Evaluation of Potential Pavement Profile Reference Devices

2013 Reference Profiler Benchmark Test Evaluation

Steven Karamihas
University of Michigan Transportation Research Institute

Rohan Perera
Soil and Materials Engineers, Inc.

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16. Abstract

This report provides the results from an evaluation of reference profilers that was performed in May 2013. The evaluation tested the profile measurement accuracy, profile measurement repeatability, and longitudinal distance measurement accuracy of the reference profilers. The accuracy of the devices was evaluated by comparing the measurements with benchmark measurements that were deemed to be correct. A self-propelled and self-piloting robotic profiler that was developed by the University of Michigan Transportation Institute was used to collect the benchmark profiles. Benchmark longitudinal distance measurements were obtained using a nylon-coated steel tape corrected for temperature.

Testing was performed at the MnROAD research facility in Albertville, MN. Six test sections were used for the evaluation. The texture types of the sections were dense-graded asphalt, chip seal, pervious asphalt, transversely tined concrete, longitudinally tined concrete, and diamond ground concrete.

Two vendors, Surface Systems and Instruments (SSI) and International Cybernetics Corporation (ICC) participated in the evaluation. Data were collected with a SSI CS 8800 unit and two ICC SurPRO units. The main report summarizes the experiment and provides a listing of which devices achieved a passing score for each criterion on each test section. The appendices provide much more detail about the performance of each device. The appendices include a summary for each device from each experiment, as well as individual "report cards" for each device on each test section.

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Acronyms and Abbreviations

CPAR	Critical Profiler Accuracy Requirements
CS	Chip Seal
DGA	Dense Graded Asphalt
DGC	Diamond Ground Concrete
FHWA	Federal Highway Administration
ICC	International Cybernetics Corporation
IRI	International Roughness Index
LT	Longitudinally Tined
PHMA	Pervious Hot Mix Asphalt
SSI	Surface Systems and Instruments
TAC	Technical Advisory Committee
TPF	Transportation Pooled Fund
TT	Transversely Tined
UMTRI	University of Michigan Transportation Research Institute
WFLHD	Western Federal Lands Highway Division

Acknowledgements

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The authors would like to thank Scott Zielinski of Soil and Materials Engineers, Inc. for his work on reference longitudinal distance measurements, rod and level surveys, and monitoring the measurements performed by the reference profilers. The authors would also like to thank Chris Winkler and Scott Bogard, who operated the Benchmark Profiler.

The authors would like to thank the following personnel who performed the reference profiler data collection: Paul Toom (Cherry Systems Research), Darel Mesher (EBA Engineering Consultants), Chase Fleeman (International Cybernetics Corporation), Flint Hixon and Brent Bergman (Surface Systems and Instruments, Inc.).

Lastly, the authors would like to thank the members of Pooled Fund Project TPF-5(063) for their support of this work and Robert Orthmeyer from the Federal Highway Administration (FHWA) for his active participation in the planning an execution of the experiment.

Background

State and federal highway agencies are using inertial profilers for monitoring and evaluating contractor compliance with smoothness specifications on pavement construction projects. These specifications often involve pay adjustments for the paving contractor and therefore can have a significant financial effect on the project participants. As a result, verification of the precision and accuracy of inertial profilers has become a high priority. For this purpose, highway agencies need a valid, portable, and efficient device 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) for certification of inertial profilers with a preference for multiple equipment manufacturers to develop such devices. In turn, highway agencies 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, which was awarded to the University of Michigan Transportation Research Institute (UMTRI). The "Critical Profiler Accuracy Requirements" (CPAR) report developed under this contract 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 pavements with diverse macrotexture types.

Subsequently, FHWA Contract DTFH61-07-C-00024 that was awarded to UMTRI, on behalf of the TPF-5(063) Technical Advisory Committee (TAC), supported the design and development of a 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 MnROAD research facility in Albertville, MN and at 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. The Benchmark Test Evaluation Report, which provides the results of the 2009 and 2010 benchmark profiler experiments. The "Report Cards" provided therein served as the official results for each candidate reference device. (*4*)

As reference profiler manufacturers have made improvements to their devices since the 2010 experiment, FHWA decided to hold another reference profiler evaluation. FHWA issued a task order to Soil and Materials Engineers, Inc., (SME) under contract DTFH61-10-D-0026 to perform this evaluation. UMTRI served as a subconsultant to SME for this study. This evaluation was held in May 2013 at MnROAD with the participation of two reference profiler manufacturers—International Cybernetics Corporation (ICC) and Surface Systems and Instruments, Inc. (SSI). This document presents the results from that evaluation. As a part of this contract, updates were made to the Benchmark Profiler, the Benchmark Profiler Field Manual, and the Benchmark Testing Plan documents that were developed under contract DTFH61-07-C-0024 (5, 6).

Test Sites

The testing was performed at six pavement sections at the MnROAD research facility in Albertville, MN. The dominant criteria for selecting test sections were macrotexture type and smoothness. The texture types included dense graded asphalt (DGA), a chip 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 was located within Cells 18 and 19 of the mainline driving lane. The track of interest was along the right wheel path of the driving lane.

CS – This section was located in the right wheel path within eastbound Cell 27 on the low-volume loop, but it was measured in the westbound direction. The track of interest was in the right wheel path 36 inches from the inner edge of the fog line.

PHMA – This section was located within eastbound Cell 88 on the low-volume loop. The track of interest was along the right wheel path 46 inches from the inner edge of the fog line.

TT – This section was located within eastbound Cells 36 and 37 on the low-volume loop. The track of interest was in the right wheel path 39 inches left of the right side concrete edge. The tine spacing was irregular with a 1-inch nominal value, and the joints were skewed with a 1:6 ratio.

LT – This test section was located within Cell 6 on the mainline driving lane. The track of interest was 48.7 inches to the right of the longitudinal joint along the left side of the lane. The section included perpendicular joints 15 feet apart and a highly variable texture depth.

DGC – This section was located within Cell 8 on the mainline driving lane. The track of interest was located in the right wheel path, 61 inches to the left of the left edge of the right side lane edge marker. The texture included about 5 ridges per inch of width, and the joints were skewed with a 1:6 ratio.

Appendix A includes photographs of the test sections. Table 1 lists the International Roughness Index (IRI) values of the test sections determined from the Benchmark Profiler measurements and the length of each test section measured with a nylon coated steel tape, and corrected for temperature.

Table 1. Test Section Length and Roughness.

Texture Type	IRI (in/mi)	Length (ft)
DGA	77.30	1038.0
CS	91.59	501.26
PHMA	130.39	185.98
TT	77.56	538.68
LT	97.51	453.53
DGC	60.59	468.04

Reference Profiling Devices

SSC CS 8800 Walking Profiler

A SSI CS 8800 Walking Profiler collected data at the test sections. After completion of all repeat runs at a test section, the data were processed to produce two data sets. One data set contained the data profile produced from the standard configuration, and the other data set called the experimental configuration incorporated readings from the pitch of an articulating arm at the front of the device into the profile produced by the standard configuration. Thus, every pass by the CS 8800 Walking Profiler produces a profile from the standard configuration and another profile from the experimental configuration. Prior to testing, SSI informed that the experimental configuration will produce a profile that will maximize performance in the short waveband but with the possibility of degraded performance on the other wavebands as well as the IRI. Table 2 shows the data sets that were used for analysis and the abbreviations assigned for each data set.

ICC SurPRO 4000

ICC brought two identical SurPRO 4000 units (#90 and #91) for the evaluation. Unit #90 was operated by Chase Fleeman of ICC and unit #91 was operated Darel Mesher of EBA Engineering Consultants. Both SurPRO's performed measurements at each test section at the same time with one unit following the other unit. With few exceptions, unit #90 followed unit #91 in each pass. Both units included two lasers on the underside of the main chassis to augment the inclinometer measurements from the standard configuration. After all repeat runs were performed at a section by a unit, the collected data were processed to create two data sets. One data set included data obtained only from the inclinometer measurements, while the other data set included data obtained from both the inclinometer and the laser sensors. Therefore, although only two SurPRO's collected data at a section, four sets of data were produced for analysis at each test section. Table 2 shows the data sets that were used for analysis and the abbreviations assigned for each data set. The data set that had the contributions from the lasers is shown as "4000L" in this table.

Table 2. Data Sets from the Reference Devices.

Data Set	Organization	Abbreviation
CS 8800 Walking Profiler	SSI	SSI CS8800
CS 8800 Walking Profiler, experimental configuration	SSI	SSI CS8800 EC
SurPRO 4000, Unit #90	ICC	ICC SP4000-90
SurPRO 4000, Unit #91	ICC	ICC SP4000-91
SurPRO 4000L Unit #90	ICC	ICC SP4000L-90
SurPRO 4000L, Unit #91	ICC	ICC SP4000L-91

Test Section Coverage

Table 3 lists the number of repeat measurements submitted for each device configuration for each test section. The number of repeat runs requested was six. A monitor was present when the reference profilers collected data to ensure the vendors followed the testing guidelines. The monitor noted the start and end time of each run, recorded the distance displayed on the reference device at the end of each run, and noted any other pertinent observations during data collection.

The SurPRO units submitted seven profiles for every test series. However, the first profile was not included in the analysis. The first profile run in each series always included loop closure, and was considered a “calibration” run used to eliminate bias in the inclinometer in the device at each test section. Both SurPRO units collected data twice on the diamond ground section due to concern over the rate at which slab curling changed the profile during the first visit. Profile data from the two visits to the diamond ground section were treated as two separate data sets.

The CS 8800 collected 6 runs on each test section. Typically, the two operators took turns measuring the section. All of the runs included loop closure. The device visited the diamond ground section twice, due to concern over the level of slab curling that was present in relation to the timing of the benchmark profile measurements. Profiles from the two visits to the diamond ground section were treated as two separate data sets. SSI returned to the dense-graded asphalt section for three additional measurements with the same operator after the first series to capture six runs with a single operator. (Runs 1, 3, 5 and 7-9 were measured by Brent.) The first six runs were treated as one data set and the Brent-only runs were treated as another data set.)

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.) The measurement procedure of the Benchmark Profiler is described in reference 5. Rod and level measurements were taken on the test sections at the time when Benchmark Profiler performed measurements using a Leica DNA03 level and an invar rod. These measurements establish the relative height of segment endpoints measured by the Benchmark Profiler within each section.

Table 3. Test Section Coverage by Each Device.

	DGA	CS	PHMA	TT	LT	DGC
SSI CS8800	9	6	6	6	6	12
SSI CS8800 EC	9	6	6	6	6	12
ICC SP 4000-90	6	6	6	6	6	12
ICC SP 4000-91	6	6	6	6	6	12
ICC SP 4000L-90	6	6	6	6	6	12
ICC SP 4000L-91	6	6	6	6	6	12

The dates and times at which the devices performed measurements at the test sections are shown in table 4. The times shown for ICC are for Unit #90. As the two ICC units followed each other, the time of measurements for ICC Unit #91 was off the time shown for Unit #90 by a couple of minutes.

Table 4. Date and Time of Measurements.

Test Section	Date and Time of Measurements		
	Benchmark	ICC	SSI
DGA	5/13, 08:30-18:00	5/15, 16:56-18:46	5/14, 08:15-11:44[1]
			5/16, 12:11-14:08[2]
CS	5/14, 12:30-15:35	5/15, 13:51-15:05	5/13, 10:47-15:42
PHMA	5/12, 10:30-11:20	5/14, 15:52-16:35	5/13, 09:18-10:22
TT	5/14, 08:30-11:04	5/15, 10:57-12:14	5/16, 08:24-10:49
LT	5/12, 12:37-15:07	5/15, 08:14-09:28	5/14, 13:54-15:48
DGC	5/12, 16:10-18:25	5/14, 11:49-13:14[1]	5/13, 15:38-17:56[1]
		5/15, 05:48-07:11[2]	5/14, 17:12-19:23[2]

[1] First Visit, [2] Second Visit

Ambient Temperature During the Test Dates

A weather station at MnROAD records ambient temperatures at 15 minute intervals. These measurements were evaluated to obtain the minimum ambient temperature, maximum ambient temperature, and the temperature at noon for each test date. These ambient temperatures are shown in table 5. The time at which the minimum and maximum ambient temperatures occurred are also shown in this table.

Table 5. Ambient Temperatures on Test Dates.

Date	Temperature (°F)			Time of Occurrence	
	Minimum	12:00 PM	Maximum	Minimum Temperature	Maximum Temperature
5/12/2013	31	49	58	5:30	17.45:18:00
5/13/2013	37	57	71	3:45	17:30-19:00
5/14/2013	48	74	95	6:15	16:15-17:15
5/15/2013	51	71	81	5:45-6:00	18:30-18:45
5/16/2013	52	77	81	5:30-6:30	14:30-15:45

Requirements for a Reference Device

Based on the criteria established in the CPAR study (1), a reference device must demonstrate accuracy on a given test section by correlating to the benchmark profile with an average rating based on 6 repeat runs of at least:

0.98 for IRI filter output

0.98 in the long waveband (slope).

0.98 in the medium waveband (slope), and

0.94 in the short waveband (slope).

The filtering section of reference 6 defines the long, medium, and short waveband and describes how they will be isolated.

A reference device must also satisfy the above mentioned criteria for repeatability based on six repeat measurements.

A reference device must also measure the longitudinal distance correctly to within 0.1 percent of the actual distance of the test section measured using a nylon coated steel tape corrected for temperature.

Detailed Results

Appendix E provides detailed results from the experiment for each device. This appendix contains a "Benchmark Test Evaluation Report" for each set of measurements on a given section by a given reference profiling device. Thus, Evaluation Reports are provided for the six device configurations shown in Table 2. Evaluation Reports are also provided for the Benchmark Profiler that shows its run-to-run consistency.

Each Evaluation Report lists the test section, device, operators, measurement date, data recording interval of the device, whether a moving average is used on the data during the analysis, notes pertinent to the analysis, and relevant observations noted during the testing. The Evaluation Reports 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 (*6*) describes the

analysis procedures for making these comparisons in detail. Appendix C provides a concise guide for interpreting the report cards.

Appendix D provides "Benchmark Test Evaluation Summaries" for each device that summarizes the information presented in appendix E. The summaries characterize a device's overall performance at each test section. The Summaries include overall profile repeatability scores, overall profile accuracy scores, and longitudinal distance measurement agreement scores. The Summaries also include observations from comparison of slope spectral density measured by each device to the benchmark measurement.

Summary Results

This section indicates whether a reference profiler passed the longitudinal distance measurement, profile repeatability, and profile accuracy requirements on each test section. The tables included in this section only indicate whether a device passed the criterion and do not provide the scores obtained in each category.

In the experiment, a passing score for repeatability or accuracy required average cross correlation of at least 0.98 for the IRI, long waveband (slope) and medium waveband (slope) and 0.94 for the short waveband (slope).

Refer to Appendix D and E, which provide a complete characterization of each device for more details. Often, knowing which reference profilers nearly met each criterion and which did not come close is more helpful than simply looking to see whether a device passed a specific criterion. For example, the ICC SP 4000-90 achieved an accuracy score of 0.971 in the medium waveband on the dense graded asphalt section, which narrowly missed the cut off value of 0.98. It was noted the SurPRO units in the standard mode achieved several repeatability scores that far exceeded a passing score (see appendix D and E).

Tables 6 and 7 list the wavebands for which each device achieved a passing accuracy score and repeatability score, respectively. Longitudinal distance measurement performance of the devices is shown in Table 8.

Table 6. Ability of Devices to meet Accuracy Requirement by Waveband.

	DGA	CS	PHMA	TT	LT	DGC
SSI CS8800	L			L		L
SSI CS8800 EC						
ICC SP 4000-90	L	L	L	L	L	
ICC SP 4000-91	L	L	L	L	L	
ICC SP 4000L-90	L	L	L	L	L	
ICC SP 4000L-91	L	L	L	L	L	

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

Table 7. Ability of Devices to meet Repeatability Requirement by Waveband.

	DGA	CS	PHMA	TT	LT	DGC
SSI CS8800		I, L, M		L	I, L,M	L
SSI CS8800 EC	L	L	I, L	L	I, M	
ICC SP 4000-90	I, L, M	I, L, M	I, L, M	I, L, M	I, L, M	I, L
ICC SP 4000-91	I, L, M	I, L, M	I, L, M	I, L, M	I, L, M	L
ICC SP 4000L-90	I, L, M	I, L, M	I, L, M	I, L, M	L	L
ICC SP 4000L-91	I, L, M	L	L	I, L, M	L	L

I – IRI; L – Long; M – Medium

Table 8. Ability of Devices to meet Longitudinal Distance Measurement Requirement.

	DGA	CS	PHMA	TT	LT	DGC
SSI CS8800	P		P		P	P
SSI CS8800 EC	P		P		P	P
ICC SP 4000-90	P	P	P	P	P	P
ICC SP 4000-91	P	P	P	P	P	P
ICC SP 4000L-90	P	P	P	P	P	P
ICC SP 4000L-91	P	P	P	P	P	P

P – Passed

Both ICC units passed the long waveband accuracy requirement for both configurations (i.e., standard mode and with laser data), but failed the IRI, medium waveband and short waveband accuracy requirement. The SSI standard configuration met the long waveband requirement only at three test sections. The SSI standard configuration did not meet the IRI, medium waveband or long waveband requirement at all test sections. The SSI experimental configuration did not meet IRI, long waveband, medium waveband, or short waveband requirements at any test sections.

As shown in Table 4, the reference profilers performed measurements at test sections on dates and times that were different when these sections were measured by the Benchmark Profiler. As shown in Table 5, there were significant changes in ambient temperature over the five days when measurements were performed at the test sections. Changes in the temperature gradient in a concrete slab can significantly affect slab curling. The accuracy scores of reference profilers at concrete sections could have been impacted by slab curling. The repeatability scores of reference profilers at concrete sections may have also been affected by slab curling because of the changes in temperature gradient of the slab over the period during which measurements were performed.

Comments

In the SurPRO units, the standard configuration (i.e., without laser measurements included in profile data) produced higher accuracy and repeatability scores than the laser configuration. In the CS 8800 unit, the standard configuration produced higher accuracy and repeatability scores than the experimental configuration.

This experiment did not produce a true measurement of the short wavelength performance of the candidate reference devices, because the Benchmark Profiler itself was not sufficiently repeatable in the short waveband.

Accuracy scores for reference profilers were affected by slab curling because Benchmark Profiler measurements and reference profiler measurements were made during times when the ambient temperature was different. Repeatability scores for reference profilers at concrete sections may also have been affected by changes in ambient temperature that caused in changes in profile due to slab curling over the period the measurements were made. Changes in slab curl primarily affected the medium waveband and the IRI waveband.

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Appendix A: Test Section Photographs

This appendix displays photographs of the test section used in the 2013 benchmark profiler experiment. The photos were provided by Steve Karamihas (UMTRI).

Figure A–1. Dense graded asphalt, downstream view with markings and chalk line.

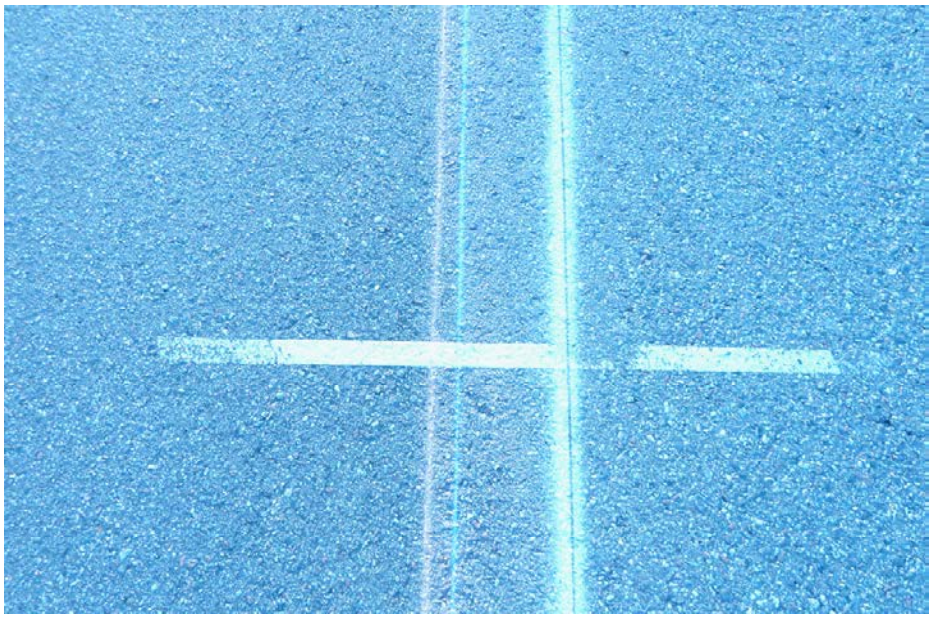


Figure A–2. Dense graded asphalt texture and chalk lines.

Figure A–3. Chip seal upstream view.

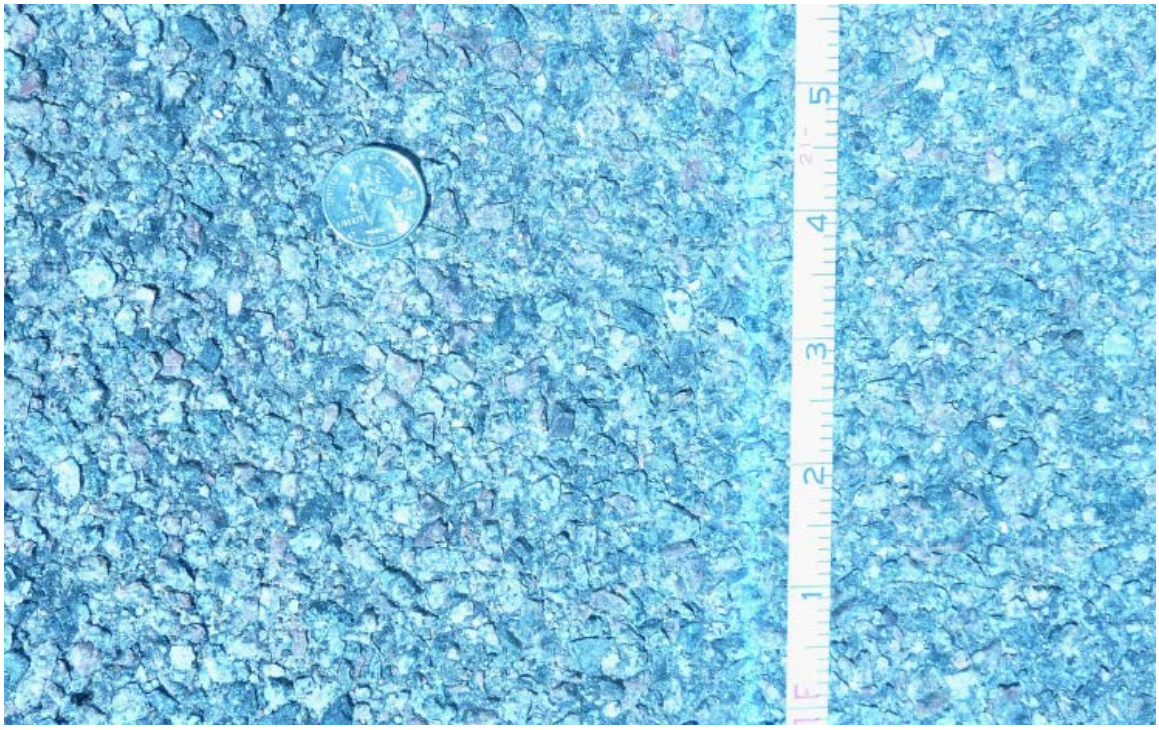


Figure A–4. Chip seal texture.

