0.840	0.840
9	10	0.997	0.982	0.747	0.752	0.752	0.752
Average		0.997	0.975	0.716	0.716	0.716	0.716

Benchmark Test Evaluation Report

Test Section: MnROAD, Diamond Ground Concrete

Date: 11/12/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.922	0.758
Long (elev.)	0.999	0.994
Medium (elev.)	0.899	0.499
Short (elev.)	0.595	0.125
Long (slope)	0.999	0.991
Medium (slope)	0.826	0.522
Short (slope)	0.577	0.056

Result for Longitudinal Distance:

Error in longitudinal distance was 0.04 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	51.7	-14.6	434.22	0.04
2	52.0	-14.0	434.22	0.04
3	52.7	-12.9	434.22	0.04
4	51.1	-15.5	434.22	0.04
5	53.4	-11.7	434.22	0.04
6	52.2	-13.7	434.22	0.04
7	52.5	-13.1	434.22	0.04
8	54.4	-10.1	434.22	0.04
9	53.6	-11.4	434.22	0.04
10	54.7	-9.6	434.22	0.04

Notes:

- Section length is 434.04 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.750	0.990	0.507	0.053	0.053	0.053	0.053
2	0.763	0.993	0.522	0.079	0.079	0.079	0.079
3	0.754	0.987	0.526	0.056	0.056	0.056	0.056
4	0.732	0.988	0.494	0.057	0.057	0.058	0.058
5	0.776	0.991	0.545	0.042	0.042	0.042	0.042
6	0.770	0.991	0.534	0.065	0.065	0.065	0.065
7	0.762	0.992	0.518	0.061	0.059	0.059	0.059
8	0.780	0.993	0.558	0.049	0.049	0.049	0.049
9	0.748	0.989	0.512	0.047	0.047	0.047	0.047
10	0.744	0.994	0.507	0.057	0.057	0.057	0.057
Ave.	0.758	0.991	0.522	0.057	0.056	0.056	0.056

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.993	0.490	0.133	0.138	0.138	0.138
2	0.996	0.506	0.141	0.145	0.145	0.145
3	0.993	0.506	0.142	0.140	0.137	0.137
4	0.992	0.483	0.090	0.089	0.089	0.089
5	0.995	0.530	0.132	0.143	0.139	0.139
6	0.995	0.491	0.128	0.130	0.130	0.130
7	0.997	0.480	0.112	0.115	0.115	0.115
8	0.995	0.526	0.122	0.126	0.126	0.126
9	0.991	0.479	0.119	0.122	0.122	0.122
10	0.996	0.498	0.109	0.111	0.111	0.111
Ave.	0.994	0.499	0.123	0.126	0.125	0.125

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.962	1.000	0.929	0.613	0.613	0.613
1	3	0.925	0.999	0.813	0.625	0.625	0.625
1	4	0.954	1.000	0.917	0.698	0.698	0.698
1	5	0.902	1.000	0.784	0.506	0.506	0.506
1	6	0.946	1.000	0.883	0.713	0.713	0.713
1	7	0.922	1.000	0.830	0.678	0.678	0.678
1	8	0.923	0.999	0.832	0.829	0.829	0.829
1	9	0.931	0.999	0.826	0.704	0.704	0.704
1	10	0.909	0.999	0.797	0.658	0.659	0.658
2	3	0.939	0.998	0.831	0.482	0.482	0.482
2	4	0.923	0.999	0.869	0.642	0.642	0.642
2	5	0.916	0.999	0.798	0.440	0.440	0.440
2	6	0.980	1.000	0.946	0.613	0.613	0.613
2	7	0.953	1.000	0.881	0.703	0.703	0.703
2	8	0.942	1.000	0.858	0.530	0.530	0.530
2	9	0.954	0.999	0.865	0.644	0.644	0.644
2	10	0.934	1.000	0.837	0.610	0.611	0.610
3	4	0.889	0.999	0.750	0.645	0.645	0.645
3	5	0.968	0.999	0.953	0.835	0.835	0.835
3	6	0.921	0.998	0.781	0.460	0.460	0.460
3	7	0.907	0.998	0.767	0.326	0.326	0.326
3	8	0.930	0.998	0.840	0.555	0.555	0.555
3	9	0.920	0.999	0.807	0.525	0.525	0.525
3	10	0.919	0.998	0.835	0.436	0.436	0.436
4	5	0.863	0.999	0.719	0.496	0.497	0.496
4	6	0.915	0.999	0.846	0.574	0.575	0.574
4	7	0.892	0.999	0.791	0.533	0.533	0.533
4	8	0.892	0.999	0.786	0.602	0.602	0.602
4	9	0.904	1.000	0.789	0.543	0.543	0.543
4	10	0.875	0.998	0.748	0.526	0.526	0.526
5	6	0.895	0.999	0.744	0.420	0.420	0.420
5	7	0.890	0.999	0.735	0.342	0.345	0.342
5	8	0.920	0.999	0.807	0.441	0.441	0.441
5	9	0.893	0.999	0.776	0.450	0.450	0.450
5	10	0.907	0.999	0.796	0.358	0.358	0.358
6	7	0.956	1.000	0.892	0.629	0.629	0.629
6	8	0.935	1.000	0.849	0.630	0.630	0.630
6	9	0.946	0.999	0.866	0.639	0.639	0.639
6	10	0.927	0.999	0.828	0.611	0.612	0.611
7	8	0.925	0.999	0.820	0.600	0.601	0.600
7	9	0.923	0.999	0.848	0.650	0.650	0.650
7	10	0.923	0.999	0.811	0.644	0.645	0.644
8	9	0.915	0.999	0.819	0.670	0.671	0.670
8	10	0.929	1.000	0.836	0.596	0.596	0.596
9	10	0.915	0.998	0.820	0.542	0.542	0.542
Average		0.922	0.999	0.826	0.577	0.577	0.577

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.999	0.947	0.818	0.801	0.801	0.801
1	3	1.000	0.896	0.553	0.553	0.553	0.553
1	4	1.000	0.964	0.683	0.677	0.677	0.677
1	5	1.000	0.854	0.454	0.453	0.453	0.453
1	6	1.000	0.962	0.752	0.754	0.754	0.754
1	7	0.999	0.940	0.725	0.725	0.725	0.725
1	8	1.000	0.887	0.838	0.839	0.839	0.839
1	9	1.000	0.955	0.766	0.766	0.766	0.766
1	10	1.000	0.913	0.698	0.699	0.699	0.699
2	3	0.999	0.918	0.436	0.437	0.437	0.437
2	4	0.999	0.918	0.598	0.595	0.595	0.595
2	5	1.000	0.878	0.387	0.389	0.389	0.389
2	6	1.000	0.949	0.819	0.819	0.819	0.819
2	7	1.000	0.932	0.782	0.781	0.781	0.781
2	8	1.000	0.917	0.760	0.758	0.758	0.758
2	9	0.999	0.918	0.806	0.805	0.805	0.805
2	10	1.000	0.944	0.714	0.713	0.713	0.713
3	4	1.000	0.871	0.371	0.362	0.362	0.362
3	5	1.000	0.949	0.872	0.876	0.876	0.876
3	6	0.999	0.856	0.403	0.399	0.399	0.399
3	7	0.999	0.843	0.325	0.325	0.326	0.326
3	8	0.999	0.917	0.418	0.418	0.418	0.418
3	9	1.000	0.868	0.458	0.396	0.395	0.395
3	10	0.999	0.896	0.378	0.379	0.379	0.379
4	5	0.999	0.828	0.429	0.421	0.421	0.421
4	6	0.999	0.940	0.574	0.573	0.573	0.573
4	7	0.999	0.916	0.509	0.507	0.507	0.507
4	8	0.999	0.869	0.581	0.577	0.577	0.577
4	9	1.000	0.932	0.557	0.554	0.554	0.554
4	10	0.999	0.888	0.496	0.492	0.493	0.493
5	6	1.000	0.815	0.343	0.355	0.355	0.355
5	7	1.000	0.805	0.309	0.310	0.310	0.310
5	8	1.000	0.898	0.361	0.363	0.362	0.362
5	9	0.999	0.825	0.403	0.350	0.349	0.349
5	10	1.000	0.852	0.323	0.326	0.325	0.325
6	7	1.000	0.956	0.773	0.771	0.771	0.771
6	8	1.000	0.881	0.714	0.716	0.716	0.716
6	9	0.999	0.939	0.724	0.725	0.725	0.725
6	10	1.000	0.903	0.735	0.731	0.731	0.731
7	8	1.000	0.856	0.701	0.700	0.700	0.700
7	9	0.998	0.917	0.730	0.729	0.729	0.729
7	10	1.000	0.891	0.753	0.750	0.750	0.750
8	9	0.999	0.860	0.744	0.741	0.741	0.741
8	10	1.000	0.899	0.671	0.672	0.672	0.672
9	10	0.999	0.895	0.636	0.635	0.635	0.635
Average		0.999	0.899	0.597	0.594	0.594	0.594