Figure A–5. Pervious hot mix asphalt downstream view.

Figure A–6. Pervious hot mix asphalt texture.

Figure A–7. Transverse tining downstream view.

Figure A–8. Transverse tining texture.

Figure A-9. Longitudinal tining downstream view.

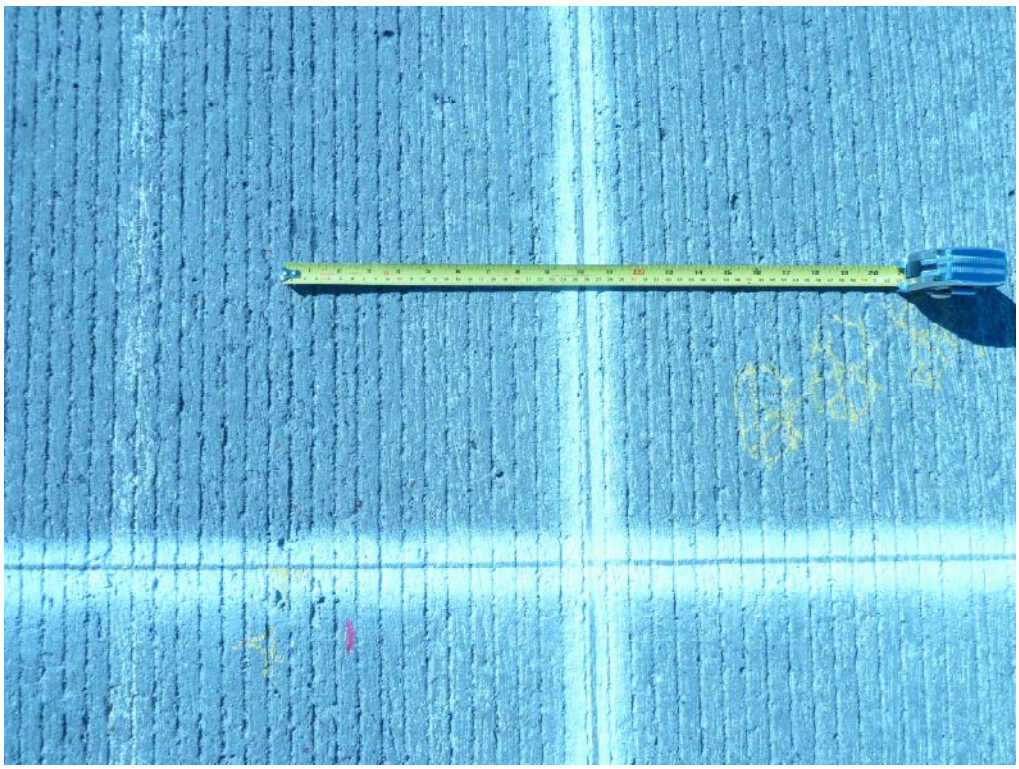


Figure A-10. Longitudinal tining texture, offset for measurements and start marking.

Figure A–11. Diamond grinding downstream view.

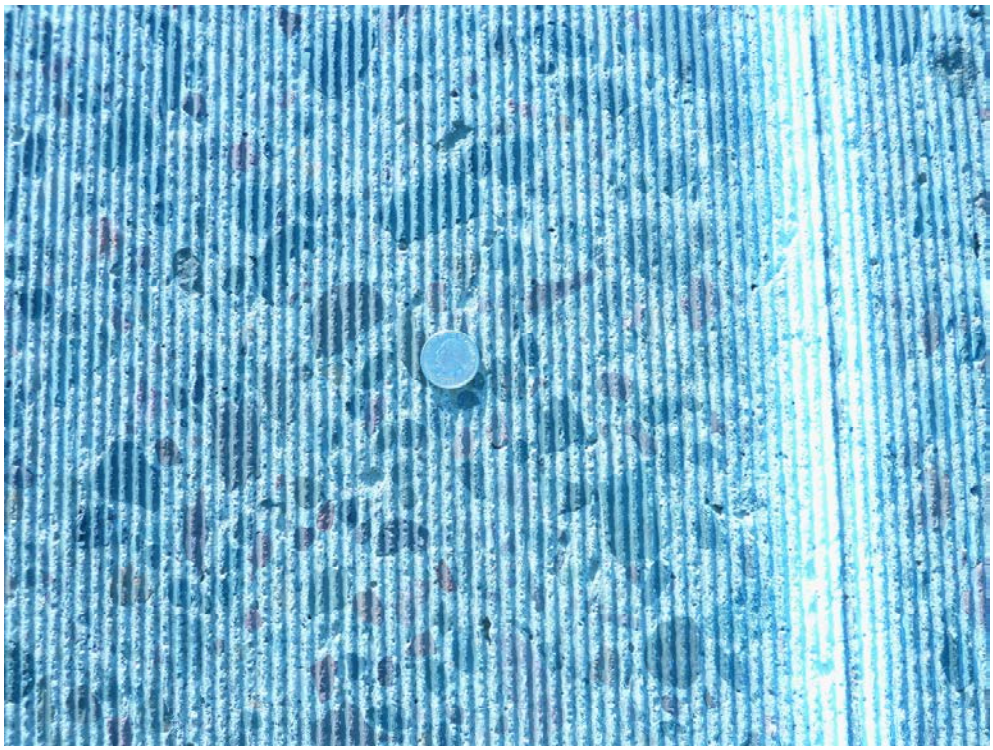


Figure A–12. Diamond grinding texture.

Appendix B: Reference Profiler Photographs

This appendix displays photographs of the reference profilers that participated in the experiment as well as some photographs of the Benchmark Profiler. The photos were provided by Steve Karamihas (UMTRI) and Bob Orthmeyer (FHWA).

Figure B–1. SSI SC8800 Walking Profiler.

Figure B-2. SSI SC8800 Walking Profiler, close-up.

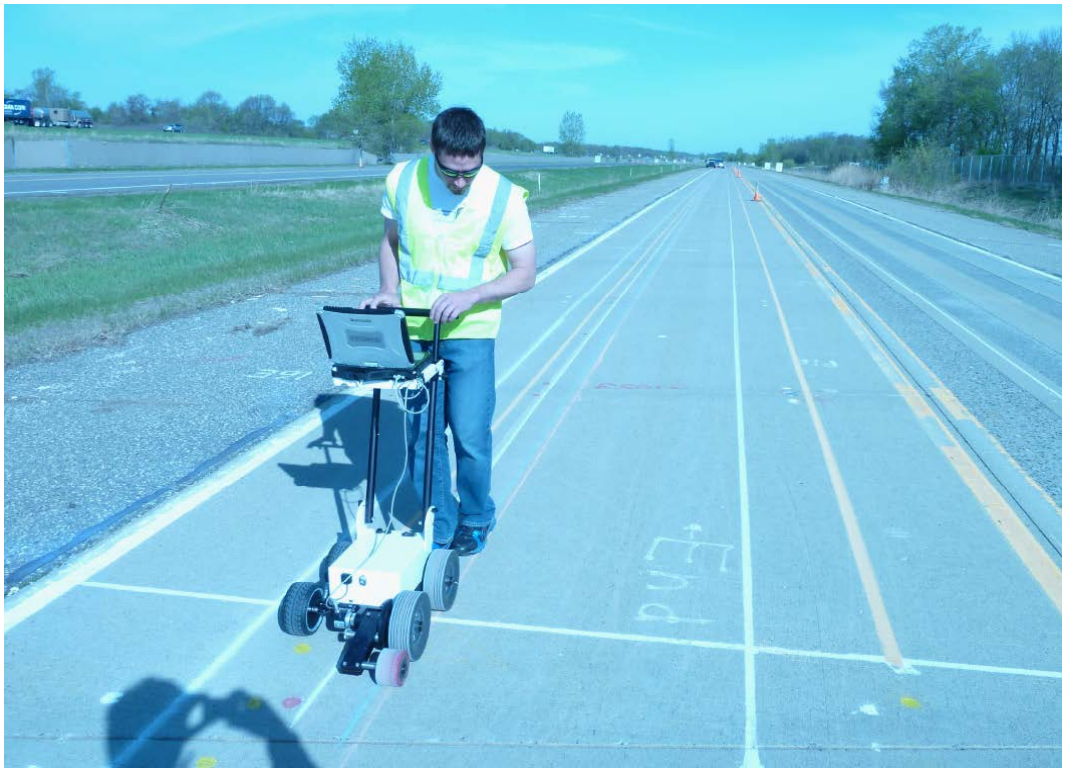


Figure B–3. SSI SC8800 Walking Profiler on transverse tining.

Figure B–4. SSI SC8800 Walking Profiler articulating arm.

Figure B–5. ICC SurPRO 4000L.

Figure B–6. ICC SurPRO 4000L close-up view.

Figure B–7. ICC SurPRO 4000L close-up view.

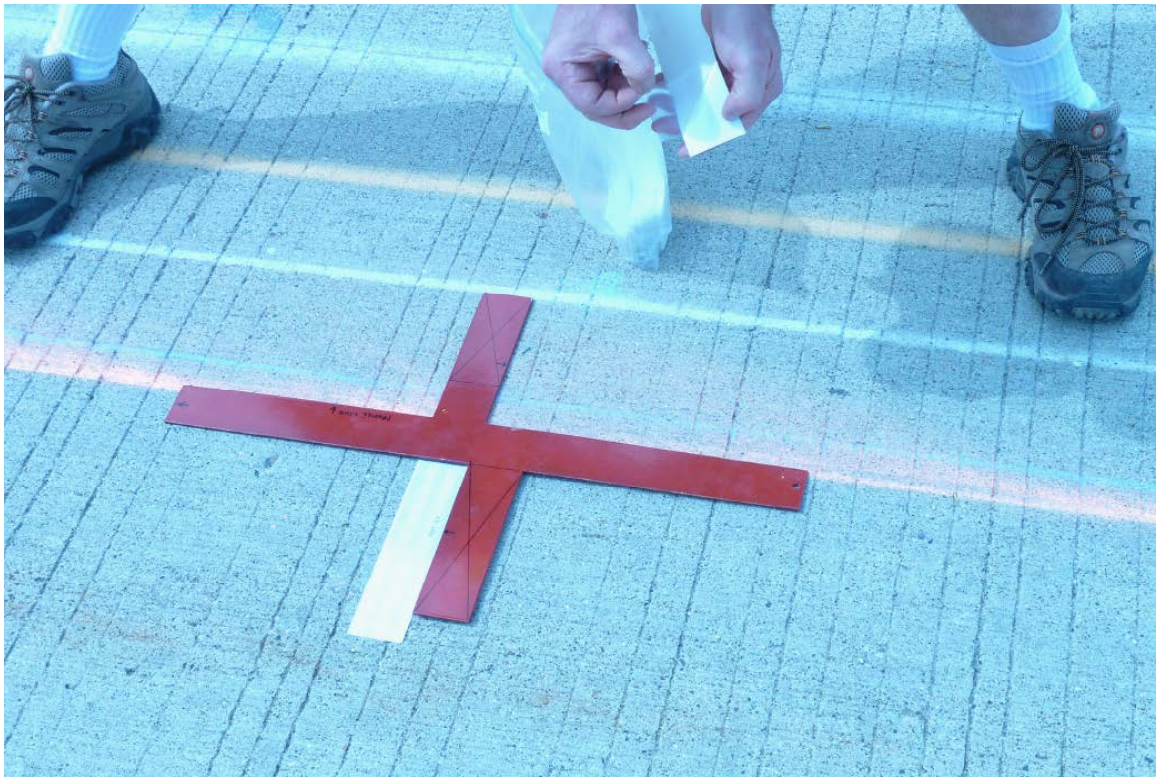


Figure B–8. ICC SurPRO 4000 pavement marking template.

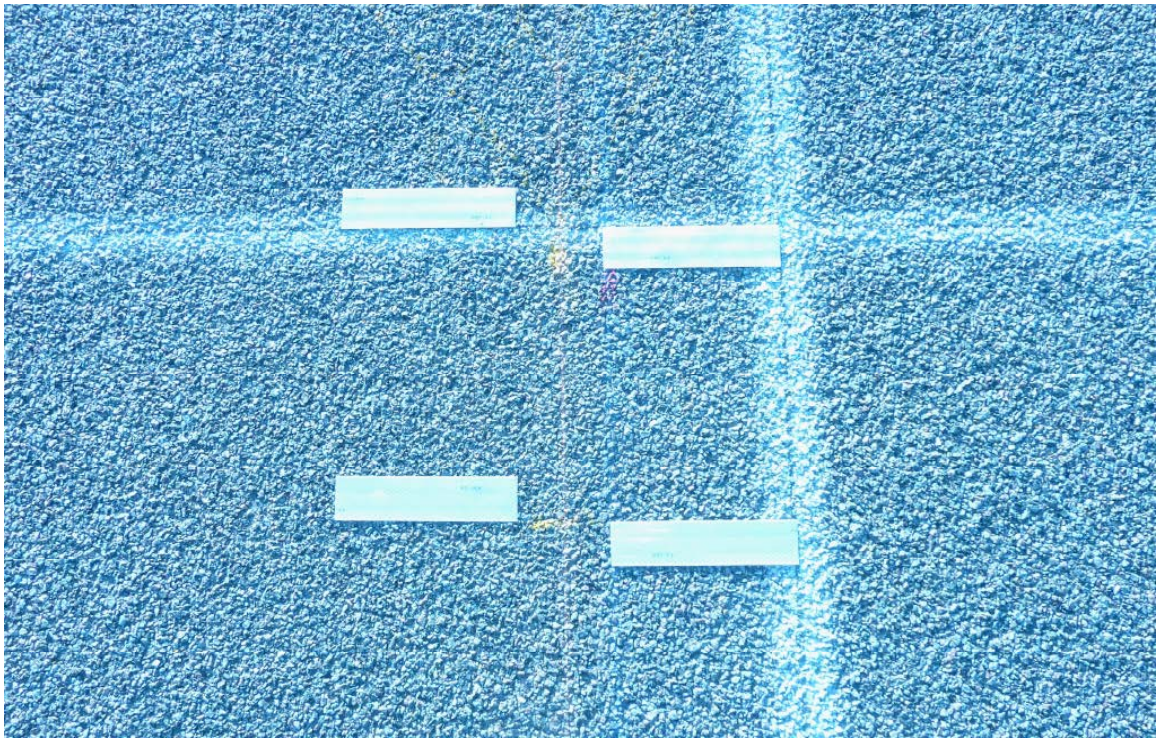


Figure B–9. ICC SurPRO 4000 pavement markings at start of chip seal section.

Figure B–10. Benchmark Profiler cart at the chip seal section.

Figure B–11. Benchmark Profiler reference laser alignment.

Figure B–12. Benchmark Profiler cart on the transverse tining section.

Figure B–13. Benchmark Profiler reference laser stand and power supply.

Figure B–14. Leica DNA 03 level.

Figure B–15. Invar rod.

Appendix C: 2013 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" (*6*) provides extensive details about the calculation methods.

Test Section: This entry identifies the test section and indicates the surface type.

Date: This entry lists the test date(s) of the measurements and the time window over which measurements were performed.

Device: This entry lists the device make and model.

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

Recording Interval: This entry lists the recording interval of the submitted profiles.

Use Moving Average: This entry explains whether the 250 mm moving average should be applied for IRI calculations. 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 presented for both elevation and slope.

The repeatability score is the average of all possible one-to-one comparisons between profiles. For example, when 6 profiles exist, 15 comparisons are possible. The score is the average of the 15 individual values.

The accuracy score is the average cross correlation to the benchmark profile. Thus, when 6 profiles exist, the accuracy score in each waveband is the average of 6 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: The results in the table are presented for elevation as well as slope for the long, medium, and short wavebands. However, the slope values are used to determine if the required criterion for

each waveband was met. The slope values were chosen because: (1) the Benchmark Testing Plan specifies it, (2) broad wavebands of the elevation profile typically include disproportionate contributions from the longer part of a given waveband, and (3) comparing agreement in each waveband using slope profile provides a more direct indication of where errors in the IRI come from. For the long, medium, and short wavebands, the profiles are converted 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 the section. The reference measurement is established with a nylon-coated steel tape, and corrected for ambient temperature. On most cases, the value for comparison is provided on-site by the candidate profiler operator.

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 profile measurement, and the percent error.

Detailed Accuracy Scores:

A table appears under this heading that lists every cross correlation value that was used to calculate the accuracy scores listed under the section "Results from Profile".

Detailed Repeatability Scores:

A table appears under this heading that lists every cross correlation value that was used to calculate the repeatability scores listed under the section "Results from Profile".

Notes:

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

- Information about measurement procedures.
- Identification of the observer.
- Cases in which more runs were performed than were submitted, and the reasoning for aborted runs.

- Information about the weather that may affect the results.

Appendix D: 2013 Benchmark Test Evaluation Summaries

Benchmark Test Evaluation Summary

Device: SurPRO 4000, Unit #90

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.961	**0.985**	0.971	0.165
Pervious HMA	0.956	**0.998**	0.961	0.186
Chip Seal	0.943	**0.994**	0.945	0.181
Transverse Tining	0.945	**0.997**	0.929	0.215
Diamond Grinding†	0.848	**0.998**	0.791	0.154
Diamond Grinding††	0.647	**0.994**	0.311	0.175
Longitudinal Tining	0.806	0.966	0.795	0.459

† First Visit †† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	**0.993**	**0.996**	**0.993**	0.707
Pervious HMA	**0.996**	**0.997**	**0.994**	0.867
Chip Seal	**0.988**	**0.999**	**0.987**	0.748
Transverse Tining	**0.992**	**0.999**	**0.987**	0.804
Diamond Grinding†	0.940	**1.000**	0.906	0.624
Diamond Grinding††	**0.991**	**1.000**	0.971	0.680
Longitudinal Tining	**0.992**	**0.999**	**0.990**	0.879

† First Visit †† Second Visit

Longitudinal Distance Measurement:

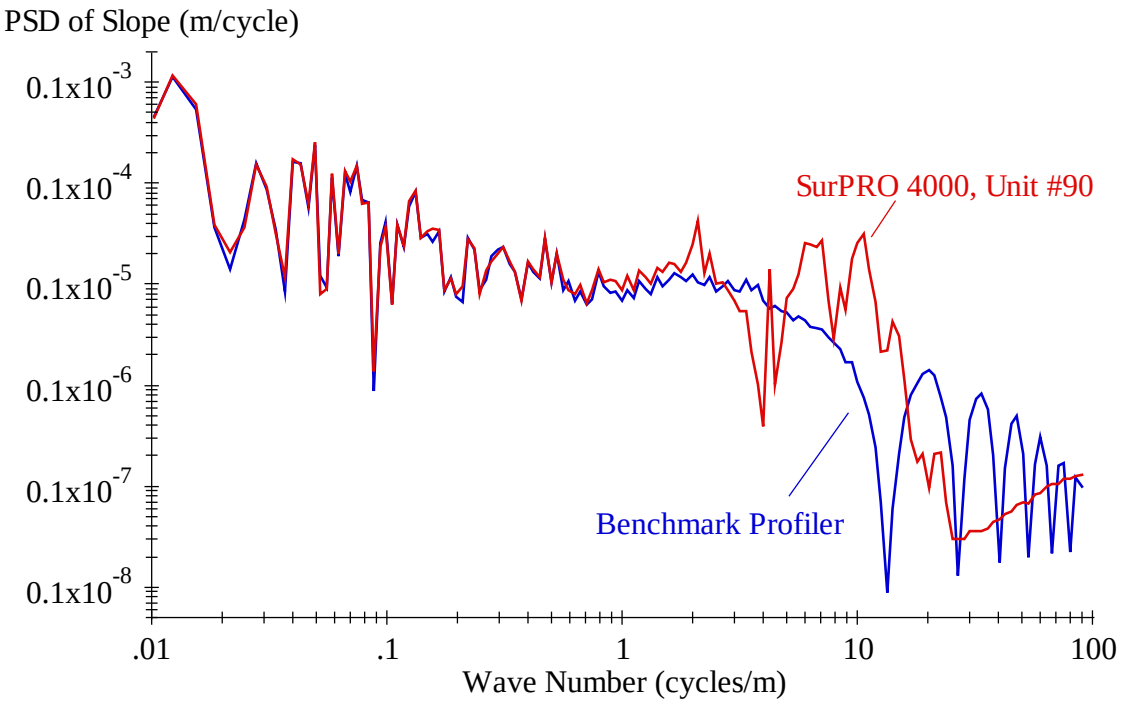
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	-0.04	-0.04	-0.04
Pervious HMA	-0.03	-0.03	-0.03
Chip Seal	-0.03	-0.03	-0.03
Transverse Tining	-0.05	-0.05	-0.05
Diamond Grinding†	0.02	0.02	0.02
Diamond Grinding††	0.02	0.02	0.03
Longitudinal Tining	-0.02	-0.02	-0.02

† First Visit †† Second Visit

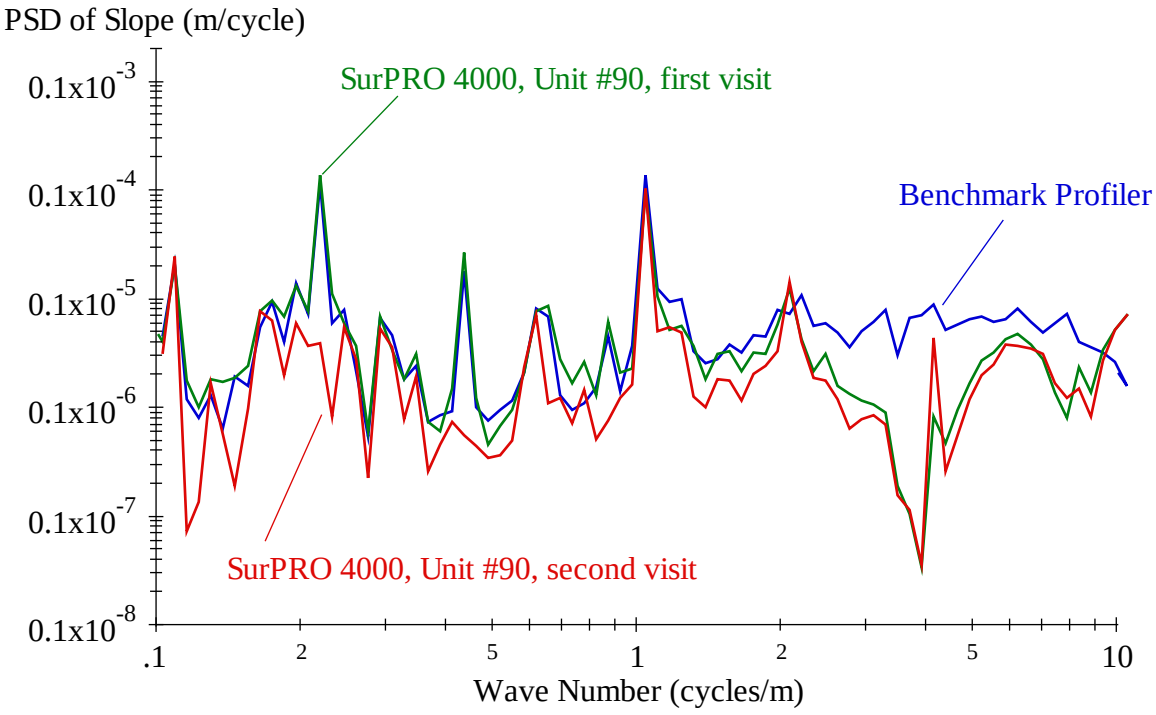
Spectral Density Plots:

Spectral density plots show a spike at about 2 cycles/m, which may correspond to content added by a wheel of 6-inch diameter. (See the plot for dense graded asphalt below.) Spectral density plots also showed a notch (i.e., a lack of content) at 4 cycles/m (a wavelength of 250 mm) due to the wheelbase filtering effect.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series. The spectral density plot for the diamond ground section, provided below, provides an example. The plot shows a high level of content at about 0.22 cycles/m (a wavelength of about 15 ft) in a profile from the benchmark profiler and the first visit by the SurPRO 4000. In the second visit by the SurPRO 4000, that content is greatly diminished due to the reduction in slab curl.