Benchmark Test Evaluation Report

Test Section: US 10 W.B. near Junction City, WI

Longitudinal Tining

Date: 11/15/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.975	0.952
Long (elev.)	0.989	0.893
Medium (elev.)	0.989	0.907
Short (elev.)	0.590	0.271
Long (slope)	0.991	0.882
Medium (slope)	0.976	0.964
Short (slope)	0.424	0.029

Result for Longitudinal Distance:

Error in longitudinal distance was -0.06 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	79.3	-4.1	499.59	-0.06
2	79.9	-3.3	499.59	-0.06
3	81.5	-1.4	499.59	-0.06
4	80.9	-2.2	499.59	-0.06
5	80.6	-2.5	499.59	-0.06
6	80.2	-3.0	499.59	-0.06
7	80.6	-2.5	499.59	-0.06
8	79.6	-3.7	499.59	-0.06
9	80.5	-2.6	499.59	-0.06
10	79.3	-4.1	499.59	-0.06

Notes:

- Section length is 499.65 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.946	0.874	0.959	0.046	0.046	0.046	0.046
2	0.959	0.890	0.973	0.017	0.017	0.040	0.017
3	0.962	0.878	0.965	0.021	0.021	0.044	0.044
4	0.951	0.872	0.966	0.046	0.046	0.046	0.046
5	0.957	0.881	0.971	0.044	0.044	0.044	0.044
6	0.946	0.889	0.959	0.018	0.018	0.018	0.018
7	0.956	0.882	0.970	0.018	0.018	0.018	0.018
8	0.941	0.886	0.955	0.018	0.018	0.018	0.018
9	0.959	0.885	0.971	0.036	0.036	0.017	0.036
10	0.942	0.880	0.955	0.017	0.017	0.017	0.017
Ave.	0.952	0.882	0.964	0.028	0.028	0.031	0.030

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.879	0.900	0.262	0.262	0.262	0.262
2	0.893	0.917	0.256	0.256	0.256	0.256
3	0.892	0.912	0.272	0.272	0.272	0.272
4	0.884	0.900	0.278	0.278	0.278	0.278
5	0.890	0.907	0.279	0.279	0.279	0.279
6	0.904	0.909	0.278	0.278	0.278	0.278
7	0.892	0.908	0.278	0.278	0.278	0.278
8	0.902	0.905	0.270	0.270	0.270	0.270
9	0.895	0.910	0.265	0.265	0.265	0.265
10	0.900	0.899	0.275	0.275	0.275	0.275
Ave.	0.893	0.907	0.271	0.271	0.271	0.271