Dense Graded Asphalt



Diamond Grinding

Benchmark Test Evaluation Summary

Device: SurPRO 4000, Unit #91

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.966	**0.984**	0.978	0.183
Pervious HMA	0.952	**0.991**	0.960	0.203
Chip Seal	0.948	**0.997**	0.953	0.151
Transverse Tining	0.945	**0.995**	0.928	0.257
Diamond Grinding†	0.848	**0.994**	0.795	0.173
Diamond Grinding††	0.644	**0.992**	0.306	0.152
Longitudinal Tining	0.812	0.962	0.801	0.466

† First Visit †† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	**0.992**	**0.998**	**0.990**	0.804
Pervious HMA	**0.995**	**0.997**	**0.994**	0.718
Chip Seal	**0.992**	**1.000**	**0.990**	0.825
Transverse Tining	**0.991**	**0.999**	**0.986**	0.880
Diamond Grinding†	0.935	**0.999**	0.899	0.668
Diamond Grinding††	**0.988**	**1.000**	0.962	0.707
Longitudinal Tining	**0.987**	**0.999**	**0.985**	0.895

† First Visit †† Second Visit

Longitudinal Distance Measurement:

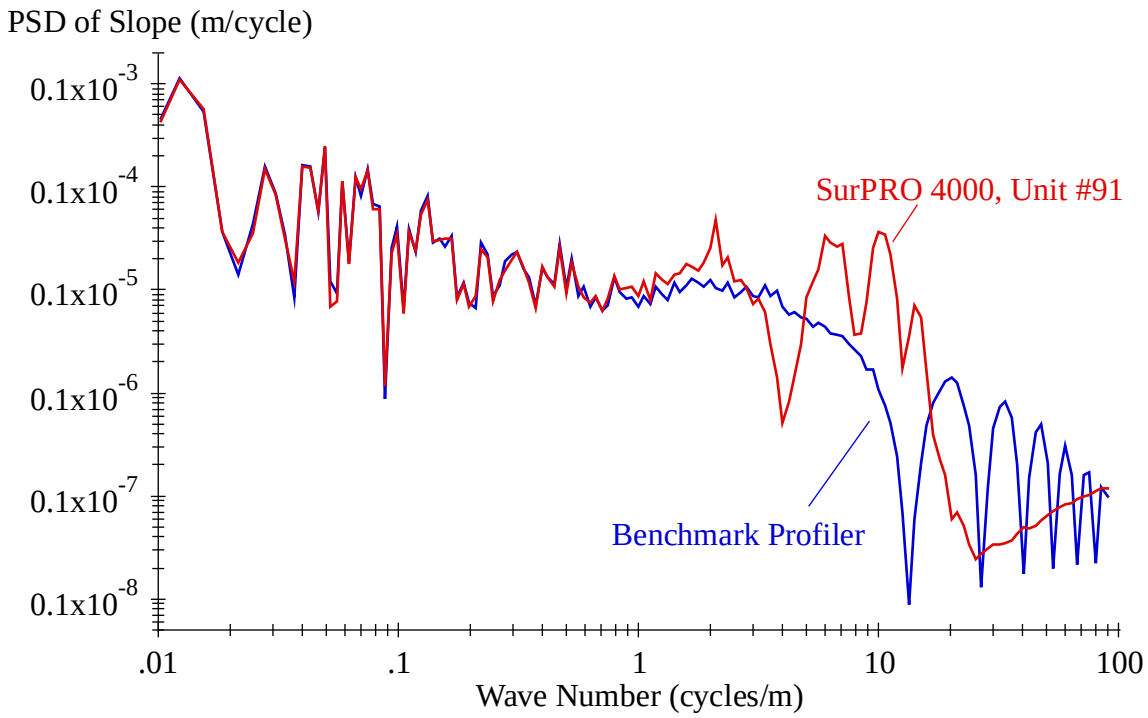
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	-0.04	-0.04	-0.04
Pervious HMA	-0.03	-0.03	-0.03
Chip Seal	-0.03	-0.03	-0.03
Transverse Tining	-0.05	-0.05	-0.05
Diamond Grinding†	0.02	0.02	0.02
Diamond Grinding††	0.02	0.02	0.03
Longitudinal Tining	-0.02	-0.02	-0.02

† First Visit †† Second Visit

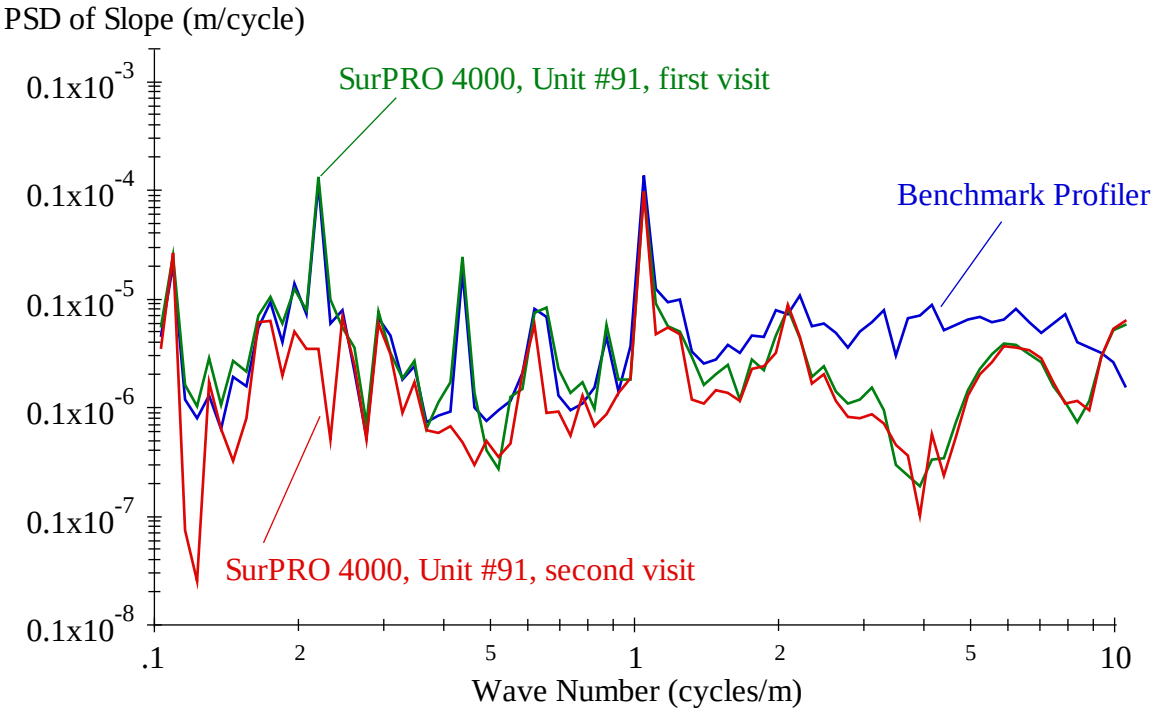
Spectral Density Plots:

Spectral density plots show a spike at about 2 cycles/m, which may correspond to content added by a wheel of 6-inch diameter. (See the plot for dense graded asphalt below.) Spectral density plots also showed a notch (i.e., a lack of content) at 4 cycles/m (a wavelength of 250 mm) due to the wheelbase filtering effect.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series. The spectral density plot for the diamond ground section, provided below, provides an example. The plot shows a high level of content at about 0.22 cycles/m (a wavelength of about 15 ft) in a profile from the benchmark profiler and the first visit by the SurPRO 4000. In the second visit by the SurPRO 4000, that content is greatly diminished due to the reduction in slab curl.



Dense Graded Asphalt



Diamond Grinding

Benchmark Test Evaluation Summary

Device: SurPRO 4000L, Unit #90

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.951	**0.985**	0.961	0.251
Pervious HMA	0.926	**0.996**	0.919	0.296
Chip Seal	0.919	**0.993**	0.919	0.188
Transverse Tining	0.935	**0.997**	0.919	0.252
Diamond Grinding†	0.751	**0.998**	0.679	0.230
Diamond Grinding††	0.595	**0.994**	0.293	0.222
Longitudinal Tining	0.728	0.965	0.724	0.398

† First Visit †† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	**0.991**	**0.996**	**0.991**	0.730
Pervious HMA	**0.991**	**0.996**	**0.988**	0.898
Chip Seal	**0.984**	**0.999**	**0.980**	0.765
Transverse Tining	**0.990**	**0.999**	**0.984**	0.793
Diamond Grinding†	0.866	**1.000**	0.819	0.563
Diamond Grinding††	0.615	**1.000**	0.388	0.484
Longitudinal Tining	0.967	**0.995**	0.965	0.869

† First Visit †† Second Visit

Longitudinal Distance Measurement:

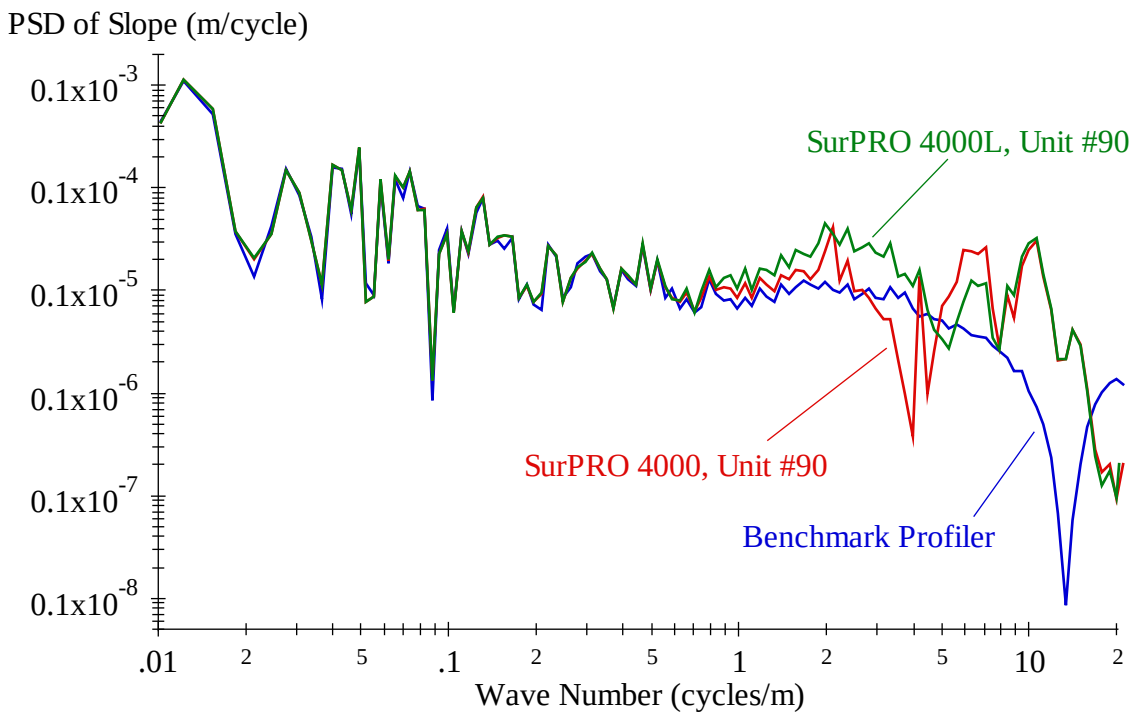
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	-0.04	-0.04	-0.04
Pervious HMA	-0.03	-0.03	-0.03
Chip Seal	-0.03	-0.03	-0.03
Transverse Tining	-0.05	-0.05	-0.05
Diamond Grinding†	0.02	0.02	0.02
Diamond Grinding††	0.02	0.02	0.03
Longitudinal Tining	-0.02	-0.02	-0.02

† First Visit †† Second Visit

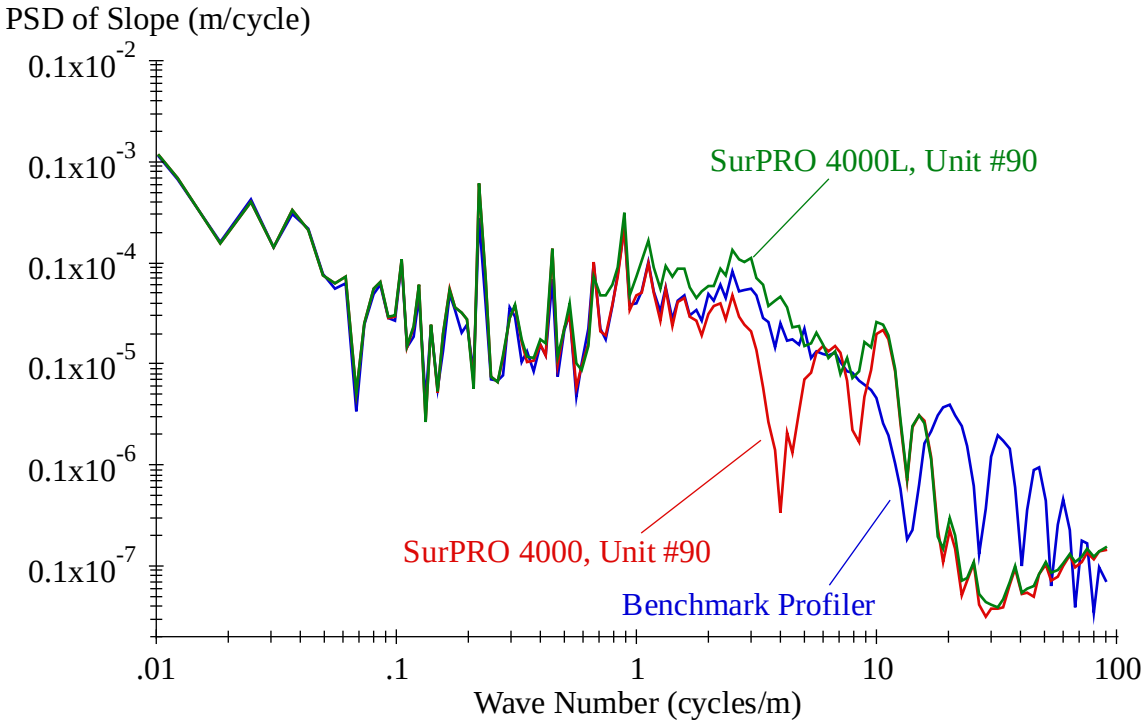
Spectral Density Plots:

Spectral density plots showed a notch (i.e., a lack of content) at 4 cycles/m (a wavelength of 250 mm) due to the wheelbase filtering effect in the standard configuration of the SurPRO 4000. This notch was not present in the profiles that included influence of the laser readings (the SurPRO 4000L) as shown in the plots below. However, the SurPRO 4000L was not able to duplicate the content from the Benchmark Profiler for wavelengths below 1 m.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series.



Dense Graded Asphalt



Longitudinal Tining

Benchmark Test Evaluation Summary

Device: SurPRO 4000L, Unit #91

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.951	**0.984**	0.961	0.241
Pervious HMA	0.922	**0.992**	0.923	0.228
Chip Seal	0.916	**0.997**	0.916	0.128
Transverse Tining	0.933	**0.996**	0.914	0.228
Diamond Grinding†	0.554	**0.997**	0.473	0.131
Diamond Grinding††	0.413	**0.992**	0.205	0.127
Longitudinal Tining	0.653	0.957	0.648	0.326

† First Visit †† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	**0.986**	**0.998**	**0.982**	0.799
Pervious HMA	0.979	**0.997**	0.970	0.665
Chip Seal	0.972	**1.000**	0.962	0.807
Transverse Tining	**0.988**	**0.998**	**0.981**	0.868
Diamond Grinding†	0.681	**0.999**	0.612	0.394
Diamond Grinding††	0.452	**0.998**	0.249	0.318
Longitudinal Tining	0.859	**0.998**	0.851	0.731

† First Visit †† Second Visit

Longitudinal Distance Measurement:

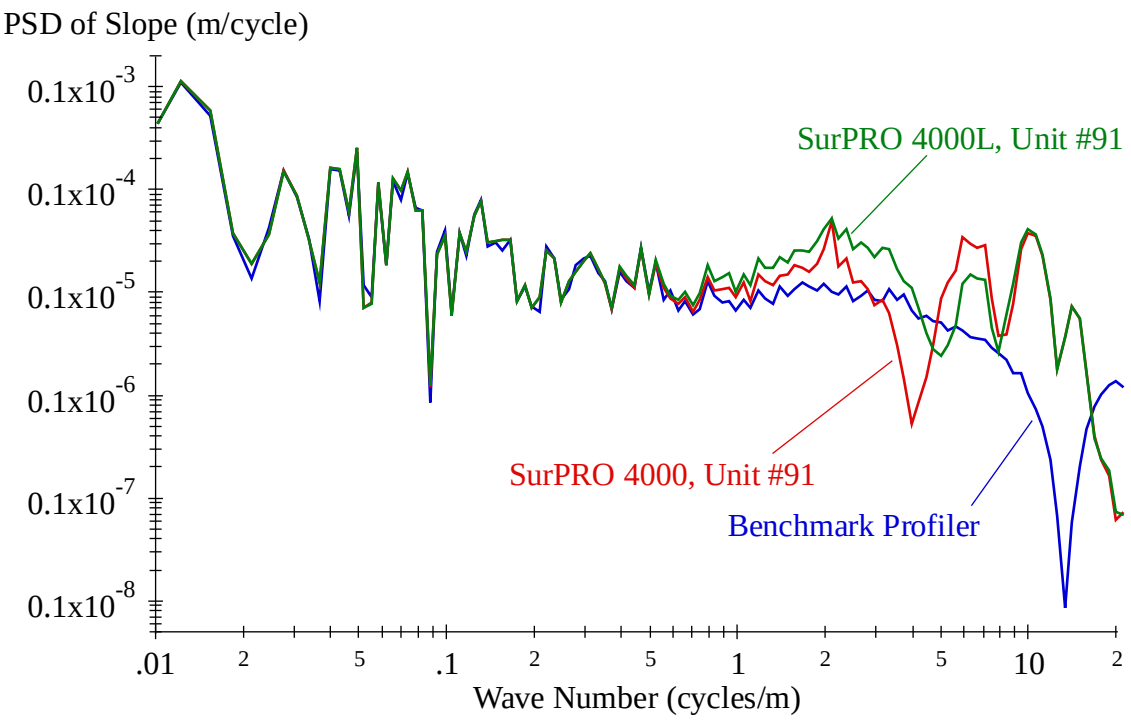
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	-0.04	-0.04	-0.04
Pervious HMA	-0.03	-0.03	-0.03
Chip Seal	-0.03	-0.03	-0.03
Transverse Tining	-0.05	-0.05	-0.05
Diamond Grinding†	0.02	0.02	0.02
Diamond Grinding††	0.02	0.02	0.03
Longitudinal Tining	-0.02	-0.02	-0.02

† First Visit †† Second Visit

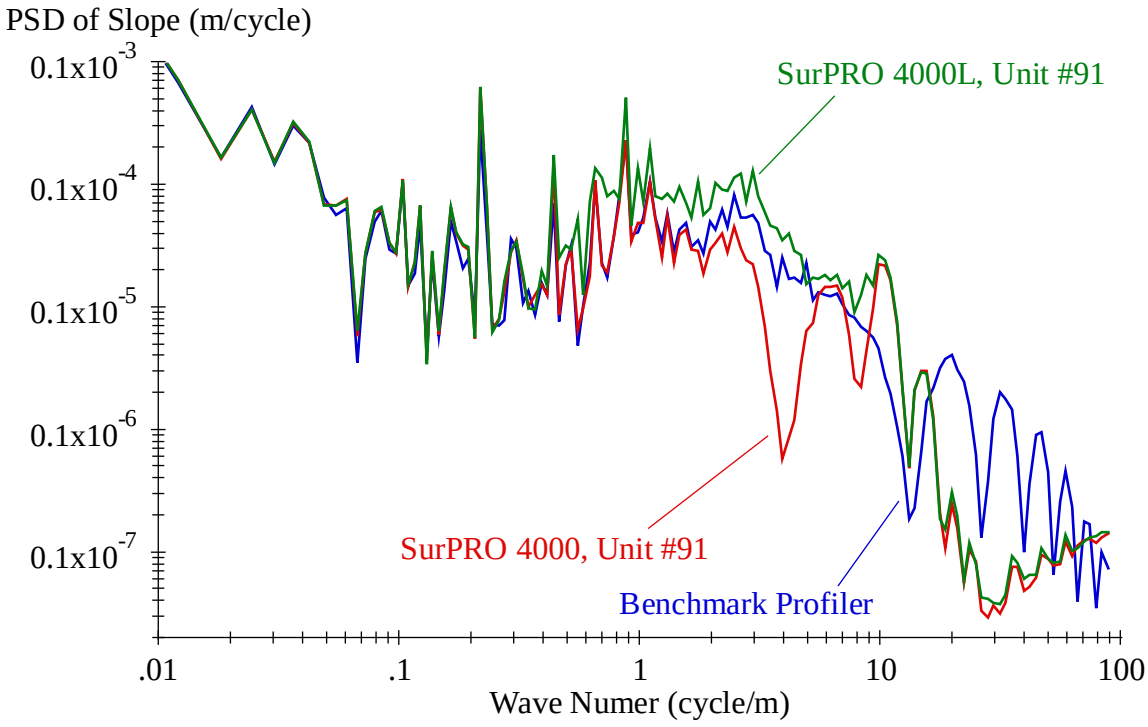
Spectral Density Plots:

Spectral density plots also showed a notch (i.e., a lack of content) at 4 cycles/m (a wavelength of 250 mm) due to the wheelbase filtering effect in the standard l configuration of the SurPRO 4000. This notch was not present in the profiles that included influence of the laser readings (the SurPRO 4000L) as shown in the plots below. However, the SurPRO 4000L was not able to duplicate the content from the Benchmark Profiler for wavelengths below 1 m.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series.