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.974	0.981	0.975	0.379	0.379	0.379
1	3	0.972	0.994	0.970	0.503	0.503	0.503
1	4	0.983	0.996	0.983	0.503	0.503	0.503
1	5	0.976	0.991	0.977	0.464	0.464	0.464
1	6	0.977	0.982	0.984	0.477	0.478	0.477
1	7	0.979	0.990	0.980	0.394	0.394	0.394
1	8	0.960	0.985	0.970	0.425	0.425	0.425
1	9	0.975	0.985	0.975	0.439	0.439	0.439
1	10	0.968	0.992	0.975	0.418	0.418	0.418
2	3	0.981	0.986	0.978	0.355	0.355	0.355
2	4	0.976	0.978	0.983	0.315	0.315	0.315
2	5	0.985	0.989	0.986	0.375	0.375	0.375
2	6	0.979	0.997	0.978	0.342	0.342	0.342
2	7	0.986	0.991	0.985	0.333	0.334	0.334
2	8	0.971	0.993	0.969	0.368	0.368	0.368
2	9	0.985	0.994	0.986	0.347	0.347	0.347
2	10	0.972	0.987	0.969	0.322	0.322	0.322
3	4	0.976	0.991	0.976	0.461	0.461	0.461
3	5	0.982	0.996	0.980	0.531	0.531	0.531
3	6	0.976	0.988	0.971	0.481	0.481	0.481
3	7	0.979	0.994	0.977	0.468	0.468	0.468
3	8	0.966	0.991	0.963	0.451	0.451	0.451
3	9	0.981	0.991	0.978	0.489	0.489	0.489
3	10	0.965	0.997	0.960	0.411	0.411	0.411
4	5	0.980	0.988	0.984	0.473	0.473	0.473
4	6	0.971	0.979	0.977	0.485	0.485	0.485
4	7	0.976	0.987	0.982	0.375	0.375	0.375
4	8	0.956	0.982	0.966	0.489	0.489	0.489
4	9	0.979	0.983	0.984	0.383	0.383	0.383
4	10	0.960	0.989	0.966	0.556	0.556	0.556
5	6	0.977	0.991	0.976	0.514	0.515	0.514
5	7	0.985	0.998	0.985	0.481	0.481	0.481
5	8	0.969	0.994	0.968	0.369	0.369	0.369
5	9	0.986	0.994	0.985	0.542	0.542	0.542
5	10	0.968	0.998	0.966	0.378	0.378	0.378
6	7	0.979	0.993	0.978	0.390	0.390	0.390
6	8	0.980	0.996	0.981	0.425	0.425	0.425
6	9	0.972	0.996	0.972	0.426	0.426	0.426
6	10	0.982	0.990	0.982	0.413	0.413	0.413
7	8	0.973	0.996	0.973	0.338	0.338	0.338
7	9	0.988	0.996	0.989	0.531	0.531	0.531
7	10	0.972	0.996	0.971	0.324	0.324	0.324
8	9	0.967	0.999	0.968	0.328	0.328	0.328
8	10	0.983	0.993	0.983	0.497	0.497	0.497
9	10	0.967	0.993	0.966	0.325	0.325	0.325
Average		0.975	0.991	0.976	0.424	0.424	0.424

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.982	0.981	0.560	0.560	0.560	0.560
1	3	0.982	0.985	0.644	0.643	0.644	0.644
1	4	0.997	0.997	0.663	0.662	0.663	0.663
1	5	0.987	0.990	0.632	0.632	0.632	0.632
1	6	0.972	0.989	0.625	0.624	0.625	0.625
1	7	0.985	0.991	0.562	0.562	0.562	0.562
1	8	0.971	0.991	0.573	0.573	0.573	0.573
1	9	0.980	0.987	0.595	0.594	0.595	0.595
1	10	0.976	0.990	0.573	0.573	0.573	0.573
2	3	0.999	0.993	0.540	0.541	0.540	0.540
2	4	0.985	0.981	0.510	0.511	0.510	0.510
2	5	0.995	0.988	0.581	0.580	0.581	0.581
2	6	0.989	0.989	0.546	0.547	0.546	0.546
2	7	0.998	0.988	0.537	0.537	0.537	0.537
2	8	0.989	0.984	0.495	0.496	0.495	0.495
2	9	0.997	0.990	0.551	0.551	0.551	0.551
2	10	0.992	0.978	0.479	0.479	0.479	0.479
3	4	0.985	0.985	0.618	0.617	0.618	0.618
3	5	0.996	0.992	0.691	0.691	0.691	0.691
3	6	0.988	0.993	0.654	0.654	0.654	0.654
3	7	0.999	0.992	0.638	0.638	0.638	0.638
3	8	0.989	0.989	0.617	0.617	0.617	0.617
3	9	0.996	0.994	0.650	0.650	0.650	0.650
3	10	0.992	0.982	0.596	0.596	0.596	0.596
4	5	0.990	0.990	0.631	0.631	0.631	0.631
4	6	0.975	0.989	0.635	0.635	0.635	0.635
4	7	0.988	0.991	0.533	0.533	0.533	0.533
4	8	0.974	0.991	0.603	0.603	0.603	0.603
4	9	0.983	0.987	0.553	0.553	0.553	0.553
4	10	0.979	0.989	0.647	0.646	0.647	0.647
5	6	0.985	0.994	0.660	0.660	0.660	0.660
5	7	0.997	0.997	0.651	0.651	0.651	0.651
5	8	0.985	0.993	0.543	0.543	0.543	0.543
5	9	0.993	0.994	0.676	0.676	0.676	0.676
5	10	0.988	0.986	0.559	0.559	0.559	0.559
6	7	0.988	0.995	0.583	0.583	0.583	0.583
6	8	0.999	0.993	0.564	0.564	0.564	0.564
6	9	0.991	0.994	0.619	0.619	0.619	0.619
6	10	0.996	0.986	0.577	0.576	0.577	0.577
7	8	0.988	0.993	0.527	0.527	0.527	0.527
7	9	0.996	0.995	0.670	0.670	0.670	0.670
7	10	0.991	0.986	0.530	0.530	0.530	0.530
8	9	0.992	0.990	0.506	0.506	0.506	0.506
8	10	0.997	0.991	0.640	0.640	0.640	0.640
9	10	0.995	0.983	0.509	0.509	0.509	0.509
Average		0.989	0.989	0.590	0.590	0.590	0.590

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 11/12/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.956	0.885
Long (elev.)	0.981	0.927
Medium (elev.)	0.946	0.880
Short (elev.)	0.721	0.530
Long (slope)	0.977	0.921
Medium (slope)	0.948	0.886
Short (slope)	0.380	0.053

Result for Longitudinal Distance:

Error in longitudinal distance was -0.09 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	120.2	-5.7	167.32	-0.09
2	121.2	-4.8	167.32	-0.09
3	118.9	-6.6	167.32	-0.09
4	118.5	-7.0	167.32	-0.09
5	121.6	-4.6	167.32	-0.09
6	116.6	-8.5	167.32	-0.09
7	126.1	-1.0	167.32	-0.09
8	120.2	-5.7	167.32	-0.09
9	121.7	-4.5	167.32	-0.09
10	120.0	-5.9	167.32	-0.09

Notes:

- Section length is 167.48 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	Cross Correlation to Benchmark Profile, Elevation			
	IRI	Long	Medium	Short
1	0.885	0.919	0.870	0.047
2	0.883	0.921	0.898	0.039
3	0.878	0.918	0.893	0.053
4	0.876	0.915	0.872	0.038
5	0.890	0.924	0.906	0.050
6	0.870	0.914	0.863	0.047
7	0.903	0.926	0.903	0.057
8	0.881	0.925	0.897	0.059
9	0.918	0.962	0.895	0.053
10	0.867	0.881	0.864	0.090
Ave.	0.885	0.921	0.886	0.053

Run	Cross Correlation to Benchmark Profile, Slope		
	Long	Medium	Short
1	0.912	0.871	0.501
2	0.920	0.907	0.533
3	0.942	0.896	0.519
4	0.916	0.861	0.549
5	0.939	0.900	0.508
6	0.917	0.866	0.521
7	0.941	0.900	0.548
8	0.933	0.906	0.533
9	0.950	0.857	0.547
10	0.899	0.841	0.538
Ave.	0.927	0.880	0.530

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation			
		IRI	Long	Medium	Short
1	2	0.980	0.995	0.946	0.591
1	3	0.954	0.966	0.971	0.634
1	4	0.963	0.998	0.965	0.312
1	5	0.974	0.972	0.959	0.635
1	6	0.965	0.992	0.963	0.319
1	7	0.942	0.991	0.921	0.318
1	8	0.987	0.989	0.958	0.631
1	9	0.959	0.945	0.962	0.323
1	10	0.972	0.962	0.979	0.286
2	3	0.937	0.972	0.941	0.554
2	4	0.948	0.993	0.926	0.287
2	5	0.954	0.978	0.964	0.532
2	6	0.955	0.992	0.930	0.380
2	7	0.952	0.993	0.954	0.283
2	8	0.977	0.993	0.979	0.662
2	9	0.956	0.949	0.924	0.344
2	10	0.959	0.965	0.938	0.313
3	4	0.983	0.978	0.964	0.273
3	5	0.974	0.998	0.970	0.664
3	6	0.978	0.987	0.959	0.338
3	7	0.898	0.983	0.904	0.285
3	8	0.962	0.991	0.965	0.634
3	9	0.938	0.956	0.965	0.316
3	10	0.957	0.962	0.957	0.294
4	5	0.972	0.978	0.940	0.297
4	6	0.989	0.997	0.983	0.268
4	7	0.913	0.991	0.901	0.289
4	8	0.968	0.991	0.939	0.323
4	9	0.944	0.941	0.962	0.329
4	10	0.968	0.969	0.956	0.313
5	6	0.969	0.989	0.934	0.333
5	7	0.916	0.991	0.927	0.273
5	8	0.979	0.995	0.984	0.616
5	9	0.956	0.964	0.947	0.322
5	10	0.975	0.960	0.947	0.278
6	7	0.918	0.992	0.902	0.304
6	8	0.971	0.995	0.940	0.354
6	9	0.938	0.947	0.948	0.305
6	10	0.974	0.977	0.957	0.296
7	8	0.939	0.998	0.941	0.312
7	9	0.920	0.966	0.897	0.409
7	10	0.930	0.961	0.925	0.322
8	9	0.950	0.961	0.937	0.341
8	10	0.976	0.966	0.950	0.322
9	10	0.946	0.918	0.958	0.298
Average		0.956	0.977	0.948	0.380