Dense Graded Asphalt



Longitudinal Tining

Benchmark Test Evaluation Summary

Device: SSI CS8800 Walking Profiler

Recording Interval: 1 inch

Use Moving Average: Yes

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

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.901	0.978	0.870	0.166
Dense Graded AC†	0.905	**0.981**	0.874	0.168
Pervious HMA	0.936	0.946	0.935	0.108
Chip Seal	0.942	0.972	0.926	0.128
Transverse Tining	0.941	**0.988**	0.937	0.053
Diamond Grinding††	0.937	**0.986**	0.910	0.077
Diamond Grinding†††	0.923	**0.987**	0.868	0.080
Longitudinal Tining	0.892	0.970	0.888	0.329

† Brent only †† First Visit ††† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.975	0.968	0.972	0.314
Dense Graded AC†	0.972	0.970	0.964	0.321
Pervious HMA	0.977	0.966	0.976	0.631
Chip Seal	**0.982**	**0.993**	**0.981**	0.694
Transverse Tining	0.960	**0.990**	0.934	0.383
Diamond Grinding††	0.927	0.979	0.900	0.234
Diamond Grinding†††	0.927	**0.989**	0.881	0.265
Longitudinal Tining	**0.987**	**0.982**	**0.988**	0.783

† Brent only †† First Visit ††† Second Visit

Longitudinal Distance Measurement:

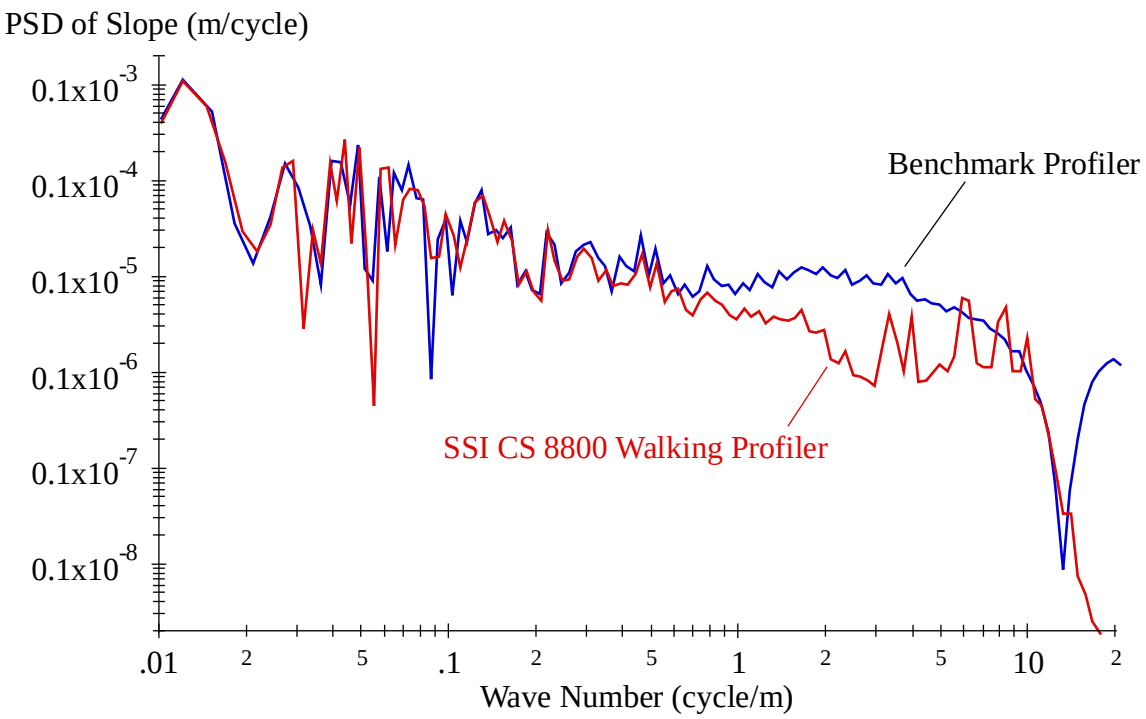
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	0.00	0.05	-0.04
Pervious HMA	0.06	0.06	0.06
Chip Seal	0.14	0.17	0.11
Transverse Tining	-0.08	-0.05	-0.12
Diamond Grinding†	0.00	0.08	-0.07
Diamond Grinding††	0.01	0.03	-0.01
Longitudinal Tining	-0.08	-0.03	-0.07

† First Visit †† Second Visit

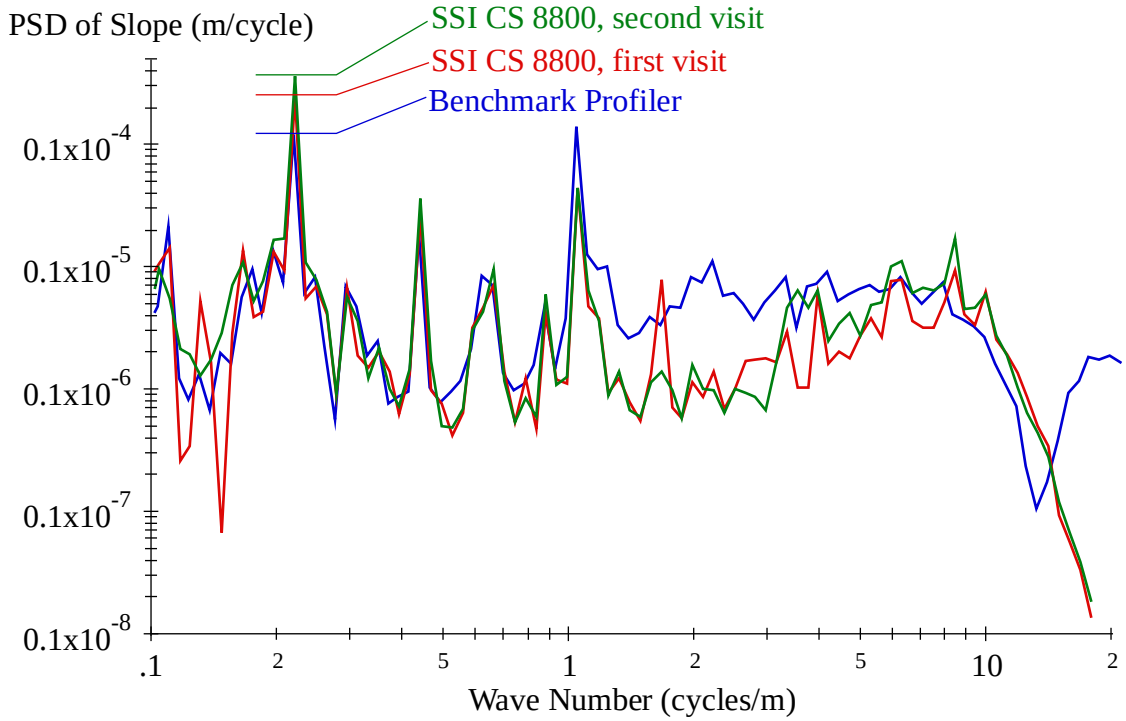
Special Observations:

Spectral density plots for the dense-graded asphalt section show that content from the SSI CS 8800 was lower than the Benchmark Profiler in the range of wave numbers from 0.5 to 10 cycles/m (wavelengths from 0.1 m to 2 m). See the plot below for an example. This is due in part to the wheelbase filtering effect.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series. The spectral density plot for the diamond ground section, shown below, provides an example. The plot shows a high level of content at about 0.22 cycles/m (a wavelength of about 15 ft) in a profile from the benchmark profiler, but a higher level from the SSI CS 8800 in its first visit to the section, and a still higher level in its second visit.



Dense Graded Asphalt



Diamond Grinding

Benchmark Test Evaluation Summary

Device: SSI CS8800 Walking Profiler, Experimental Config.

Recording Interval: 1 inch

Use Moving Average: Yes

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

Profile Accuracy Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.962	0.958	0.952	0.172
Dense Graded AC†	0.943	0.945	0.933	0.178
Pervious HMA	0.942	0.948	0.910	0.111
Chip Seal	0.882	0.909	0.905	0.103
Transverse Tining	0.942	0.932	0.928	0.051
Diamond Grinding††	0.888	0.946	0.875	0.083
Diamond Grinding†††	0.829	0.950	0.781	0.081
Longitudinal Tining	0.940	0.970	0.934	0.346

† Brent only †† First Visit ††† Second Visit

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	0.975	**0.980**	0.967	0.385
Dense Graded AC†	0.958	0.975	0.953	0.393
Pervious HMA	**0.980**	**0.988**	0.970	0.690
Chip Seal	0.972	**0.985**	0.966	0.726
Transverse Tining	0.959	**0.981**	0.927	0.434
Diamond Grinding††	0.934	0.979	0.912	0.250
Diamond Grinding†††	0.889	0.976	0.831	0.267
Longitudinal Tining	**0.989**	0.974	**0.988**	0.837

† Brent only †† First Visit ††† Second Visit

Longitudinal Distance Measurement:

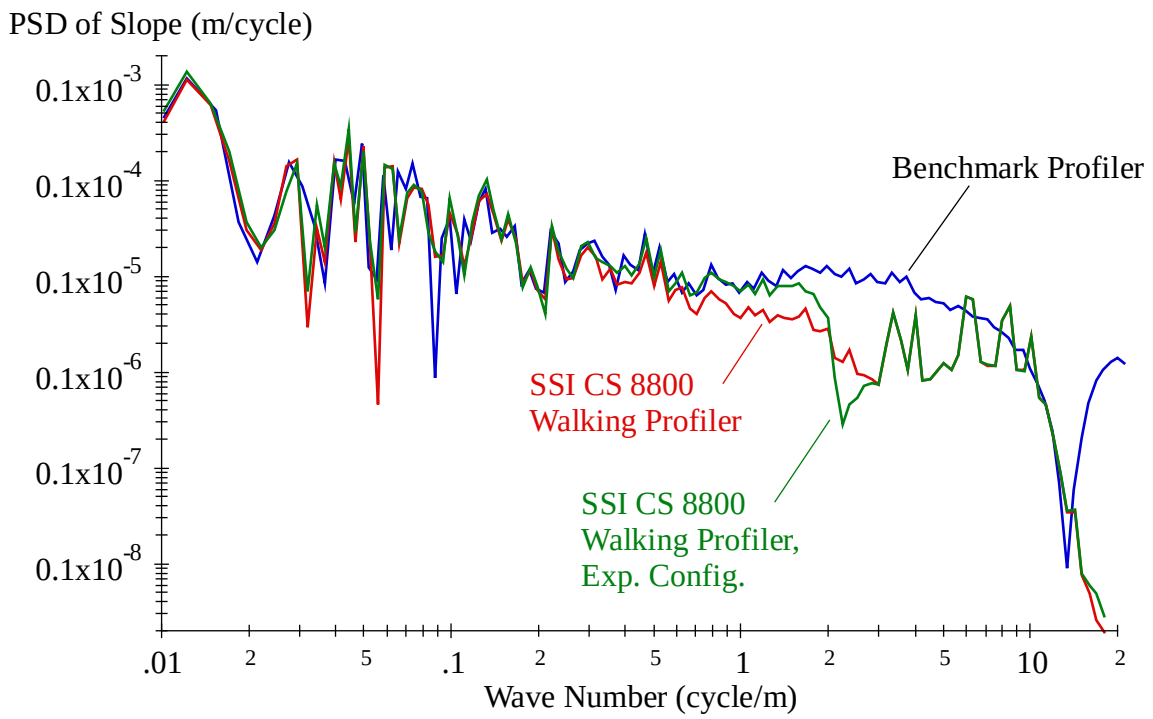
	DMI Error (%)		
Test Section	Average	High	Low
Dense Graded AC	0.00	0.05	-0.04
Pervious HMA	0.06	0.06	0.06
Chip Seal	0.14	0.17	0.11
Transverse Tining	-0.08	-0.05	-0.12
Diamond Grinding†	0.00	0.08	-0.07
Diamond Grinding††	0.01	0.03	-0.01
Longitudinal Tining	-0.05	-0.03	-0.07

† First Visit †† Second Visit

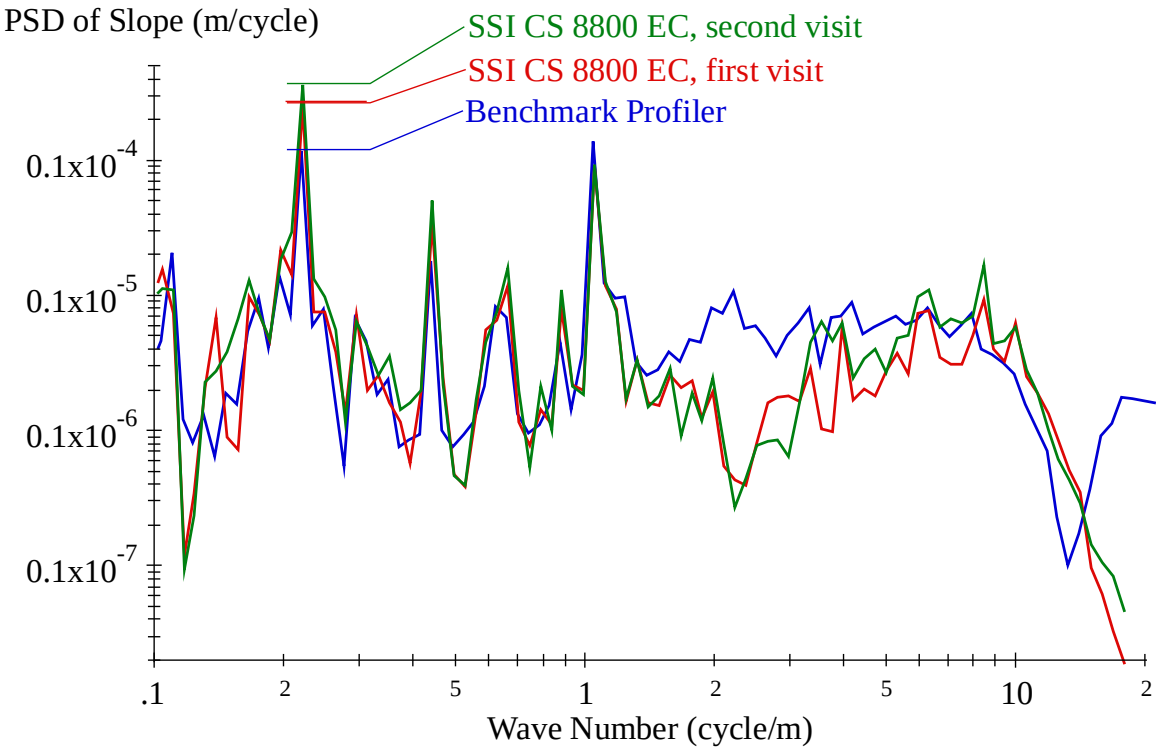
Special Observations:

Spectral density plots for the dense-graded asphalt section show that content from the SSI CS 8800 was lower than the Benchmark Profiler in the range of wave numbers from 1 to 10 cycles/m (wavelengths from 0.1 m to 1 m). See the plot below for an example.

Spectral density plots also revealed the influence of curl and warp on accuracy and repeatability scores for the jointed concrete sections. Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions. Repeatability scores were affected by slab curling because of changing conditions during the measurement series. The spectral density plot for the diamond ground section, provided below, provides an example. The plot shows a high level of content at about 0.22 cycles/m (a wavelength of about 15 ft) in a profile from the benchmark profiler, but a higher level from the SSI CS 8800 EC in its first visit to the section, and a still higher level in its second visit.



Dense Graded Asphalt



Diamond Grinding

Benchmark Test Evaluation Summary

Device: Benchmark Profiler

Recording Interval: 5.08 mm

Use Moving Average: Yes

Profile Repeatability Scores (Slope):

	Waveband			
Test Section	IRI	Long	Medium	Short
Dense Graded AC	**0.986**	**0.997**	**0.982**	0.804
Pervious HMA	**0.992**	**0.997**	**0.985**	0.860
Chip Seal	**0.990**	**1.000**	**0.986**	0.868
Transverse Tining	**0.994**	**1.000**	**0.992**	0.934
Diamond Grinding	0.974	**0.999**	0.954	0.404
Longitudinal Tining	0.979	**0.981**	0.979	0.773

Appendix E: 2013 Benchmark Test Evaluation Reports

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-13, 08:30 – 18:00

Device: Benchmark Profiler

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

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.)	0.999
Medium (elev.)	0.989
Short (elev.)	0.952
Long (slope)	0.997
Medium (slope)	0.982
Short (slope)	0.804

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	77.67	1038.48
2	76.30	1038.50
3	76.22	1038.48
Comb.	77.30	1038.48

Repeatability:

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	0.982	0.996	0.978	0.823	0.821	0.821	0.819
1	3	0.983	0.999	0.978	0.791	0.789	0.789	0.788
2	3	0.992	0.997	0.990	0.804	0.802	0.802	0.799
Average		0.986	0.997	0.982	0.806	0.804	0.804	0.802

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	0.985	0.963	0.964	0.964	0.963
1	3	0.999	0.984	0.952	0.949	0.949	0.947
2	3	1.000	0.996	0.946	0.944	0.944	0.942
Average		0.999	0.989	0.954	0.953	0.953	0.951

Notes:

- Section length is 1038.00 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All “repeat” measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-14, 12:30 – 15:35

Device: Benchmark Profiler

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

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	0.990
Long (elev.)	1.000
Medium (elev.)	0.992
Short (elev.)	0.944
Long (slope)	1.000
Medium (slope)	0.986
Short (slope)	0.868

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	92.25	501.12
2	92.23	501.12
3	91.28	501.15
Comb.	91.59	501.12

Repeatability:

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	0.990	0.897	0.899	0.899	0.899
1	3	0.991	1.000	0.987	0.850	0.851	0.851	0.851
2	3	0.986	1.000	0.980	0.853	0.854	0.854	0.854
Average		0.990	1.000	0.986	0.867	0.868	0.868	0.868

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	0.991	0.935	0.936	0.936	0.936
1	3	1.000	0.996	0.931	0.931	0.931	0.931
2	3	1.000	0.989	0.965	0.966	0.966	0.966
Average		1.000	0.992	0.944	0.945	0.945	0.945

Notes:

- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All “repeat” measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding

Date: 2013-May-12, 16:10 – 18:25

Device: Benchmark Profiler

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

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	0.974
Long (elev.)	1.000
Medium (elev.)	0.972
Short (elev.)	0.750
Long (slope)	0.999
Medium (slope)	0.954
Short (slope)	0.404

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	61.48	468.03
2	61.39	468.02
3	60.44	468.03
Comb.	60.59	468.03

Repeatability:

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	0.975	0.999	0.958	0.405	0.405	0.405	0.405
1	3	0.974	0.999	0.949	0.411	0.411	0.411	0.411
2	3	0.974	0.999	0.954	0.396	0.396	0.396	0.396
Average		0.974	0.999	0.954	0.404	0.404	0.404	0.404

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	0.976	0.781	0.783	0.783	0.783
1	3	1.000	0.968	0.745	0.746	0.746	0.746
2	3	1.000	0.972	0.722	0.723	0.723	0.723
Average		1.000	0.972	0.749	0.751	0.751	0.751

Notes:

- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- "Combined" profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All "repeat" measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-12, 12:37 – 15:07

Device: Benchmark Profiler

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

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.)	0.986
Medium (elev.)	0.983
Short (elev.)	0.965
Long (slope)	0.981
Medium (slope)	0.979
Short (slope)	0.773

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	98.49	453.47
2	98.81	453.48
3	98.34	453.47
Comb.	97.51	453.47

Repeatability:

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	0.975	0.992	0.978	0.772	0.772	0.772	0.772
1	3	0.982	0.979	0.983	0.781	0.781	0.781	0.781
2	3	0.981	0.972	0.976	0.767	0.767	0.767	0.767
Average		0.981	0.979	0.773	0.773	0.773	0.773	0.981

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	0.987	0.957	0.957	0.957	0.957
1	3	0.980	0.984	0.973	0.973	0.973	0.973
2	3	0.980	0.979	0.966	0.966	0.966	0.966
Average		0.986	0.983	0.965	0.965	0.965	0.965

Notes:

- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All “repeat” measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-12, 10:30 – 11:20

Device: Benchmark Profiler

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

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	0.992
Long (elev.)	0.997
Medium (elev.)	0.980
Short (elev.)	0.948
Long (slope)	0.997
Medium (slope)	0.985
Short (slope)	0.860

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	130.26	185.97
2	130.13	185.97
3	131.25	185.98
Comb.	130.39	185.98

Repeatability:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short
1	2	0.992	0.997	0.986	0.862
1	3	0.992	0.997	0.986	0.874
2	3	0.993	0.999	0.984	0.843
Average		0.992	0.997	0.985	0.860

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short
1	2	0.998	0.973	0.942
1	3	0.996	0.985	0.954
2	3	0.999	0.981	0.949
Average		0.997	0.980	0.948

Notes:

- The first 45 feet of run 1 excluded from subsequent analysis due to a gap in reference laser detection.
- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- "Combined" profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All "repeat" measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-14, 08:30 – 11:04

Device: Benchmark Profiler

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

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.)	0.996
Medium (elev.)	0.995
Short (elev.)	0.968
Long (slope)	1.000
Medium (slope)	0.992
Short (slope)	0.934

IRI, DMI Results:

Run	IRI (in/mi)	Length (ft)
1	77.25	538.60
2	77.19	538.60
3	77.53	538.58
Comb.	77.56	538.58

Repeatability:

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	0.992	1.000	0.993	0.917	0.917	0.917	0.917
1	3	0.993	0.999	0.991	0.964	0.965	0.965	0.965
2	3	0.998	0.999	0.993	0.919	0.922	0.922	0.922
Average		0.994	0.994	1.000	0.992	0.933	0.934	0.934

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	0.997	0.968	0.965	0.965	0.965
1	3	0.998	0.994	0.971	0.971	0.971	0.971
2	3	0.994	0.993	0.970	0.968	0.968	0.968
Average		0.996	0.995	0.969	0.968	0.968	0.968

Notes:

- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values derived from data files.
- “Combined” profile includes the forward measurement from each segment with the lowest target camera noise level during dwell. This is used as the benchmark profile.
- All “repeat” measurements share the same laser and steel tape set-up.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-15, 16:56 – 18:46

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.993	0.961
Long (elev.)	0.999	0.981
Medium (elev.)	0.993	0.979
Short (elev.)	0.915	0.756
Long (slope)	0.996	0.985
Medium (slope)	0.993	0.971
Short (slope)	0.707	0.165

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	16:56	17:19	—	—	—	—
2	17:25	17:34	79.28	2.56	316.269	-0.04
3	17:40	17:48	78.69	1.80	316.268	-0.04
4	17:51	18:04	78.65	1.75	316.268	-0.04
5	18:09	18:18	78.47	1.51	316.267	-0.04
6	18:23	18:32	78.39	1.41	316.268	-0.04
7	18:37	18:46	79.14	2.38	316.268	-0.04

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.954	0.980	0.964	0.178	0.197	0.197	0.188
3	0.962	0.986	0.972	0.209	0.201	0.201	0.192
4	0.962	0.984	0.974	0.179	0.174	0.174	0.169
5	0.966	0.986	0.976	0.148	0.141	0.141	0.133
6	0.965	0.990	0.975	0.150	0.143	0.143	0.137
7	0.957	0.987	0.967	0.144	0.140	0.140	0.133
Ave.	0.961	0.985	0.971	0.168	0.166	0.166	0.159

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.978	0.970	0.765	0.769	0.769	0.771
3	0.979	0.981	0.760	0.763	0.763	0.765
4	0.980	0.980	0.763	0.763	0.763	0.759
5	0.980	0.978	0.760	0.761	0.761	0.756
6	0.983	0.984	0.762	0.767	0.767	0.767
7	0.983	0.983	0.719	0.720	0.720	0.719
Ave.	0.981	0.979	0.755	0.757	0.757	0.756

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	0.990	0.994	0.990	0.744	0.741	0.741	0.736
2	4	0.990	0.996	0.988	0.745	0.742	0.742	0.734
2	5	0.988	0.994	0.987	0.679	0.676	0.676	0.668
2	6	0.987	0.990	0.988	0.660	0.668	0.668	0.658
2	7	0.994	0.993	0.995	0.649	0.647	0.647	0.642
3	4	0.998	0.998	0.997	0.755	0.758	0.758	0.749
3	5	0.996	1.000	0.996	0.702	0.706	0.706	0.696
3	6	0.996	0.995	0.996	0.712	0.724	0.724	0.715
3	7	0.992	0.999	0.990	0.628	0.626	0.626	0.618
4	5	0.996	0.998	0.998	0.682	0.687	0.687	0.682
4	6	0.996	0.993	0.998	0.761	0.775	0.775	0.770
4	7	0.992	0.996	0.988	0.684	0.685	0.685	0.683
5	6	0.999	0.995	0.998	0.816	0.813	0.813	0.810
5	7	0.990	0.999	0.988	0.679	0.678	0.678	0.677
6	7	0.990	0.997	0.989	0.716	0.712	0.712	0.711
Average		0.993	0.996	0.993	0.707	0.709	0.709	0.703

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	0.987	0.910	0.908	0.908	0.901
2	4	1.000	0.989	0.901	0.904	0.904	0.901
2	5	1.000	0.991	0.937	0.938	0.938	0.933
2	6	0.998	0.986	0.921	0.919	0.919	0.917
2	7	0.998	0.986	0.878	0.875	0.875	0.865
3	4	1.000	0.996	0.926	0.929	0.929	0.932
3	5	1.000	0.994	0.918	0.918	0.918	0.922
3	6	0.998	0.997	0.930	0.926	0.926	0.925
3	7	0.998	0.998	0.938	0.936	0.936	0.930
4	5	1.000	0.997	0.934	0.937	0.937	0.933
4	6	0.999	0.995	0.952	0.948	0.948	0.940
4	7	0.999	0.995	0.878	0.879	0.879	0.878
5	6	0.999	0.994	0.965	0.962	0.962	0.955
5	7	0.999	0.994	0.877	0.875	0.875	0.874
6	7	1.000	0.998	0.890	0.886	0.886	0.881
Average		0.999	0.993	0.917	0.916	0.916	0.912

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 1038.00 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The operator observed a change in end elevation with increasing run numbers. They believe it was caused by the inclinometer cooling. The temperature at start of run 1 was 82°F and temperature dropped to about 75°F for last run.
- The operator returned to the section start after each run (except run 1) by riding in a van.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-15, 13:51 – 15:05

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.988	0.943
Long (elev.)	0.999	0.990
Medium (elev.)	0.995	0.962
Short (elev.)	0.891	0.621
Long (slope)	0.999	0.994
Medium (slope)	0.987	0.945
Short (slope)	0.748	0.181

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	13:51	14:08	—	—	—	—
2	14:12	14:20	95.99	4.80	152.743	-0.03
3	14:23	14:30	96.91	5.81	152.744	-0.03
4	14:33	14:39	97.09	6.01	152.743	-0.03
5	14:41	14:47	96.44	5.30	152.744	-0.03
6	14:50	14:56	97.63	6.59	152.744	-0.03
7	14:59	15:05	97.89	6.88	152.743	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.953	0.995	0.953	0.273	0.276	0.276	0.276
3	0.945	0.992	0.949	0.179	0.180	0.180	0.180
4	0.942	0.990	0.947	0.143	0.144	0.144	0.144
5	0.950	0.994	0.952	0.173	0.175	0.175	0.175
6	0.936	0.998	0.937	0.158	0.159	0.159	0.159
7	0.932	0.993	0.932	0.156	0.157	0.157	0.157
Ave.	0.943	0.994	0.945	0.180	0.182	0.182	0.182

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.989	0.962	0.784	0.786	0.786	0.786
3	0.989	0.965	0.633	0.635	0.635	0.635
4	0.990	0.959	0.548	0.546	0.546	0.546
5	0.990	0.963	0.608	0.611	0.611	0.611
6	0.995	0.963	0.571	0.573	0.573	0.573
7	0.989	0.961	0.575	0.578	0.578	0.578
Ave.	0.990	0.962	0.620	0.621	0.621	0.621

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	0.990	0.999	0.992	0.609	0.610	0.610	0.610
2	4	0.986	0.999	0.990	0.489	0.491	0.491	0.491
2	5	0.995	1.000	0.996	0.578	0.581	0.581	0.581
2	6	0.982	0.999	0.981	0.509	0.510	0.510	0.510
2	7	0.977	0.999	0.975	0.511	0.512	0.512	0.512
3	4	0.995	0.999	0.996	0.773	0.775	0.775	0.775
3	5	0.992	1.000	0.993	0.913	0.916	0.916	0.916
3	6	0.991	0.997	0.987	0.811	0.811	0.811	0.811
3	7	0.986	1.000	0.981	0.816	0.816	0.816	0.816
4	5	0.990	0.999	0.992	0.802	0.801	0.801	0.801
4	6	0.994	0.996	0.988	0.905	0.906	0.906	0.906
4	7	0.988	0.999	0.981	0.882	0.884	0.884	0.884
5	6	0.986	0.998	0.983	0.828	0.826	0.826	0.826
5	7	0.980	1.000	0.976	0.837	0.835	0.835	0.835
6	7	0.992	0.998	0.990	0.944	0.945	0.944	0.945
Average		0.988	0.999	0.987	0.747	0.748	0.748	0.748

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	0.996	0.859	0.859	0.859	0.859
2	4	1.000	0.995	0.763	0.765	0.765	0.765
2	5	1.000	0.996	0.824	0.827	0.827	0.827
2	6	0.997	0.994	0.792	0.793	0.793	0.793
2	7	1.000	0.996	0.795	0.796	0.796	0.796
3	4	1.000	0.993	0.891	0.892	0.892	0.892
3	5	1.000	0.997	0.948	0.950	0.950	0.950
3	6	0.998	0.997	0.923	0.924	0.924	0.924
3	7	1.000	0.995	0.926	0.927	0.927	0.927
4	5	1.000	0.995	0.907	0.906	0.906	0.906
4	6	0.998	0.994	0.939	0.940	0.940	0.940
4	7	1.000	0.995	0.944	0.944	0.944	0.944
5	6	0.998	0.997	0.938	0.937	0.937	0.937
5	7	1.000	0.996	0.933	0.933	0.933	0.933
6	7	0.998	0.996	0.969	0.970	0.970	0.970
Average		0.999	0.995	0.890	0.891	0.891	0.891

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took 30-40 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-14, 11:49 – 13:14

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.940	0.848
Long (elev.)	1.000	0.999
Medium (elev.)	0.908	0.805
Short (elev.)	0.885	0.660
Long (slope)	1.000	0.998
Medium (slope)	0.906	0.791
Short (slope)	0.624	0.154

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	11:49	12:10	—	—	—	—
2	12:14	12:22	64.38	6.26	142.681	0.02
3	12:27	12:35	66.94	10.48	142.681	0.02
4	12:38	12:45	69.31	14.39	142.683	0.02
5	12:48	12:54	71.17	17.46	142.682	0.02
6	12:59	13:05	72.29	19.31	142.681	0.02
7	13:09	13:14	73.24	20.88	142.683	0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.918	0.999	0.893	0.129	0.129	0.104	0.129
3	0.883	0.999	0.836	0.145	0.145	0.124	0.145
4	0.850	0.998	0.792	0.164	0.164	0.125	0.125
5	0.830	0.998	0.762	0.188	0.188	0.134	0.188
6	0.812	0.999	0.737	0.177	0.177	0.139	0.139
7	0.799	0.998	0.724	0.197	0.197	0.157	0.197
Ave.	0.848	0.998	0.791	0.167	0.167	0.130	0.154

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	1.000	0.909	0.621	0.618	0.618	0.618
3	0.999	0.852	0.639	0.636	0.636	0.636
4	1.000	0.807	0.661	0.658	0.658	0.658
5	0.999	0.776	0.681	0.678	0.678	0.678
6	1.000	0.750	0.686	0.682	0.682	0.682
7	0.999	0.739	0.690	0.687	0.686	0.686
Ave.	0.999	0.805	0.663	0.660	0.660	0.660

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	0.962	1.000	0.935	0.677	0.677	0.677	0.677
2	4	0.927	1.000	0.884	0.670	0.670	0.670	0.670
2	5	0.904	0.999	0.850	0.562	0.562	0.562	0.562
2	6	0.886	1.000	0.822	0.590	0.590	0.590	0.590
2	7	0.873	0.999	0.807	0.477	0.477	0.477	0.477
3	4	0.963	1.000	0.945	0.680	0.680	0.680	0.680
3	5	0.941	1.000	0.909	0.549	0.549	0.549	0.549
3	6	0.923	1.000	0.879	0.641	0.641	0.641	0.641
3	7	0.909	1.000	0.863	0.514	0.514	0.514	0.514
4	5	0.976	1.000	0.961	0.601	0.601	0.601	0.601
4	6	0.958	1.000	0.930	0.701	0.701	0.701	0.701
4	7	0.944	1.000	0.913	0.619	0.619	0.619	0.619
5	6	0.981	1.000	0.967	0.694	0.694	0.694	0.694
5	7	0.967	1.000	0.950	0.748	0.748	0.748	0.748
6	7	0.985	1.000	0.981	0.636	0.636	0.636	0.636
Average		0.940	1.000	0.906	0.624	0.624	0.624	0.624

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	0.936	0.897	0.895	0.895	0.895
2	4	1.000	0.884	0.913	0.913	0.913	0.913
2	5	1.000	0.851	0.849	0.850	0.850	0.850
2	6	1.000	0.822	0.842	0.842	0.842	0.842
2	7	1.000	0.810	0.809	0.808	0.808	0.808
3	4	1.000	0.944	0.902	0.902	0.902	0.902
3	5	1.000	0.910	0.855	0.856	0.854	0.856
3	6	1.000	0.879	0.898	0.898	0.898	0.898
3	7	1.000	0.866	0.811	0.811	0.811	0.811
4	5	0.999	0.962	0.914	0.914	0.914	0.914
4	6	1.000	0.930	0.909	0.908	0.908	0.908
4	7	1.000	0.917	0.888	0.887	0.887	0.887
5	6	1.000	0.966	0.954	0.954	0.954	0.954
5	7	1.000	0.953	0.939	0.938	0.938	0.938
6	7	1.000	0.985	0.903	0.902	0.902	0.902
Average		1.000	0.908	0.886	0.885	0.885	0.885

Notes:

- A three person crew set up the test section.
- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line (11:10-11:20), placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end (11:25-11:38).
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-15, 05:48 – 07:11

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.991	0.647
Long (elev.)	1.000	0.997
Medium (elev.)	0.979	0.340
Short (elev.)	0.889	0.491
Long (slope)	1.000	0.994
Medium (slope)	0.971	0.311
Short (slope)	0.680	0.175

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	05:48	06:08	—	—	—	—
2	06:11	06:19	48.71	-19.61	142.695	0.03
3	06:23	06:30	48.70	-19.62	142.694	0.02
4	06:33	06:40	48.70	-19.62	142.693	0.02
5	06:45	06:52	48.86	-19.36	142.694	0.02
6	06:55	07:02	49.00	-19.13	142.694	0.02
7	07:04	07:11	49.18	-18.83	142.694	0.02

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.636	0.994	0.297	0.133	0.133	0.983	0.133
3	0.631	0.994	0.282	0.132	0.132	0.113	0.132
4	0.640	0.995	0.303	0.152	0.152	0.114	0.152
5	0.651	0.994	0.317	0.155	0.155	0.120	0.155
6	0.656	0.993	0.324	0.151	0.151	0.122	0.151
7	0.667	0.994	0.343	0.170	0.170	0.123	0.123
Ave.	0.647	0.994	0.311	0.149	0.149	0.262	0.141

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.998	0.333	0.483	0.481	0.481	0.481
3	0.998	0.311	0.475	0.473	0.473	0.473
4	0.998	0.333	0.491	0.490	0.490	0.490
5	0.997	0.344	0.498	0.497	0.497	0.497
6	0.997	0.356	0.492	0.490	0.490	0.490
7	0.997	0.366	0.513	0.511	0.511	0.511
Ave.	0.997	0.340	0.492	0.490	0.490	0.490

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	0.994	1.000	0.970	0.687	0.687	0.687	0.687
2	4	0.992	1.000	0.988	0.708	0.708	0.708	0.708
2	5	0.994	1.000	0.988	0.676	0.676	0.676	0.676
2	6	0.995	1.000	0.977	0.708	0.708	0.708	0.708
2	7	0.987	1.000	0.964	0.553	0.553	0.553	0.553
3	4	0.995	1.000	0.968	0.686	0.686	0.686	0.686
3	5	0.989	1.000	0.962	0.677	0.677	0.677	0.677
3	6	0.991	1.000	0.969	0.724	0.724	0.724	0.724
3	7	0.984	1.000	0.941	0.656	0.656	0.656	0.656
4	5	0.990	1.000	0.986	0.748	0.748	0.748	0.748
4	6	0.991	0.999	0.979	0.726	0.726	0.726	0.726
4	7	0.984	1.000	0.964	0.630	0.630	0.630	0.630
5	6	0.995	1.000	0.978	0.682	0.682	0.682	0.682
5	7	0.990	1.000	0.967	0.679	0.679	0.679	0.679
6	7	0.990	1.000	0.961	0.655	0.655	0.655	0.655
Average		0.991	1.000	0.971	0.680	0.680	0.680	0.680

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	0.970	0.922	0.923	0.923	0.923
2	4	1.000	0.987	0.839	0.837	0.837	0.837
2	5	1.000	0.991	0.872	0.870	0.870	0.870
2	6	1.000	0.989	0.898	0.898	0.898	0.898
2	7	1.000	0.982	0.790	0.790	0.790	0.790
3	4	1.000	0.975	0.900	0.897	0.897	0.897
3	5	1.000	0.968	0.871	0.867	0.867	0.867
3	6	1.000	0.964	0.930	0.929	0.929	0.929
3	7	1.000	0.955	0.880	0.880	0.880	0.880
4	5	1.000	0.987	0.950	0.951	0.951	0.951
4	6	1.000	0.986	0.964	0.964	0.961	0.961
4	7	1.000	0.974	0.884	0.884	0.884	0.884
5	6	1.000	0.992	0.928	0.929	0.928	0.928
5	7	1.000	0.979	0.831	0.832	0.831	0.832
6	7	1.000	0.982	0.888	0.887	0.887	0.887
Average		1.000	0.979	0.890	0.889	0.889	0.889

Notes:

- This was a return visit to the section over concerns about curling.
- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 30 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The crew added additional sand to fill a wide crack prior to testing.
- Scott Zielinski observed the testing.
- Temperatures near 50 F and clear.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-15, 08:14 – 09:28

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.992	0.806
Long (elev.)	0.999	0.991
Medium (elev.)	0.987	0.762
Short (elev.)	0.981	0.936
Long (slope)	0.999	0.966
Medium (slope)	0.990	0.795
Short (slope)	0.879	0.459

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	08:14	08:30	—	—	—	—
2	08:34	08:42	122.14	25.26	138.210	-0.02
3	08:46	08:51	121.71	24.82	138.210	-0.02
4	08:56	09:03	122.01	25.13	138.212	-0.02
5	09:05	09:11	121.32	24.42	138.210	-0.02
6	09:15	09:21	120.57	23.65	138.212	-0.02
7	09:23	09:28	120.04	23.11	138.210	-0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.800	0.965	0.787	0.466	0.466	0.466	0.466
3	0.802	0.966	0.791	0.469	0.469	0.469	0.469
4	0.801	0.967	0.789	0.467	0.467	0.467	0.467
5	0.806	0.967	0.794	0.458	0.458	0.458	0.458
6	0.810	0.964	0.800	0.460	0.460	0.460	0.460
7	0.817	0.966	0.807	0.435	0.435	0.435	0.435
Ave.	0.806	0.966	0.795	0.459	0.459	0.459	0.459

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.992	0.752	0.923	0.923	0.923	0.923
3	0.994	0.759	0.934	0.934	0.934	0.934
4	0.990	0.756	0.930	0.930	0.930	0.930
5	0.990	0.761	0.930	0.930	0.930	0.930
6	0.990	0.768	0.946	0.946	0.946	0.946
7	0.990	0.777	0.952	0.952	0.952	0.952
Ave.	0.991	0.762	0.936	0.936	0.936	0.936

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	0.998	0.999	0.997	0.893	0.893	0.893	0.893
2	4	0.998	0.999	0.998	0.904	0.904	0.904	0.904
2	5	0.994	0.999	0.993	0.910	0.910	0.910	0.910
2	6	0.990	1.000	0.987	0.823	0.823	0.823	0.823
2	7	0.983	0.999	0.979	0.794	0.794	0.794	0.794
3	4	0.999	0.999	0.998	0.927	0.927	0.927	0.927
3	5	0.995	1.000	0.996	0.930	0.930	0.930	0.930
3	6	0.992	0.999	0.990	0.882	0.882	0.882	0.882
3	7	0.985	1.000	0.982	0.852	0.852	0.852	0.852
4	5	0.995	1.000	0.994	0.938	0.938	0.938	0.938
4	6	0.991	0.999	0.989	0.857	0.857	0.857	0.857
4	7	0.984	0.999	0.981	0.835	0.835	0.835	0.835
5	6	0.996	0.999	0.994	0.866	0.866	0.866	0.866
5	7	0.989	0.999	0.986	0.840	0.840	0.840	0.840
6	7	0.992	0.999	0.991	0.937	0.937	0.937	0.937
Average		0.992	0.999	0.990	0.879	0.879	0.879	0.879

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	0.999	0.993	0.985	0.985	0.985	0.985
2	4	0.999	0.996	0.989	0.989	0.989	0.989
2	5	0.999	0.990	0.989	0.989	0.989	0.989
2	6	0.999	0.982	0.965	0.965	0.965	0.965
2	7	0.999	0.972	0.961	0.961	0.961	0.961
3	4	0.998	0.997	0.993	0.993	0.993	0.993
3	5	0.998	0.996	0.995	0.995	0.995	0.995
3	6	0.998	0.988	0.981	0.981	0.981	0.981
3	7	0.997	0.978	0.975	0.975	0.975	0.975
4	5	1.000	0.994	0.997	0.997	0.997	0.997
4	6	1.000	0.986	0.973	0.973	0.973	0.973
4	7	0.999	0.976	0.969	0.969	0.969	0.969
5	6	1.000	0.991	0.977	0.977	0.977	0.977
5	7	0.999	0.981	0.972	0.972	0.972	0.972
6	7	0.999	0.989	0.992	0.992	0.992	0.992
Average		0.999	0.987	0.981	0.981	0.981	0.981

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 45 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 60 F, partly cloudy.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-14, 15:52 – 16:35

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.996	0.956
Long (elev.)	0.995	0.995
Medium (elev.)	0.995	0.982
Short (elev.)	0.973	0.831
Long (slope)	0.997	0.998
Medium (slope)	0.994	0.961
Short (slope)	0.867	0.186

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	15:52	16:02	—	—	—	—
2	16:05	16:09	134.43	3.10	56.667	-0.03
3	16:11	16:14	135.26	3.73	56.670	-0.03
4	16:16	16:19	135.01	3.54	56.669	-0.03
5	16:22	16:25	134.94	3.49	56.670	-0.03
6	16:27	16:30	134.96	3.50	56.670	-0.03
7	16:31	16:35	135.53	3.94	56.667	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
2	0.962	0.999	0.970	0.173
3	0.955	0.997	0.961	0.173
4	0.958	0.999	0.962	0.182
5	0.956	0.996	0.957	0.188
6	0.955	0.999	0.958	0.193
7	0.953	0.996	0.957	0.204
Ave.	0.956	0.998	0.961	0.186

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
2	0.999	0.990	0.818
3	0.995	0.979	0.825
4	0.995	0.981	0.827
5	1.000	0.979	0.837
6	0.998	0.978	0.835
7	0.986	0.982	0.846
Ave.	0.995	0.982	0.831