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope		
		Long	Medium	Short
1	2	0.984	0.940	0.820
1	3	0.972	0.972	0.836
1	4	0.999	0.969	0.726
1	5	0.975	0.969	0.851
1	6	0.998	0.976	0.664
1	7	0.969	0.924	0.687
1	8	0.976	0.953	0.847
1	9	0.959	0.949	0.690
1	10	0.995	0.975	0.683
2	3	0.985	0.939	0.815
2	4	0.987	0.914	0.696
2	5	0.988	0.953	0.798
2	6	0.990	0.926	0.698
2	7	0.984	0.965	0.702
2	8	0.993	0.979	0.863
2	9	0.969	0.901	0.702
2	10	0.978	0.918	0.698
3	4	0.978	0.953	0.698
3	5	0.999	0.986	0.838
3	6	0.979	0.962	0.681
3	7	0.996	0.912	0.663
3	8	0.996	0.965	0.848
3	9	0.985	0.939	0.681
3	10	0.966	0.945	0.659
4	5	0.978	0.947	0.703
4	6	0.999	0.987	0.691
4	7	0.971	0.899	0.708
4	8	0.978	0.930	0.720
4	9	0.962	0.976	0.704
4	10	0.992	0.972	0.693
5	6	0.982	0.956	0.659
5	7	0.995	0.928	0.658
5	8	0.998	0.976	0.837
5	9	0.984	0.934	0.681
5	10	0.968	0.944	0.670
6	7	0.974	0.907	0.686
6	8	0.981	0.941	0.681
6	9	0.964	0.969	0.657
6	10	0.990	0.983	0.657
7	8	0.995	0.949	0.699
7	9	0.990	0.874	0.713
7	10	0.962	0.910	0.695
8	9	0.980	0.916	0.701
8	10	0.970	0.929	0.693
9	10	0.949	0.957	0.709
Average		0.981	0.946	0.721

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 11/12/2010

Device: VPTL Terrain measurement system

Operator(s): Virginia Tech

Recording Interval: 25 mm

Use Moving Average: Yes

No low-pass filtering was evident.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.990	0.894
Long (elev.)	0.993	0.954
Medium (elev.)	0.990	0.796
Short (elev.)	0.760	0.362
Long (slope)	0.996	0.942
Medium (slope)	0.985	0.846
Short (slope)	0.597	0.060

Result for Longitudinal Distance:

Error in longitudinal distance was -0.01 percent.

Run Log, DMI Results:

Run	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	72.5	-5.5	538.47	-0.01
2	72.6	-5.4	538.47	-0.01
3	72.5	-5.5	538.47	-0.01
4	73.0	-4.9	538.47	-0.01
5	73.0	-4.9	538.47	-0.01
6	72.0	-6.1	538.47	-0.01
7	72.9	-5.0	538.47	-0.01
8	72.7	-5.2	538.47	-0.01
9	72.5	-5.4	538.47	-0.01
10	73.1	-4.7	538.47	-0.01

Notes:

- Section length is 538.54 ft, measured by a steel tape and corrected for temperature.
- All length values derived from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.

Detailed Accuracy Scores:

Run	IRI	Cross Correlation to Benchmark Profile, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.895	0.933	0.851	0.035	0.036	0.102	0.036
2	0.892	0.942	0.842	0.034	0.035	0.035	0.035
3	0.898	0.948	0.851	0.031	0.032	0.032	0.091
4	0.894	0.950	0.845	0.050	0.051	0.051	0.051
5	0.892	0.941	0.846	0.086	0.085	0.085	0.085
6	0.885	0.945	0.835	0.040	0.041	0.041	0.041
7	0.897	0.943	0.849	0.048	0.050	0.050	0.050
8	0.892	0.936	0.848	0.032	0.032	0.032	0.032
9	0.892	0.949	0.841	0.117	0.116	0.116	0.116
10	0.898	0.933	0.856	0.090	0.090	0.090	0.090
Ave.	0.894	0.942	0.846	0.056	0.057	0.063	0.063

Run	Cross Correlation to Benchmark Profile, Slope					
	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.948	0.794	0.361	0.354	0.355	0.354
2	0.950	0.799	0.382	0.374	0.374	0.374
3	0.962	0.799	0.335	0.328	0.329	0.328
4	0.960	0.794	0.404	0.396	0.396	0.396
5	0.953	0.796	0.336	0.329	0.329	0.329
6	0.956	0.788	0.398	0.392	0.392	0.392
7	0.955	0.801	0.334	0.327	0.327	0.327
8	0.949	0.793	0.320	0.313	0.313	0.313
9	0.960	0.798	0.414	0.406	0.406	0.406
10	0.945	0.801	0.390	0.381	0.381	0.382
Ave.	0.954	0.796	0.367	0.360	0.360	0.360

Detailed Repeatability Scores:

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3
1	2	0.992	0.995	0.984	0.643	0.647	0.647
1	3	0.993	0.989	0.986	0.653	0.653	0.653
1	4	0.992	0.988	0.986	0.598	0.599	0.599
1	5	0.988	0.996	0.984	0.522	0.521	0.521
1	6	0.984	0.993	0.975	0.555	0.555	0.555
1	7	0.994	0.994	0.991	0.444	0.444	0.444
1	8	0.989	1.000	0.987	0.527	0.526	0.526
1	9	0.993	0.988	0.984	0.469	0.468	0.468
1	10	0.994	1.000	0.991	0.487	0.491	0.491
2	3	0.992	0.997	0.987	0.646	0.648	0.648
2	4	0.994	0.997	0.990	0.589	0.591	0.591
2	5	0.993	1.000	0.988	0.526	0.528	0.528
2	6	0.989	0.999	0.986	0.543	0.545	0.545
2	7	0.990	1.000	0.984	0.395	0.396	0.396
2	8	0.993	0.997	0.989	0.522	0.524	0.524
2	9	0.993	0.997	0.992	0.492	0.495	0.495
2	10	0.990	0.995	0.982	0.401	0.404	0.404
3	4	0.994	1.000	0.991	0.638	0.639	0.639
3	5	0.989	0.997	0.987	0.702	0.703	0.703
3	6	0.983	0.999	0.977	0.556	0.556	0.556
3	7	0.992	0.998	0.987	0.636	0.637	0.637
3	8	0.990	0.991	0.989	0.754	0.756	0.756
3	9	0.991	1.000	0.988	0.498	0.498	0.498
3	10	0.990	0.989	0.982	0.478	0.478	0.478
4	5	0.993	0.996	0.993	0.677	0.679	0.679
4	6	0.985	0.999	0.979	0.785	0.786	0.786
4	7	0.991	0.997	0.988	0.647	0.648	0.648
4	8	0.991	0.990	0.991	0.679	0.681	0.681
4	9	0.992	1.000	0.990	0.705	0.706	0.706
4	10	0.990	0.988	0.983	0.613	0.613	0.613
5	6	0.987	0.999	0.979	0.666	0.666	0.666
5	7	0.990	1.000	0.989	0.730	0.731	0.731
5	8	0.993	0.998	0.992	0.804	0.806	0.806
5	9	0.990	0.996	0.991	0.553	0.553	0.553
5	10	0.986	0.996	0.981	0.552	0.552	0.552
6	7	0.981	1.000	0.974	0.619	0.619	0.619
6	8	0.990	0.995	0.981	0.628	0.629	0.629
6	9	0.984	0.999	0.981	0.692	0.692	0.692
6	10	0.982	0.993	0.971	0.605	0.605	0.605
7	8	0.988	0.997	0.989	0.784	0.785	0.785
7	9	0.993	0.998	0.987	0.656	0.657	0.657
7	10	0.992	0.995	0.986	0.552	0.552	0.552
8	9	0.989	0.991	0.989	0.535	0.534	0.534
8	10	0.987	1.000	0.983	0.486	0.485	0.485
9	10	0.992	0.988	0.982	0.614	0.614	0.614
Average		0.990	0.996	0.985	0.597	0.598	0.598

Detailed Repeatability Scores (cont.):