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short
2	3	0.993	0.996	0.991	0.906
2	4	0.995	0.998	0.992	0.875
2	5	0.994	0.999	0.987	0.858
2	6	0.993	0.999	0.988	0.821
2	7	0.991	0.995	0.987	0.751
3	4	0.998	0.999	0.999	0.922
3	5	0.999	0.993	0.996	0.907
3	6	0.999	0.998	0.997	0.862
3	7	0.998	0.999	0.996	0.791
4	5	0.999	0.995	0.995	0.925
4	6	0.997	1.000	0.996	0.895
4	7	0.996	0.998	0.995	0.823
5	6	0.999	0.996	0.999	0.917
5	7	0.997	0.991	0.999	0.853
6	7	0.998	0.997	0.999	0.894
Average		0.996	0.997	0.994	0.867

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short
2	3	0.997	0.988	0.984
2	4	0.997	0.991	0.973
2	5	0.999	0.989	0.963
2	6	0.999	0.988	0.964
2	7	0.988	0.992	0.944
3	4	1.000	0.997	0.986
3	5	0.995	0.998	0.977
3	6	0.999	0.999	0.975
3	7	0.992	0.995	0.955
4	5	0.995	0.998	0.984
4	6	0.999	0.997	0.983
4	7	0.993	0.998	0.962
5	6	0.997	0.998	0.995
5	7	0.986	0.996	0.976
6	7	0.989	0.995	0.977
Average		0.995	0.995	0.973

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Processing time to get longitudinal distance to report the value verbally was about 1.5 minutes after each run.
- Processed data for profiles from 16:37-17:12. Processing took extra time because files were not named properly.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-15, 10:57 – 12:14

Device: SurPRO 4000, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.992	0.945
Long (elev.)	0.998	0.995
Medium (elev.)	0.988	0.926
Short (elev.)	0.934	0.732
Long (slope)	0.999	0.997
Medium (slope)	0.987	0.929
Short (slope)	0.804	0.215

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	10:57	11:14	—	—	—	—
2	11:17	11:25	79.43	2.82	164.111	-0.05
3	11:28	11:35	79.72	3.20	164.112	-0.05
4	11:37	11:44	79.59	3.03	164.113	-0.05
5	11:47	11:54	80.08	3.66	164.113	-0.05
6	11:57	11:04	80.18	3.79	164.112	-0.05
7	12:07	12:14	80.69	4.45	164.111	-0.05

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.953	0.995	0.941	0.200	0.200	0.200	0.200
3	0.950	0.998	0.936	0.211	0.211	0.211	0.211
4	0.951	0.996	0.939	0.220	0.220	0.220	0.220
5	0.945	0.996	0.928	0.216	0.215	0.215	0.215
6	0.940	0.998	0.923	0.230	0.229	0.229	0.229
7	0.931	0.998	0.906	0.218	0.218	0.218	0.218
Ave.	0.945	0.997	0.929	0.216	0.215	0.215	0.215

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.998	0.936	0.775	0.770	0.770	0.770
3	0.993	0.931	0.743	0.740	0.740	0.740
4	0.994	0.932	0.738	0.736	0.736	0.736
5	0.995	0.926	0.743	0.739	0.739	0.739
6	0.995	0.924	0.693	0.692	0.692	0.692
7	0.995	0.905	0.717	0.712	0.712	0.712
Ave.	0.995	0.926	0.735	0.731	0.731	0.731

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	0.997	0.999	0.994	0.725	0.727	0.727	0.727
2	4	0.997	1.000	0.996	0.751	0.752	0.752	0.752
2	5	0.993	1.000	0.988	0.762	0.764	0.764	0.764
2	6	0.989	0.999	0.984	0.678	0.679	0.679	0.679
2	7	0.983	0.999	0.970	0.758	0.758	0.758	0.758
3	4	0.999	0.999	0.997	0.870	0.870	0.870	0.870
3	5	0.995	0.999	0.993	0.877	0.880	0.880	0.880
3	6	0.991	1.000	0.989	0.786	0.787	0.787	0.787
3	7	0.985	1.000	0.975	0.850	0.853	0.853	0.853
4	5	0.995	1.000	0.991	0.858	0.859	0.859	0.859
4	6	0.991	1.000	0.987	0.816	0.818	0.818	0.818
4	7	0.985	0.999	0.973	0.865	0.866	0.866	0.866
5	6	0.995	0.999	0.994	0.790	0.791	0.791	0.791
5	7	0.990	0.999	0.981	0.853	0.855	0.855	0.855
6	7	0.994	1.000	0.986	0.810	0.813	0.812	0.813
Average		0.992	0.999	0.987	0.803	0.805	0.805	0.805

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	0.995	0.994	0.928	0.929	0.929	0.929
2	4	0.996	0.995	0.923	0.923	0.923	0.923
2	5	0.997	0.990	0.939	0.939	0.939	0.939
2	6	0.997	0.988	0.874	0.876	0.876	0.876
2	7	0.997	0.972	0.910	0.910	0.910	0.910
3	4	0.999	0.998	0.959	0.957	0.957	0.957
3	5	0.997	0.995	0.981	0.980	0.980	0.980
3	6	0.998	0.993	0.929	0.930	0.930	0.930
3	7	0.998	0.977	0.938	0.937	0.937	0.937
4	5	0.999	0.994	0.965	0.964	0.964	0.964
4	6	0.999	0.993	0.925	0.926	0.926	0.926
4	7	0.999	0.976	0.927	0.926	0.926	0.926
5	6	1.000	0.997	0.922	0.923	0.923	0.923
5	7	1.000	0.982	0.951	0.951	0.951	0.951
6	7	1.000	0.983	0.936	0.938	0.938	0.938
Average		0.998	0.988	0.934	0.934	0.934	0.934

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 15 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 70 F, sunny with some clouds.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-15, 16:56-19:03

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.992	0.966
Long (elev.)	0.999	0.979
Medium (elev.)	0.995	0.987
Short (elev.)	0.908	0.753
Long (slope)	0.998	0.984
Medium (slope)	0.990	0.978
Short (slope)	0.804	0.183

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	16:56	17:20	—	—	—	—
2	17:25	17:33	77.92	0.80	316.270	-0.04
3	17:40	17:48	77.39	0.12	316.269	-0.04
4	17:55	18:04	77.61	0.40	316.270	-0.04
5	18:09	18:18	77.42	0.16	316.269	-0.04
6	18:23	18:32	77.50	0.26	316.267	-0.04
8	18:54	19:03	76.88	-0.54	316.271	-0.04

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.959	0.981	0.971	0.173	0.172	0.172	0.166
3	0.968	0.984	0.981	0.203	0.200	0.200	0.192
4	0.962	0.984	0.974	0.180	0.174	0.174	0.152
5	0.967	0.983	0.979	0.184	0.179	0.179	0.167
6	0.967	0.985	0.979	0.209	0.206	0.206	0.198
8	0.972	0.985	0.983	0.189	0.184	0.184	0.161
Ave.	0.966	0.984	0.978	0.189	0.186	0.186	0.173

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.977	0.984	0.702	0.705	0.705	0.707
3	0.979	0.988	0.755	0.760	0.760	0.758
4	0.980	0.986	0.742	0.748	0.748	0.747
5	0.978	0.984	0.783	0.787	0.787	0.792
6	0.978	0.988	0.768	0.775	0.775	0.776
8	0.980	0.990	0.740	0.746	0.746	0.746
Ave.	0.979	0.987	0.749	0.754	0.754	0.754

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	0.990	0.997	0.988	0.770	0.772	0.772	0.771
2	4	0.994	0.997	0.994	0.803	0.805	0.805	0.807
2	5	0.990	0.998	0.989	0.799	0.799	0.799	0.793
2	6	0.989	0.996	0.987	0.743	0.745	0.745	0.743
2	8	0.986	0.996	0.984	0.790	0.786	0.786	0.781
3	4	0.993	1.000	0.990	0.790	0.789	0.789	0.783
3	5	0.997	0.999	0.994	0.833	0.833	0.833	0.824
3	6	0.996	0.999	0.994	0.755	0.755	0.755	0.750
3	8	0.994	0.999	0.993	0.800	0.804	0.804	0.802
4	5	0.993	0.999	0.991	0.843	0.843	0.843	0.833
4	6	0.992	0.999	0.990	0.822	0.823	0.823	0.817
4	8	0.989	0.999	0.986	0.812	0.810	0.810	0.802
5	6	0.996	0.998	0.994	0.850	0.853	0.853	0.854
5	8	0.993	0.997	0.990	0.848	0.851	0.851	0.844
6	8	0.994	0.999	0.992	0.811	0.819	0.819	0.817
Average		0.992	0.998	0.990	0.805	0.806	0.806	0.802

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	0.994	0.854	0.851	0.851	0.851
2	4	0.999	0.996	0.892	0.889	0.889	0.889
2	5	1.000	0.997	0.885	0.883	0.883	0.879
2	6	1.000	0.994	0.876	0.873	0.873	0.870
2	8	0.999	0.992	0.903	0.900	0.900	0.897
3	4	1.000	0.995	0.901	0.901	0.901	0.896
3	5	1.000	0.994	0.929	0.930	0.930	0.920
3	6	1.000	0.996	0.903	0.900	0.900	0.891
3	8	0.999	0.997	0.873	0.872	0.872	0.868
4	5	0.999	0.996	0.919	0.921	0.921	0.912
4	6	0.999	0.995	0.939	0.939	0.939	0.934
4	8	1.000	0.994	0.933	0.936	0.936	0.930
5	6	1.000	0.994	0.954	0.956	0.956	0.950
5	8	0.999	0.992	0.931	0.932	0.932	0.926
6	8	0.999	0.996	0.948	0.947	0.947	0.945
Average		0.999	0.995	0.909	0.909	0.909	0.904

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 1038.00 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The operator observed a change in end elevation with increasing run numbers. They believe it was caused by the inclinometer cooling. The temperature at start of run 1 was 82°F and temperature dropped to about 75°F for last run.
- The operator returned to the section start after each run (except run 1) by riding in a van.
- Run 7 was aborted and an additional run was made.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-15, 13:50 – 15:14

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.992	0.948
Long (elev.)	1.000	0.995
Medium (elev.)	0.994	0.962
Short (elev.)	0.906	0.540
Long (slope)	1.000	0.997
Medium (slope)	0.990	0.953
Short (slope)	0.825	0.151

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	13:50	14:06	—	—	—	—
2	14:09	14:15	93.97	2.60	152.743	-0.03
3	14:18	14:23	94.95	3.67	152.743	-0.03
4	14:28	14:34	94.82	3.53	152.743	-0.03
5	14:36	14:42	95.24	3.99	152.744	-0.03
6	14:44	14:50	94.54	3.22	152.743	-0.03
7	15:09	15:14	94.86	3.57	152.743	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.952	0.997	0.958	0.185	0.186	0.186	0.186
3	0.951	0.996	0.959	0.147	0.147	0.147	0.147
4	0.945	0.997	0.950	0.160	0.161	0.161	0.161
5	0.943	0.997	0.948	0.136	0.136	0.136	0.136
6	0.950	0.997	0.954	0.135	0.135	0.135	0.135
7	0.945	0.998	0.950	0.143	0.143	0.143	0.143
Ave.	0.948	0.997	0.953	0.151	0.151	0.151	0.151

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.995	0.963	0.624	0.626	0.626	0.626
3	0.995	0.964	0.524	0.526	0.526	0.526
4	0.996	0.958	0.569	0.570	0.570	0.570
5	0.993	0.963	0.498	0.500	0.501	0.500
6	0.994	0.964	0.494	0.495	0.495	0.495
7	0.997	0.959	0.522	0.523	0.523	0.523
Ave.	0.995	0.962	0.538	0.540	0.540	0.540

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	1.000	0.993	0.756	0.756	0.756	0.756
2	4	0.989	1.000	0.987	0.839	0.839	0.839	0.839
2	5	0.988	1.000	0.985	0.699	0.698	0.698	0.698
2	6	0.995	1.000	0.991	0.695	0.694	0.694	0.694
2	7	0.990	1.000	0.988	0.737	0.736	0.736	0.736
3	4	0.990	1.000	0.985	0.885	0.885	0.885	0.885
3	5	0.990	1.000	0.984	0.876	0.874	0.874	0.874
3	6	0.996	0.999	0.989	0.840	0.839	0.839	0.839
3	7	0.991	0.999	0.986	0.913	0.912	0.912	0.912
4	5	0.995	1.000	0.993	0.815	0.814	0.814	0.814
4	6	0.992	1.000	0.993	0.797	0.796	0.796	0.796
4	7	0.998	1.000	0.997	0.848	0.846	0.846	0.846
5	6	0.990	1.000	0.989	0.929	0.929	0.929	0.929
5	7	0.996	1.000	0.994	0.879	0.879	0.879	0.879
6	7	0.992	1.000	0.992	0.867	0.868	0.868	0.868
Average		0.992	1.000	0.990	0.825	0.824	0.824	0.824

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	0.995	0.874	0.874	0.874	0.874
2	4	1.000	0.992	0.926	0.927	0.927	0.927
2	5	1.000	0.995	0.830	0.830	0.830	0.830
2	6	1.000	0.996	0.832	0.834	0.834	0.834
2	7	1.000	0.993	0.858	0.858	0.858	0.858
3	4	1.000	0.991	0.923	0.923	0.923	0.923
3	5	1.000	0.997	0.927	0.928	0.928	0.928
3	6	1.000	0.996	0.917	0.919	0.919	0.919
3	7	1.000	0.992	0.955	0.956	0.956	0.956
4	5	0.999	0.991	0.891	0.891	0.891	0.891
4	6	1.000	0.993	0.886	0.887	0.887	0.887
4	7	1.000	0.998	0.910	0.910	0.910	0.910
5	6	1.000	0.996	0.974	0.974	0.974	0.974
5	7	0.999	0.991	0.942	0.942	0.942	0.942
6	7	1.000	0.993	0.939	0.940	0.940	0.940
Average		1.000	0.994	0.906	0.906	0.906	0.906

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took 30-40 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- The operator stopped working between runs 6 and 7 for a phone call.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-14, 11:50 – 13:14

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.935	0.848
Long (elev.)	1.000	0.999
Medium (elev.)	0.904	0.803
Short (elev.)	0.859	0.650
Long (slope)	0.999	0.994
Medium (slope)	0.899	0.795
Short (slope)	0.668	0.173

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	11:49	12:08	—	—	—	—
2	12:12	12:20	64.09	5.78	142.680	0.02
3	12:23	12:30	66.35	9.51	142.682	0.02
4	12:35	12:41	68.83	13.60	142.684	0.02
5	12:47	12:53	70.76	16.78	142.682	0.02
6	12:57	13:03	72.32	19.36	142.681	0.02
7	13:08	13:13	72.98	20.45	142.680	0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.921	0.994	0.905	0.156	0.156	0.119	0.156
3	0.886	0.996	0.845	0.162	0.162	0.124	0.162
4	0.850	0.994	0.795	0.194	0.194	0.139	0.139
5	0.825	0.992	0.761	0.207	0.207	0.138	0.138
6	0.807	0.994	0.738	0.220	0.220	0.144	0.220
7	0.801	0.996	0.728	0.217	0.217	0.151	0.217
Ave.	0.848	0.994	0.795	0.193	0.193	0.136	0.172

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.998	0.909	0.606	0.603	0.603	0.603
3	0.999	0.851	0.617	0.615	0.615	0.615
4	0.999	0.804	0.641	0.638	0.638	0.638
5	0.998	0.768	0.684	0.679	0.679	0.679
6	0.998	0.749	0.690	0.685	0.685	0.685
7	0.999	0.738	0.677	0.676	0.676	0.676
Ave.	0.999	0.803	0.653	0.649	0.649	0.649

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	0.960	0.999	0.930	0.770	0.770	0.770	0.770
2	4	0.923	0.999	0.876	0.650	0.650	0.650	0.650
2	5	0.896	1.000	0.837	0.581	0.581	0.581	0.581
2	6	0.876	0.999	0.810	0.512	0.512	0.512	0.512
2	7	0.868	0.999	0.797	0.574	0.574	0.574	0.574
3	4	0.961	0.999	0.939	0.700	0.700	0.700	0.700
3	5	0.934	0.999	0.898	0.636	0.636	0.636	0.636
3	6	0.913	0.999	0.869	0.556	0.556	0.556	0.556
3	7	0.906	0.999	0.856	0.646	0.646	0.646	0.646
4	5	0.969	0.999	0.952	0.729	0.729	0.729	0.729
4	6	0.947	0.999	0.920	0.693	0.693	0.693	0.693
4	7	0.939	0.999	0.907	0.735	0.735	0.735	0.735
5	6	0.977	0.999	0.965	0.738	0.738	0.738	0.738
5	7	0.970	0.998	0.951	0.751	0.751	0.751	0.751
6	7	0.990	0.999	0.982	0.753	0.753	0.753	0.753
Average		0.935	0.999	0.899	0.668	0.668	0.668	0.668

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	0.999	0.934	0.963	0.963	0.963	0.963
2	4	0.999	0.884	0.868	0.868	0.868	0.868
2	5	1.000	0.842	0.790	0.789	0.789	0.789
2	6	1.000	0.819	0.752	0.751	0.751	0.751
2	7	0.999	0.806	0.824	0.824	0.824	0.824
3	4	1.000	0.945	0.895	0.895	0.895	0.895
3	5	0.999	0.901	0.823	0.822	0.820	0.822
3	6	0.999	0.875	0.777	0.775	0.775	0.775
3	7	1.000	0.861	0.847	0.847	0.847	0.847
4	5	0.999	0.951	0.897	0.896	0.894	0.896
4	6	1.000	0.923	0.834	0.831	0.830	0.831
4	7	1.000	0.909	0.904	0.903	0.903	0.903
5	6	1.000	0.970	0.932	0.930	0.930	0.930
5	7	1.000	0.956	0.907	0.905	0.905	0.905
6	7	1.000	0.983	0.890	0.889	0.889	0.889
Average		1.000	0.904	0.860	0.859	0.859	0.859

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- A three person crew set up the test section.
- Set up included placement of a chalk line (11:10-11:20), placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end (11:25-11:38).
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures in the mid 80s and sunny.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-15, 05:46 – 07:06

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.988	0.644
Long (elev.)	1.000	0.996
Medium (elev.)	0.973	0.343
Short (elev.)	0.896	0.485
Long (slope)	1.000	0.992
Medium (slope)	0.962	0.306
Short (slope)	0.707	0.152

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	05:46	06:06	—	—	—	—
2	06:09	06:16	48.75	-19.54	142.696	0.03
3	06:20	06:26	49.17	-18.85	142.696	0.03
4	06:29	06:36	48.72	-19.59	142.695	0.03
5	06:40	06:47	48.60	-19.79	142.693	0.02
6	06:49	06:56	49.12	-18.93	142.695	0.03
7	06:58	07:06	48.58	-19.82	142.696	0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.632	0.992	0.285	0.141	0.141	0.103	0.141
3	0.636	0.992	0.290	0.149	0.149	0.115	0.149
4	0.634	0.993	0.294	0.169	0.169	0.129	0.169
5	0.646	0.992	0.313	0.158	0.158	0.126	0.158
6	0.657	0.992	0.325	0.182	0.182	0.124	0.182
7	0.659	0.993	0.333	0.174	0.174	0.127	0.174
Ave.	0.644	0.992	0.306	0.162	0.162	0.121	0.162

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.996	0.322	0.464	0.463	0.463	0.463
3	0.997	0.322	0.477	0.475	0.475	0.475
4	0.996	0.333	0.486	0.480	0.480	0.480
5	0.996	0.353	0.490	0.489	0.489	0.489
6	0.995	0.358	0.507	0.504	0.504	0.504
7	0.997	0.370	0.498	0.496	0.496	0.496
Ave.	0.996	0.343	0.487	0.485	0.485	0.485

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	0.989	1.000	0.957	0.686	0.686	0.686	0.686
2	4	0.994	1.000	0.972	0.660	0.660	0.660	0.660
2	5	0.993	1.000	0.968	0.756	0.756	0.756	0.756
2	6	0.983	1.000	0.948	0.631	0.631	0.631	0.631
2	7	0.988	1.000	0.953	0.636	0.636	0.636	0.636
3	4	0.989	1.000	0.968	0.715	0.715	0.715	0.715
3	5	0.990	1.000	0.959	0.709	0.709	0.709	0.709
3	6	0.986	1.000	0.965	0.661	0.661	0.661	0.661
3	7	0.990	1.000	0.963	0.761	0.761	0.761	0.761
4	5	0.992	1.000	0.975	0.715	0.715	0.715	0.715
4	6	0.982	1.000	0.961	0.773	0.773	0.773	0.773
4	7	0.988	1.000	0.967	0.775	0.775	0.775	0.775
5	6	0.984	1.000	0.953	0.668	0.668	0.668	0.668
5	7	0.991	1.000	0.963	0.692	0.692	0.692	0.692
6	7	0.985	1.000	0.959	0.761	0.761	0.761	0.761
Average		0.988	1.000	0.962	0.707	0.707	0.707	0.707

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	0.986	0.854	0.855	0.855	0.855
2	4	1.000	0.982	0.919	0.918	0.918	0.918
2	5	1.000	0.975	0.944	0.944	0.944	0.944
2	6	1.000	0.966	0.860	0.860	0.860	0.860
2	7	1.000	0.960	0.876	0.877	0.877	0.877
3	4	1.000	0.985	0.899	0.895	0.895	0.895
3	5	1.000	0.980	0.904	0.906	0.906	0.906
3	6	1.000	0.968	0.792	0.791	0.791	0.791
3	7	1.000	0.962	0.942	0.940	0.940	0.940
4	5	1.000	0.985	0.958	0.957	0.954	0.957
4	6	1.000	0.973	0.901	0.902	0.902	0.902
4	7	1.000	0.966	0.943	0.944	0.944	0.944
5	6	1.000	0.970	0.876	0.876	0.876	0.876
5	7	1.000	0.966	0.921	0.922	0.922	0.922
6	7	1.000	0.978	0.856	0.856	0.855	0.856
Average		1.000	0.973	0.896	0.896	0.896	0.896

Notes:

- This was a return visit to the section over concerns about curling.
- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 30 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The crew added additional sand to fill a wide crack prior to testing.
- Temperatures near 50 F and clear.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-15, 08:13 – 09:28

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.987	0.812
Long (elev.)	0.997	0.987
Medium (elev.)	0.982	0.768
Short (elev.)	0.984	0.925
Long (slope)	0.999	0.962
Medium (slope)	0.985	0.801
Short (slope)	0.895	0.466

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	08:13	08:29	—	—	—	—
2	08:32	08:38	120.65	23.73	138.211	-0.02
3	08:41	08:48	118.33	21.35	138.215	-0.02
4	08:54	09:02	118.36	21.38	138.213	-0.02
5	09:04	09:10	118.70	21.73	138.212	-0.02
6	09:14	09:20	117.40	20.40	138.214	-0.02
7	09:22	09:28	116.93	19.92	138.212	-0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.796	0.961	0.782	0.458	0.458	0.458	0.458
3	0.810	0.962	0.800	0.477	0.477	0.477	0.477
4	0.810	0.959	0.799	0.459	0.459	0.459	0.459
5	0.810	0.964	0.800	0.468	0.468	0.468	0.468
6	0.819	0.963	0.811	0.479	0.479	0.479	0.479
7	0.824	0.963	0.816	0.454	0.454	0.454	0.454
Ave.	0.812	0.962	0.801	0.466	0.466	0.466	0.466

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.991	0.747	0.917	0.917	0.917	0.917
3	0.989	0.765	0.929	0.929	0.929	0.929
4	0.981	0.765	0.916	0.916	0.916	0.916
5	0.987	0.767	0.925	0.925	0.925	0.925
6	0.987	0.778	0.931	0.931	0.931	0.931
7	0.986	0.784	0.931	0.931	0.931	0.931
Ave.	0.987	0.768	0.925	0.925	0.925	0.925

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	0.984	0.999	0.981	0.884	0.884	0.884	0.884
2	4	0.984	0.999	0.981	0.929	0.929	0.929	0.929
2	5	0.984	0.999	0.981	0.925	0.925	0.925	0.925
2	6	0.975	0.999	0.969	0.860	0.860	0.860	0.860
2	7	0.969	0.999	0.964	0.844	0.844	0.844	0.844
3	4	0.999	0.998	0.999	0.879	0.879	0.879	0.879
3	5	0.998	0.999	0.998	0.906	0.906	0.906	0.906
3	6	0.989	1.000	0.987	0.944	0.944	0.944	0.944
3	7	0.983	0.999	0.982	0.921	0.921	0.921	0.921
4	5	0.998	0.997	0.998	0.931	0.931	0.931	0.931
4	6	0.990	0.998	0.987	0.872	0.872	0.872	0.872
4	7	0.984	0.998	0.982	0.842	0.842	0.842	0.842
5	6	0.990	0.999	0.987	0.901	0.901	0.901	0.901
5	7	0.984	1.000	0.982	0.874	0.874	0.874	0.874
6	7	0.993	0.999	0.994	0.909	0.909	0.909	0.909
Average		0.987	0.999	0.985	0.895	0.895	0.895	0.895

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	0.999	0.978	0.984	0.984	0.984	0.984
2	4	0.991	0.978	0.994	0.994	0.994	0.994
2	5	0.997	0.976	0.991	0.991	0.991	0.991
2	6	0.997	0.963	0.976	0.976	0.976	0.976
2	7	0.996	0.956	0.975	0.975	0.975	0.975
3	4	0.993	0.999	0.981	0.981	0.981	0.981
3	5	0.998	0.997	0.990	0.990	0.990	0.990
3	6	0.998	0.985	0.992	0.992	0.992	0.992
3	7	0.997	0.977	0.991	0.991	0.991	0.991
4	5	0.996	0.997	0.989	0.989	0.989	0.989
4	6	0.996	0.985	0.974	0.974	0.974	0.974
4	7	0.997	0.977	0.971	0.971	0.971	0.971
5	6	1.000	0.986	0.984	0.984	0.984	0.984
5	7	1.000	0.979	0.982	0.982	0.982	0.982
6	7	1.000	0.991	0.994	0.994	0.994	0.994
Average		0.997	0.982	0.984	0.984	0.984	0.984

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 45 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 60 F, partly cloudy.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-14, 15:52 – 16:31

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.995	0.952
Long (elev.)	0.997	0.982
Medium (elev.)	0.994	0.976
Short (elev.)	0.932	0.826
Long (slope)	0.997	0.991
Medium (slope)	0.994	0.960
Short (slope)	0.718	0.203

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	15:52	16:00	—	—	—	—
2	16:03	16:06	131.68	0.99	56.667	-0.03
3	16:08	16:12	132.53	1.64	56.670	-0.03
4	16:15	16:17	132.95	1.96	56.670	-0.03
5	16:21	16:23	133.01	2.01	56.669	-0.03
6	16:25	16:27	131.88	1.14	56.667	-0.03
7	16:29	16:31	133.23	2.18	56.672	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
2	0.953	0.994	0.959	0.196
3	0.953	0.989	0.961	0.222
4	0.952	0.994	0.960	0.193
5	0.958	0.994	0.966	0.204
6	0.947	0.987	0.954	0.220
7	0.951	0.986	0.960	0.182
Ave.	0.952	0.991	0.960	0.203

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
2	0.980	0.976	0.835
3	0.978	0.976	0.852
4	0.986	0.981	0.828
5	0.985	0.980	0.848
6	0.981	0.969	0.821
7	0.982	0.973	0.774
Ave.	0.982	0.976	0.826

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short
2	3	0.999	0.997	0.998	0.807
2	4	0.999	1.000	0.998	0.839
2	5	0.995	1.000	0.992	0.881
2	6	0.994	0.996	0.994	0.678
2	7	0.998	0.995	0.995	0.554
3	4	0.999	0.997	0.999	0.699
3	5	0.994	0.997	0.993	0.849
3	6	0.995	0.999	0.993	0.799
3	7	0.999	0.999	0.996	0.671
4	5	0.994	1.000	0.993	0.776
4	6	0.994	0.995	0.993	0.605
4	7	0.998	0.994	0.995	0.482
5	6	0.989	0.996	0.987	0.719
5	7	0.993	0.994	0.994	0.611
6	7	0.994	1.000	0.990	0.797
Average		0.995	0.997	0.994	0.718

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short
2	3	0.999	0.999	0.957
2	4	0.996	0.993	0.978
2	5	0.997	0.995	0.970
2	6	0.999	0.992	0.920
2	7	0.999	0.997	0.875
3	4	0.994	0.993	0.938
3	5	0.995	0.996	0.973
3	6	0.998	0.992	0.956
3	7	0.997	0.998	0.916
4	5	1.000	0.997	0.955
4	6	0.996	0.986	0.905
4	7	0.997	0.991	0.855
5	6	0.997	0.988	0.939
5	7	0.998	0.994	0.896
6	7	1.000	0.993	0.949
Average		0.997	0.994	0.932

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Processing time to get longitudinal distance to report the value verbally was about 1.5 minutes after each run.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-15, 10:56 – 12:09

Device: SurPRO 4000, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.991	0.945
Long (elev.)	0.995	0.996
Medium (elev.)	0.983	0.927
Short (elev.)	0.939	0.628
Long (slope)	0.999	0.995
Medium (slope)	0.986	0.928
Short (slope)	0.880	0.257

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	10:56	11:11	—	—	—	—
2	11:16	11:22	78.27	1.32	164.111	-0.05
3	11:25	11:31	78.80	2.01	164.115	-0.05
4	11:36	11:42	78.91	2.15	164.115	-0.05
5	11:45	11:51	78.56	1.70	164.114	-0.05
6	11:54	12:00	79.39	2.77	164.112	-0.05
7	12:03	12:09	79.75	3.24	164.112	-0.05

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.956	0.997	0.944	0.250	0.251	0.251	0.251
3	0.947	0.998	0.930	0.262	0.262	0.262	0.262
4	0.947	0.990	0.933	0.241	0.239	0.239	0.239
5	0.947	0.994	0.931	0.258	0.257	0.257	0.257
6	0.940	0.997	0.920	0.266	0.264	0.264	0.264
7	0.934	0.996	0.909	0.267	0.265	0.265	0.265
Ave.	0.945	0.995	0.928	0.257	0.256	0.256	0.256

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.997	0.945	0.643	0.633	0.633	0.633
3	0.997	0.929	0.648	0.642	0.642	0.642
4	0.991	0.933	0.597	0.589	0.582	0.589
5	0.995	0.930	0.643	0.635	0.635	0.635
6	0.997	0.921	0.636	0.628	0.628	0.628
7	0.998	0.905	0.637	0.631	0.631	0.631
Ave.	0.996	0.927	0.634	0.626	0.625	0.626

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	0.992	0.999	0.987	0.892	0.894	0.894	0.894
2	4	0.990	0.997	0.989	0.822	0.823	0.823	0.823
2	5	0.992	0.999	0.989	0.863	0.862	0.862	0.862
2	6	0.986	1.000	0.978	0.868	0.868	0.868	0.868
2	7	0.980	1.000	0.968	0.892	0.893	0.893	0.893
3	4	0.997	0.995	0.996	0.819	0.821	0.821	0.821
3	5	0.998	0.998	0.996	0.883	0.883	0.883	0.883
3	6	0.993	1.000	0.989	0.894	0.894	0.894	0.894
3	7	0.988	0.999	0.980	0.908	0.909	0.909	0.909
4	5	0.997	0.999	0.997	0.867	0.870	0.870	0.870
4	6	0.994	0.997	0.987	0.869	0.872	0.872	0.872
4	7	0.989	0.998	0.978	0.853	0.854	0.854	0.854
5	6	0.993	0.999	0.987	0.931	0.931	0.931	0.931
5	7	0.987	1.000	0.977	0.906	0.906	0.906	0.906
6	7	0.993	1.000	0.988	0.917	0.917	0.917	0.917
Average		0.991	0.999	0.986	0.879	0.880	0.880	0.880

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	0.996	0.982	0.912	0.910	0.910	0.910
2	4	0.994	0.986	0.903	0.903	0.903	0.903
2	5	0.998	0.985	0.957	0.957	0.957	0.957
2	6	0.996	0.976	0.948	0.949	0.949	0.949
2	7	0.997	0.959	0.949	0.952	0.952	0.952
3	4	0.990	0.994	0.883	0.879	0.879	0.879
3	5	0.994	0.995	0.947	0.943	0.943	0.943
3	6	1.000	0.993	0.946	0.944	0.944	0.944
3	7	0.999	0.976	0.948	0.947	0.947	0.947
4	5	0.996	0.997	0.918	0.916	0.916	0.916
4	6	0.990	0.988	0.937	0.935	0.935	0.935
4	7	0.991	0.972	0.919	0.915	0.915	0.915
5	6	0.994	0.990	0.974	0.975	0.975	0.975
5	7	0.995	0.973	0.974	0.976	0.976	0.976
6	7	0.999	0.981	0.979	0.980	0.980	0.980
Average		0.995	0.983	0.940	0.939	0.939	0.939

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 15 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 70 F, sunny with some clouds.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-15, 17:51 – 19:33

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.991	0.951
Long (elev.)	0.999	0.980
Medium (elev.)	0.993	0.978
Short (elev.)	0.919	0.663
Long (slope)	0.996	0.985
Medium (slope)	0.991	0.961
Short (slope)	0.730	0.251

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	16:56	17:19	—	—	—	—
2	17:25	17:34	80.00	3.49	316.269	-0.04
3	17:40	17:48	79.39	2.70	316.268	-0.04
4	17:51	18:04	79.26	2.54	316.268	-0.04
5	18:09	18:18	79.18	2.43	316.267	-0.04
6	18:23	18:32	78.92	2.10	316.268	-0.04
7	18:37	18:46	79.80	3.23	316.268	-0.04

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.944	0.980	0.954	0.291	0.289	0.289	0.284
3	0.952	0.986	0.961	0.291	0.289	0.289	0.285
4	0.952	0.983	0.965	0.265	0.262	0.262	0.256
5	0.955	0.986	0.965	0.229	0.225	0.225	0.220
6	0.955	0.990	0.965	0.229	0.228	0.228	0.222
7	0.946	0.987	0.955	0.219	0.216	0.216	0.212
Ave.	0.951	0.985	0.961	0.254	0.251	0.251	0.246

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.978	0.969	0.663	0.665	0.665	0.671
3	0.978	0.980	0.651	0.654	0.654	0.659
4	0.980	0.979	0.669	0.670	0.670	0.670
5	0.980	0.977	0.654	0.656	0.656	0.655
6	0.982	0.983	0.669	0.672	0.672	0.676
7	0.983	0.982	0.653	0.659	0.659	0.665
Ave.	0.980	0.978	0.660	0.663	0.663	0.980

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	0.989	0.995	0.990	0.786	0.791	0.791	0.781
2	4	0.990	0.997	0.988	0.771	0.766	0.766	0.759
2	5	0.987	0.995	0.987	0.733	0.731	0.731	0.725
2	6	0.986	0.990	0.987	0.715	0.719	0.719	0.711
2	7	0.993	0.993	0.993	0.653	0.652	0.652	0.649
3	4	0.997	0.998	0.996	0.792	0.796	0.796	0.785
3	5	0.996	1.000	0.996	0.753	0.757	0.757	0.747
3	6	0.995	0.995	0.995	0.749	0.760	0.760	0.752
3	7	0.989	0.999	0.986	0.641	0.641	0.641	0.632
4	5	0.995	0.998	0.997	0.703	0.707	0.707	0.703
4	6	0.995	0.993	0.997	0.766	0.775	0.775	0.774
4	7	0.989	0.996	0.985	0.678	0.678	0.678	0.681
5	6	0.997	0.995	0.996	0.810	0.808	0.808	0.805
5	7	0.988	0.999	0.986	0.692	0.696	0.696	0.681
6	7	0.987	0.996	0.985	0.711	0.707	0.707	0.706
Average		0.991	0.996	0.991	0.730	0.732	0.732	0.726

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	0.987	0.929	0.929	0.929	0.922
2	4	0.999	0.990	0.933	0.934	0.934	0.937
2	5	0.999	0.991	0.955	0.953	0.953	0.941
2	6	0.997	0.986	0.919	0.918	0.918	0.917
2	7	0.997	0.985	0.909	0.906	0.906	0.898
3	4	1.000	0.996	0.933	0.936	0.936	0.939
3	5	1.000	0.994	0.933	0.934	0.934	0.938
3	6	0.998	0.997	0.909	0.908	0.908	0.906
3	7	0.998	0.997	0.903	0.897	0.897	0.888
4	5	1.000	0.997	0.924	0.926	0.926	0.920
4	6	0.999	0.995	0.930	0.927	0.927	0.919
4	7	0.999	0.995	0.901	0.906	0.906	0.894
5	6	0.999	0.994	0.929	0.927	0.927	0.919
5	7	0.999	0.993	0.908	0.904	0.904	0.889
6	7	1.000	0.998	0.900	0.902	0.902	0.900
Average		0.999	0.993	0.921	0.921	0.921	0.915

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 1038.00 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The operator observed a change in end elevation with increasing run numbers. They believe it was caused by the inclinometer cooling. The temperature at start of run 1 was 82°F and temperature dropped to about 75°F for last run.
- The operator returned to the section start after each run (except run 1) by riding in a van.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-15, 13:51 – 15:05

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.984	0.919
Long (elev.)	0.999	0.989
Medium (elev.)	0.992	0.955
Short (elev.)	0.895	0.531
Long (slope)	0.999	0.993
Medium (slope)	0.980	0.919
Short (slope)	0.765	0.188

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	13:51	14:08	—	—	—	—
2	14:12	14:20	98.49	7.53	152.743	-0.03
3	14:23	14:30	98.31	7.34	152.744	-0.03
4	14:33	14:39	98.86	7.94	152.743	-0.03
5	14:41	14:47	98.21	7.23	152.744	-0.03
6	14:50	14:56	99.23	8.34	152.744	-0.03
7	14:59	15:05	99.52	8.66	152.743	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.923	0.995	0.921	0.308	0.311	0.311	0.311
3	0.924	0.993	0.931	0.185	0.186	0.186	0.186
4	0.920	0.989	0.923	0.144	0.146	0.146	0.146
5	0.924	0.992	0.921	0.176	0.179	0.179	0.179
6	0.913	0.998	0.912	0.149	0.151	0.151	0.151
7	0.907	0.993	0.906	0.153	0.155	0.155	0.155
Ave.	0.919	0.993	0.919	0.186	0.188	0.188	0.188

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.988	0.953	0.596	0.597	0.597	0.597
3	0.990	0.961	0.535	0.536	0.536	0.536
4	0.988	0.953	0.501	0.502	0.502	0.502
5	0.985	0.953	0.527	0.529	0.529	0.529
6	0.993	0.955	0.504	0.506	0.506	0.506
7	0.989	0.955	0.515	0.517	0.517	0.517
Ave.	0.989	0.955	0.530	0.531	0.531	0.531

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	0.999	0.983	0.666	0.667	0.667	0.667
2	4	0.988	0.998	0.985	0.542	0.543	0.543	0.543
2	5	0.990	0.999	0.987	0.651	0.654	0.654	0.654
2	6	0.982	0.999	0.982	0.572	0.572	0.572	0.572
2	7	0.975	0.999	0.973	0.571	0.571	0.571	0.571
3	4	0.989	0.999	0.986	0.776	0.780	0.780	0.780
3	5	0.990	1.000	0.983	0.897	0.904	0.904	0.904
3	6	0.982	0.998	0.974	0.819	0.821	0.821	0.821
3	7	0.976	1.000	0.967	0.818	0.821	0.821	0.821
4	5	0.988	1.000	0.990	0.807	0.805	0.805	0.805
4	6	0.986	0.996	0.980	0.880	0.880	0.880	0.880
4	7	0.980	0.999	0.973	0.865	0.865	0.865	0.865
5	6	0.982	0.997	0.981	0.833	0.830	0.830	0.830
5	7	0.976	1.000	0.975	0.834	0.831	0.831	0.831
6	7	0.983	0.998	0.979	0.928	0.928	0.927	0.928
Average		0.984	0.999	0.980	0.764	0.765	0.765	0.765

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	0.991	0.877	0.880	0.880	0.880
2	4	1.000	0.994	0.814	0.815	0.815	0.815
2	5	0.999	0.994	0.867	0.869	0.869	0.869
2	6	0.999	0.991	0.833	0.833	0.833	0.833
2	7	1.000	0.991	0.842	0.842	0.842	0.842
3	4	1.000	0.989	0.885	0.888	0.888	0.888
3	5	0.998	0.990	0.924	0.928	0.928	0.928
3	6	0.999	0.993	0.903	0.904	0.904	0.904
3	7	1.000	0.992	0.910	0.912	0.912	0.912
4	5	0.999	0.996	0.917	0.916	0.916	0.916
4	6	0.999	0.992	0.918	0.918	0.918	0.918
4	7	1.000	0.992	0.917	0.916	0.916	0.916
5	6	0.996	0.992	0.932	0.932	0.932	0.932
5	7	0.999	0.993	0.937	0.936	0.936	0.936
6	7	0.999	0.995	0.946	0.946	0.946	0.946
Average		0.999	0.992	0.895	0.896	0.896	0.896

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took 30-40 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-14, 11:50 – 13:14

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.866	0.751
Long (elev.)	1.000	0.999
Medium (elev.)	0.892	0.784
Short (elev.)	0.576	0.355
Long (slope)	1.000	0.998
Medium (slope)	0.819	0.679
Short (slope)	0.563	0.230

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	11:49	12:10	—	—	—	—
2	12:14	12:22	69.83	15.25	142.681	0.02
3	12:27	12:35	71.06	17.28	142.681	0.02
4	12:38	12:45	74.30	22.63	142.683	0.02
5	12:48	12:54	75.98	25.40	142.682	0.02
6	12:59	13:05	78.61	29.74	142.681	0.02
7	13:09	13:14	77.86	28.50	142.683	0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.801	0.999	0.748	0.228	0.228	0.228	0.228
3	0.788	0.999	0.720	0.250	0.250	0.192	0.250
4	0.752	0.998	0.674	0.251	0.251	0.138	0.251
5	0.735	0.998	0.659	0.248	0.248	0.249	0.248
6	0.715	0.999	0.633	0.265	0.265	0.164	0.265
7	0.716	0.998	0.640	0.218	0.218	0.160	0.218
Ave.	0.751	0.998	0.679	0.244	0.244	0.188	0.244

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.999	0.877	0.374	0.374	0.374	0.374
3	0.999	0.832	0.371	0.362	0.362	0.362
4	1.000	0.786	0.351	0.350	0.350	0.350
5	0.999	0.755	0.358	0.358	0.358	0.358
6	1.000	0.731	0.357	0.355	0.355	0.355
7	0.999	0.723	0.330	0.328	0.328	0.328
Ave.	0.999	0.784	0.357	0.355	0.355	0.355

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	0.909	1.000	0.864	0.572	0.572	0.572	0.572
2	4	0.870	1.000	0.808	0.600	0.600	0.600	0.600
2	5	0.854	0.999	0.791	0.527	0.527	0.527	0.527
2	6	0.809	1.000	0.732	0.508	0.508	0.508	0.508
2	7	0.820	0.999	0.756	0.484	0.484	0.484	0.484
3	4	0.850	1.000	0.796	0.602	0.602	0.602	0.602
3	5	0.850	1.000	0.795	0.565	0.565	0.565	0.565
3	6	0.819	1.000	0.758	0.576	0.576	0.576	0.576
3	7	0.829	1.000	0.784	0.520	0.520	0.520	0.520
4	5	0.896	1.000	0.873	0.537	0.537	0.537	0.537
4	6	0.865	1.000	0.821	0.538	0.538	0.538	0.538
4	7	0.876	1.000	0.843	0.608	0.608	0.608	0.608
5	6	0.913	1.000	0.881	0.633	0.633	0.633	0.633
5	7	0.896	1.000	0.875	0.606	0.606	0.606	0.606
6	7	0.929	1.000	0.902	0.573	0.573	0.573	0.573
Average		0.866	1.000	0.819	0.563	0.563	0.563	0.563

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	0.928	0.595	0.578	0.578	0.578
2	4	1.000	0.874	0.679	0.678	0.678	0.678
2	5	1.000	0.842	0.606	0.605	0.605	0.605
2	6	1.000	0.808	0.585	0.583	0.583	0.583
2	7	1.000	0.802	0.610	0.609	0.609	0.609
3	4	0.999	0.917	0.591	0.567	0.567	0.567
3	5	1.000	0.887	0.576	0.565	0.565	0.565
3	6	1.000	0.855	0.562	0.567	0.567	0.567
3	7	1.000	0.849	0.560	0.555	0.555	0.555
4	5	0.999	0.943	0.551	0.547	0.547	0.547
4	6	1.000	0.911	0.452	0.451	0.451	0.451
4	7	1.000	0.903	0.645	0.641	0.641	0.641
5	6	0.999	0.953	0.571	0.570	0.570	0.570
5	7	1.000	0.939	0.526	0.523	0.523	0.523
6	7	1.000	0.974	0.581	0.579	0.579	0.579
Average		1.000	0.892	0.579	0.575	0.575	0.575

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- A three person crew set up the test section.
- Set up included placement of a chalk line (11:10-11:20), placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end (11:25-11:38).
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-15, 05:48 – 07:11