Run 1	Run 2	Cross Correlation by Waveband, Slope					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	2	0.997	0.990	0.802	0.801	0.801	0.801
1	3	0.985	0.995	0.813	0.812	0.812	0.812
1	4	0.987	0.994	0.767	0.764	0.764	0.764
1	5	0.994	0.992	0.745	0.742	0.742	0.742
1	6	0.991	0.988	0.740	0.738	0.738	0.738
1	7	0.992	0.991	0.684	0.682	0.682	0.682
1	8	0.998	0.992	0.715	0.713	0.713	0.713
1	9	0.987	0.989	0.673	0.671	0.671	0.671
1	10	0.997	0.991	0.717	0.714	0.714	0.714
2	3	0.988	0.988	0.798	0.798	0.798	0.798
2	4	0.990	0.989	0.808	0.805	0.805	0.805
2	5	0.997	0.993	0.735	0.733	0.733	0.733
2	6	0.993	0.983	0.787	0.785	0.785	0.785
2	7	0.995	0.995	0.657	0.655	0.655	0.655
2	8	0.999	0.987	0.719	0.718	0.718	0.718
2	9	0.990	0.996	0.742	0.740	0.740	0.740
2	10	0.995	0.997	0.695	0.692	0.692	0.692
3	4	0.998	0.995	0.769	0.767	0.767	0.767
3	5	0.991	0.989	0.847	0.847	0.847	0.847
3	6	0.994	0.987	0.715	0.713	0.713	0.713
3	7	0.993	0.990	0.772	0.769	0.769	0.769
3	8	0.987	0.991	0.844	0.844	0.844	0.844
3	9	0.998	0.986	0.684	0.682	0.682	0.682
3	10	0.982	0.988	0.662	0.658	0.658	0.658
4	5	0.992	0.992	0.810	0.808	0.808	0.808
4	6	0.996	0.990	0.886	0.887	0.887	0.887
4	7	0.995	0.989	0.800	0.799	0.799	0.799
4	8	0.989	0.994	0.786	0.784	0.784	0.784
4	9	0.999	0.987	0.819	0.818	0.818	0.818
4	10	0.984	0.988	0.810	0.808	0.808	0.808
5	6	0.996	0.985	0.794	0.792	0.792	0.792
5	7	0.998	0.993	0.816	0.814	0.814	0.814
5	8	0.996	0.989	0.876	0.876	0.876	0.876
5	9	0.993	0.992	0.702	0.699	0.699	0.699
5	10	0.992	0.991	0.702	0.698	0.698	0.698
6	7	0.999	0.982	0.772	0.772	0.772	0.772
6	8	0.993	0.993	0.751	0.750	0.750	0.750
6	9	0.996	0.981	0.824	0.822	0.822	0.822
6	10	0.988	0.982	0.803	0.803	0.803	0.803
7	8	0.994	0.986	0.816	0.814	0.814	0.814
7	9	0.995	0.994	0.773	0.772	0.772	0.772
7	10	0.990	0.995	0.708	0.706	0.706	0.706
8	9	0.989	0.984	0.688	0.685	0.685	0.685
8	10	0.996	0.986	0.649	0.645	0.645	0.645
9	10	0.985	0.996	0.771	0.769	0.769	0.769
Average		0.993	0.990	0.761	0.759	0.759	0.759

Benchmark Test Evaluation Report

Test Section: MnROAD, Tight Mix Asphalt
Date: 2010-Sept-16, 14:40 - 16:00
Device: DipStick model 2000, Serial Number 02130, manual read
Operator(s): Jesse Dickes, Stantec
Recording Interval: 305.16 mm
Use Moving Average: No

The sample interval is larger than the 250-mm base length.

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

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.988	0.894
Long (elev.)	0.994	0.972
Medium (elev.)	0.987	0.940
Short (elev.)	0.811	0.536
Long (slope)	0.988	0.970
Medium (slope)	0.977	0.867
Short (slope)	0.705	0.099

Run Log, IRI Results:

Run	IRI (in/mi)	Percent Error
Downstream	80.3	-4.4
Upstream	81.1	-3.4

Notes:

- Two runs were performed.
- The first run included 500 turns collected downstream, starting at the section start.
- The second run followed immediately, included the same number of turns, and was collected upstream.
- “Accuracy Score” was obtained by cross correlating the downstream run to the benchmark profile.
- “Repeatability Score” was obtained by cross correlating the downstream run with the upstream run.
- Zero check performed.
- 32 mm footpads installed.
- Temperature 12.5 degrees C, cloudy.