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.615	0.595
Long (elev.)	1.000	0.998
Medium (elev.)	0.707	0.340
Short (elev.)	0.339	0.204
Long (slope)	1.000	0.994
Medium (slope)	0.388	0.293
Short (slope)	0.484	0.222

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	05:48	06:08	—	—	—	—
2	06:11	06:19	56.95	-6.01	142.695	0.03
3	06:23	06:30	58.41	-3.60	142.694	0.02
4	06:33	06:40	58.61	-3.27	142.693	0.02
5	06:45	06:52	61.51	1.52	142.694	0.02
6	06:55	07:02	68.87	13.67	142.694	0.02
7	07:04	07:11	73.56	21.41	142.694	0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.653	0.994	0.314	0.258	0.258	0.159	0.258
3	0.657	0.994	0.317	0.289	0.289	0.289	0.289
4	0.641	0.996	0.300	0.252	0.252	0.252	0.252
5	0.611	0.993	0.313	0.251	0.251	0.188	0.251
6	0.529	0.993	0.319	0.207	0.207	0.119	0.207
7	0.420	0.993	0.197	0.171	0.107	0.107	0.171
Ave.	0.585	0.994	0.293	0.238	0.227	0.186	0.238

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.998	0.331	0.286	0.287	0.287	0.287
3	0.998	0.312	0.301	0.300	0.300	0.300
4	0.998	0.331	0.217	0.215	0.215	0.215
5	0.998	0.336	0.207	0.208	0.208	0.208
6	0.997	0.372	0.120	0.121	0.121	0.121
7	0.997	0.357	0.094	0.095	0.095	0.095
Ave.	0.998	0.340	0.204	0.204	0.204	0.204

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	0.824	1.000	0.632	0.489	0.489	0.489	0.489
2	4	0.791	1.000	0.558	0.591	0.591	0.591	0.591
2	5	0.730	1.000	0.508	0.489	0.489	0.489	0.489
2	6	0.566	1.000	0.343	0.370	0.370	0.370	0.370
2	7	0.450	1.000	0.200	0.346	0.346	0.346	0.346
3	4	0.794	1.000	0.540	0.569	0.569	0.569	0.569
3	5	0.751	1.000	0.528	0.515	0.515	0.515	0.515
3	6	0.579	1.000	0.370	0.517	0.517	0.517	0.517
3	7	0.449	1.000	0.201	0.438	0.438	0.438	0.438
4	5	0.702	0.999	0.444	0.492	0.492	0.492	0.492
4	6	0.545	0.999	0.314	0.449	0.449	0.449	0.449
4	7	0.432	0.999	0.175	0.440	0.440	0.440	0.440
5	6	0.623	1.000	0.431	0.487	0.487	0.487	0.487
5	7	0.453	1.000	0.230	0.550	0.550	0.550	0.550
6	7	0.540	1.000	0.342	0.514	0.514	0.514	0.514
Average		0.615	1.000	0.388	0.484	0.484	0.484	0.484

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	0.896	0.417	0.418	0.418	0.418
2	4	1.000	0.863	0.440	0.438	0.438	0.438
2	5	1.000	0.817	0.383	0.382	0.382	0.382
2	6	1.000	0.673	0.253	0.251	0.251	0.251
2	7	1.000	0.568	0.178	0.175	0.175	0.135
3	4	1.000	0.851	0.372	0.375	0.375	0.375
3	5	1.000	0.822	0.427	0.424	0.424	0.424
3	6	0.999	0.666	0.363	0.361	0.361	0.361
3	7	1.000	0.552	0.284	0.271	0.270	0.270
4	5	1.000	0.789	0.340	0.323	0.327	0.329
4	6	1.000	0.650	0.190	0.206	0.206	0.195
4	7	1.000	0.543	0.294	0.284	0.284	0.284
5	6	1.000	0.711	0.383	0.385	0.385	0.385
5	7	1.000	0.560	0.455	0.452	0.452	0.452
6	7	1.000	0.645	0.340	0.351	0.351	0.351
Average		1.000	0.707	0.341	0.340	0.340	0.337

Notes:

- This was a return visit to the section over concerns about curling.
- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 30 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The crew added additional sand to fill a wide crack prior to testing.
- Temperatures near 50 F and clear.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-15, 08:14 – 09:28

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.967	0.728
Long (elev.)	0.997	0.989
Medium (elev.)	0.983	0.747
Short (elev.)	0.908	0.635
Long (slope)	0.995	0.965
Medium (slope)	0.965	0.724
Short (slope)	0.869	0.398

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	08:14	08:30	—	—	—	—
2	08:34	08:42	127.11	30.36	138.210	-0.02
3	08:46	08:51	126.67	29.90	138.210	-0.02
4	08:56	09:03	128.64	31.92	138.212	-0.02
5	09:05	09:11	128.23	31.50	138.210	-0.02
6	09:15	09:21	126.28	29.50	138.212	-0.02
7	09:23	09:28	126.58	29.81	138.210	-0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.736	0.965	0.729	0.408	0.408	0.408	0.408
3	0.726	0.968	0.727	0.400	0.400	0.400	0.400
4	0.720	0.968	0.718	0.407	0.407	0.407	0.407
5	0.719	0.966	0.714	0.407	0.407	0.407	0.407
6	0.730	0.955	0.723	0.388	0.388	0.388	0.388
7	0.736	0.967	0.735	0.376	0.376	0.376	0.376
Ave.	0.728	0.965	0.724	0.398	0.398	0.398	0.398

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.992	0.742	0.622	0.622	0.622	0.622
3	0.993	0.746	0.655	0.655	0.655	0.655
4	0.989	0.743	0.613	0.613	0.613	0.613
5	0.987	0.743	0.633	0.633	0.633	0.633
6	0.985	0.745	0.638	0.638	0.638	0.638
7	0.989	0.763	0.650	0.650	0.650	0.650
Ave.	0.989	0.747	0.635	0.635	0.635	0.635

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	0.975	0.998	0.985	0.906	0.906	0.906	0.906
2	4	0.964	0.996	0.972	0.905	0.905	0.905	0.905
2	5	0.945	0.997	0.944	0.826	0.826	0.826	0.826
2	6	0.965	0.992	0.963	0.857	0.857	0.857	0.857
2	7	0.964	0.998	0.970	0.801	0.801	0.801	0.801
3	4	0.976	0.999	0.975	0.921	0.921	0.921	0.921
3	5	0.965	0.997	0.952	0.863	0.863	0.863	0.863
3	6	0.978	0.986	0.967	0.888	0.888	0.888	0.888
3	7	0.975	1.000	0.977	0.825	0.825	0.825	0.825
4	5	0.974	0.996	0.963	0.871	0.871	0.871	0.871
4	6	0.970	0.985	0.969	0.905	0.905	0.905	0.905
4	7	0.964	0.999	0.963	0.840	0.840	0.840	0.840
5	6	0.959	0.991	0.958	0.867	0.867	0.867	0.867
5	7	0.963	0.996	0.953	0.872	0.872	0.872	0.872
6	7	0.968	0.988	0.958	0.893	0.893	0.893	0.893
Average		0.967	0.995	0.965	0.869	0.869	0.869	0.869

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	0.990	0.932	0.932	0.932	0.932
2	4	0.998	0.993	0.936	0.936	0.936	0.936
2	5	0.997	0.992	0.884	0.884	0.883	0.883
2	6	0.996	0.988	0.952	0.952	0.952	0.952
2	7	0.998	0.969	0.903	0.903	0.903	0.903
3	4	0.998	0.993	0.894	0.894	0.894	0.894
3	5	0.996	0.986	0.865	0.865	0.865	0.865
3	6	0.994	0.983	0.918	0.918	0.918	0.918
3	7	0.997	0.978	0.911	0.911	0.911	0.911
4	5	0.997	0.989	0.896	0.896	0.896	0.896
4	6	0.994	0.987	0.944	0.944	0.944	0.944
4	7	1.000	0.973	0.869	0.869	0.869	0.869
5	6	0.999	0.992	0.917	0.917	0.917	0.917
5	7	0.997	0.969	0.892	0.892	0.892	0.892
6	7	0.994	0.965	0.907	0.907	0.907	0.907
Average		0.997	0.983	0.908	0.908	0.908	0.908

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 45 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 60 F, partly cloudy.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-14, 15:52 – 16:35

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.991	0.926
Long (elev.)	0.993	0.996
Medium (elev.)	0.988	0.964
Short (elev.)	0.949	0.627
Long (slope)	0.996	0.996
Medium (slope)	0.988	0.919
Short (slope)	0.898	0.296

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	15:52	16:02	—	—	—	—
2	16:05	16:09	136.31	4.54	56.667	-0.03
3	16:11	16:14	137.17	5.20	56.670	-0.03
4	16:16	16:19	136.92	5.01	56.669	-0.03
5	16:22	16:25	137.21	5.23	56.670	-0.03
6	16:27	16:30	134.99	3.53	56.670	-0.03
7	16:31	16:35	137.85	5.72	56.667	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
2	0.931	0.995	0.925	0.303
3	0.925	0.998	0.919	0.304
4	0.929	0.999	0.926	0.299
5	0.922	0.992	0.911	0.306
6	0.929	0.998	0.920	0.279
7	0.920	0.997	0.914	0.284
Ave.	0.926	0.996	0.919	0.296

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
2	0.998	0.965	0.627
3	0.998	0.959	0.630
4	0.996	0.978	0.628
5	0.996	0.956	0.639
6	0.999	0.958	0.612
7	0.988	0.971	0.623
Ave.	0.996	0.964	0.627

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short
2	3	0.992	0.995	0.992	0.949
2	4	0.995	0.997	0.995	0.929
2	5	0.989	0.998	0.982	0.927
2	6	0.995	0.999	0.991	0.895
2	7	0.985	0.993	0.985	0.883
3	4	0.994	0.999	0.989	0.933
3	5	0.996	0.992	0.988	0.931
3	6	0.991	0.998	0.992	0.864
3	7	0.992	0.999	0.991	0.869
4	5	0.991	0.993	0.979	0.920
4	6	0.995	0.999	0.988	0.886
4	7	0.989	0.998	0.985	0.868
5	6	0.989	0.996	0.984	0.863
5	7	0.992	0.989	0.989	0.861
6	7	0.985	0.995	0.987	0.889
Average		0.991	0.996	0.988	0.898

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short
2	3	0.996	0.993	0.979
2	4	0.992	0.984	0.965
2	5	0.999	0.991	0.961
2	6	0.999	0.992	0.946
2	7	0.984	0.989	0.940
3	4	0.998	0.978	0.964
3	5	0.994	0.997	0.958
3	6	0.998	0.998	0.929
3	7	0.990	0.983	0.929
4	5	0.990	0.976	0.964
4	6	0.995	0.977	0.948
4	7	0.993	0.993	0.938
5	6	0.997	0.997	0.939
5	7	0.982	0.981	0.934
6	7	0.986	0.982	0.943
Average		0.993	0.988	0.949

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Processing time to get longitudinal distance to report the value verbally was about 1.5 minutes after each run.
- Processed data for profiles from 16:37-17:12. Processing took extra time because files were not named properly.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-15, 10:57 – 12:14

Device: SurPRO 4000L, Unit #90

Operator(s): Chase Fleeman

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.990	0.935
Long (elev.)	0.997	0.993
Medium (elev.)	0.988	0.922
Short (elev.)	0.926	0.690
Long (slope)	0.999	0.997
Medium (slope)	0.984	0.919
Short (slope)	0.793	0.252

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	10:57	11:14	—	—	—	—
2	11:17	11:25	80.17	3.78	164.111	-0.05
3	11:28	11:35	80.41	4.09	164.112	-0.05
4	11:37	11:44	80.69	4.45	164.113	-0.05
5	11:47	11:54	81.07	4.94	164.113	-0.05
6	11:57	11:04	80.91	4.74	164.112	-0.05
7	12:07	12:14	81.35	5.31	164.111	-0.05

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.946	0.996	0.935	0.245	0.247	0.247	0.247
3	0.941	0.999	0.926	0.247	0.249	0.249	0.249
4	0.938	0.997	0.925	0.243	0.245	0.245	0.245
5	0.932	0.997	0.915	0.257	0.259	0.259	0.259
6	0.932	0.997	0.917	0.253	0.255	0.255	0.255
7	0.923	0.998	0.897	0.256	0.258	0.258	0.258
Ave.	0.935	0.997	0.919	0.250	0.252	0.252	0.252

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.995	0.933	0.726	0.721	0.721	0.721
3	0.990	0.927	0.696	0.691	0.691	0.691
4	0.993	0.928	0.693	0.687	0.687	0.687
5	0.991	0.920	0.692	0.687	0.687	0.687
6	0.995	0.922	0.679	0.673	0.673	0.673
7	0.991	0.901	0.680	0.676	0.676	0.676
Ave.	0.993	0.922	0.694	0.689	0.689	0.689

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	0.998	0.989	0.735	0.736	0.736	0.736
2	4	0.989	1.000	0.986	0.750	0.752	0.752	0.752
2	5	0.986	0.999	0.979	0.737	0.741	0.741	0.741
2	6	0.986	0.999	0.981	0.680	0.681	0.681	0.681
2	7	0.980	0.998	0.965	0.755	0.756	0.756	0.756
3	4	0.993	0.999	0.995	0.851	0.852	0.852	0.852
3	5	0.990	0.999	0.988	0.867	0.869	0.869	0.869
3	6	0.991	0.999	0.990	0.786	0.787	0.787	0.787
3	7	0.984	1.000	0.973	0.821	0.822	0.822	0.822
4	5	0.993	1.000	0.989	0.844	0.845	0.845	0.845
4	6	0.994	1.000	0.992	0.801	0.802	0.802	0.802
4	7	0.987	0.999	0.975	0.845	0.847	0.847	0.847
5	6	0.997	1.000	0.994	0.777	0.777	0.777	0.777
5	7	0.992	0.999	0.984	0.838	0.839	0.839	0.839
6	7	0.991	0.999	0.981	0.798	0.799	0.799	0.799
Average		0.990	0.999	0.984	0.792	0.794	0.794	0.794

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	0.995	0.992	0.914	0.916	0.916	0.916
2	4	0.998	0.993	0.906	0.906	0.906	0.906
2	5	0.996	0.986	0.903	0.906	0.905	0.906
2	6	1.000	0.989	0.895	0.895	0.895	0.895
2	7	0.996	0.971	0.893	0.895	0.895	0.895
3	4	0.997	0.998	0.952	0.950	0.950	0.950
3	5	0.999	0.993	0.950	0.951	0.951	0.951
3	6	0.995	0.995	0.937	0.935	0.935	0.935
3	7	0.998	0.977	0.929	0.928	0.929	0.928
4	5	0.998	0.992	0.945	0.945	0.945	0.945
4	6	0.998	0.994	0.928	0.925	0.925	0.925
4	7	0.998	0.976	0.926	0.925	0.925	0.925
5	6	0.996	0.995	0.936	0.932	0.932	0.932
5	7	0.999	0.983	0.951	0.950	0.950	0.950
6	7	0.996	0.980	0.934	0.934	0.934	0.934
Average		0.993	0.997	0.988	0.927	0.926	0.926

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 15 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 70 F, sunny with some clouds.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-15, 16:56-19:03

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.986	0.951
Long (elev.)	1.000	0.978
Medium (elev.)	0.993	0.984
Short (elev.)	0.895	0.672
Long (slope)	0.998	0.984
Medium (slope)	0.982	0.961
Short (slope)	0.799	0.241

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.04 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	16:56	17:20	—	—	—	—
2	17:25	17:33	79.03	2.24	316.270	-0.04
3	17:40	17:48	78.29	1.28	316.269	-0.04
4	17:55	18:04	78.17	1.13	316.270	-0.04
5	18:09	18:18	78.06	0.98	316.269	-0.04
6	18:23	18:32	78.15	1.10	316.267	-0.04
8	18:54	19:03	77.70	0.54	316.271	-0.04

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.941	0.981	0.951	0.234	0.232	0.232	0.229
3	0.950	0.985	0.960	0.254	0.251	0.251	0.247
4	0.949	0.984	0.959	0.245	0.242	0.242	0.238
5	0.953	0.983	0.963	0.256	0.254	0.254	0.251
6	0.954	0.985	0.965	0.262	0.259	0.259	0.254
8	0.956	0.986	0.966	0.216	0.213	0.213	0.201
Ave.	0.951	0.984	0.961	0.245	0.242	0.242	0.237

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.977	0.981	0.621	0.626	0.626	0.632
3	0.978	0.986	0.659	0.672	0.672	0.680
4	0.979	0.983	0.669	0.677	0.677	0.679
5	0.978	0.981	0.674	0.676	0.676	0.680
6	0.977	0.986	0.688	0.698	0.698	0.703
8	0.979	0.987	0.681	0.686	0.686	0.692
Ave.	0.978	0.984	0.666	0.673	0.673	0.678

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	0.983	0.996	0.977	0.794	0.796	0.796	0.792
2	4	0.984	0.996	0.979	0.810	0.813	0.813	0.813
2	5	0.980	0.998	0.974	0.807	0.810	0.810	0.803
2	6	0.979	0.996	0.973	0.738	0.741	0.741	0.739
2	8	0.980	0.995	0.975	0.766	0.764	0.764	0.757
3	4	0.990	1.000	0.986	0.806	0.806	0.806	0.796
3	5	0.988	0.998	0.984	0.826	0.828	0.828	0.818
3	6	0.987	1.000	0.983	0.758	0.760	0.760	0.753
3	8	0.988	0.999	0.985	0.809	0.810	0.810	0.802
4	5	0.988	0.998	0.984	0.849	0.850	0.850	0.840
4	6	0.987	0.999	0.983	0.796	0.797	0.797	0.791
4	8	0.988	0.999	0.984	0.795	0.794	0.794	0.784
5	6	0.990	0.998	0.985	0.803	0.805	0.805	0.803
5	8	0.991	0.997	0.986	0.842	0.847	0.847	0.839
6	8	0.993	0.999	0.990	0.787	0.793	0.793	0.786
Average		0.986	0.998	0.982	0.799	0.801	0.801	0.794

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	0.992	0.883	0.875	0.875	0.867
2	4	0.999	0.994	0.862	0.860	0.860	0.859
2	5	1.000	0.995	0.875	0.878	0.878	0.877
2	6	1.000	0.991	0.842	0.837	0.837	0.834
2	8	0.999	0.990	0.843	0.843	0.843	0.838
3	4	1.000	0.995	0.916	0.924	0.924	0.926
3	5	1.000	0.992	0.908	0.923	0.923	0.916
3	6	1.000	0.996	0.876	0.879	0.879	0.876
3	8	1.000	0.995	0.878	0.891	0.891	0.886
4	5	1.000	0.994	0.942	0.937	0.937	0.933
4	6	1.000	0.994	0.919	0.917	0.917	0.910
4	8	1.000	0.994	0.915	0.921	0.921	0.912
5	6	1.000	0.991	0.911	0.904	0.904	0.897
5	8	1.000	0.991	0.925	0.924	0.924	0.916
6	8	0.999	0.996	0.932	0.926	0.926	0.922
Average		1.000	0.993	0.895	0.896	0.896	0.891

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 1038.00 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The operator observed a change in end elevation with increasing run numbers. They believe it was caused by the inclinometer cooling. The temperature at start of run 1 was 82°F and temperature dropped to about 75°F for last run.
- The operator returned to the section start after each run (except run 1) by riding in a van.
- Run 7 was aborted and an additional run was made.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-15, 13:50 – 15:14

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.972	0.916
Long (elev.)	1.000	0.995
Medium (elev.)	0.987	0.955
Short (elev.)	0.866	0.477
Long (slope)	1.000	0.997
Medium (slope)	0.962	0.916
Short (slope)	0.807	0.128

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	13:50	14:06	—	—	—	—
2	14:09	14:15	96.49	5.35	152.743	-0.03
3	14:18	14:23	97.05	5.96	152.743	-0.03
4	14:28	14:34	98.19	7.21	152.743	-0.03
5	14:36	14:42	97.59	6.55	152.744	-0.03
6	14:44	14:50	96.43	5.28	152.743	-0.03
7	15:09	15:14	96.80	5.69	152.743	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.922	0.997	0.922	0.174	0.174	0.174	0.174
3	0.920	0.996	0.922	0.120	0.121	0.121	0.121
4	0.907	0.997	0.900	0.137	0.137	0.137	0.137
5	0.912	0.998	0.916	0.111	0.112	0.112	0.112
6	0.925	0.997	0.927	0.110	0.110	0.110	0.110
7	0.911	0.998	0.908	0.117	0.117	0.117	0.117
Ave.	0.916	0.997	0.916	0.128	0.129	0.129	0.129

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.994	0.958	0.516	0.517	0.517	0.517
3	0.996	0.957	0.466	0.469	0.469	0.469
4	0.996	0.947	0.495	0.496	0.496	0.496
5	0.996	0.953	0.464	0.467	0.467	0.467
6	0.994	0.961	0.447	0.448	0.448	0.448
7	0.997	0.951	0.465	0.466	0.466	0.466
Ave.	0.995	0.955	0.476	0.477	0.477	0.477

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	0.981	1.000	0.971	0.733	0.734	0.734	0.734
2	4	0.966	1.000	0.954	0.811	0.811	0.811	0.811
2	5	0.970	0.999	0.968	0.695	0.694	0.694	0.694
2	6	0.979	1.000	0.972	0.685	0.685	0.685	0.685
2	7	0.976	1.000	0.968	0.727	0.727	0.726	0.727
3	4	0.967	1.000	0.950	0.865	0.867	0.867	0.867
3	5	0.974	0.999	0.968	0.855	0.854	0.854	0.854
3	6	0.974	1.000	0.969	0.799	0.798	0.798	0.798
3	7	0.973	0.999	0.957	0.879	0.878	0.878	0.878
4	5	0.975	0.999	0.955	0.812	0.811	0.811	0.811
4	6	0.962	1.000	0.950	0.791	0.791	0.791	0.791
4	7	0.978	1.000	0.969	0.846	0.845	0.845	0.845
5	6	0.962	0.999	0.958	0.895	0.895	0.895	0.895
5	7	0.979	1.000	0.967	0.867	0.868	0.868	0.868
6	7	0.969	1.000	0.960	0.849	0.849	0.849	0.849
Average		0.972	1.000	0.962	0.807	0.807	0.807	0.807

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	0.825	0.827	0.827	0.827
2	4	1.000	0.983	0.880	0.880	0.880	0.880
2	5	1.000	0.989	0.827	0.829	0.829	0.829
2	6	1.000	0.989	0.803	0.804	0.804	0.804
2	7	0.999	0.989	0.830	0.831	0.831	0.831
3	4	1.000	0.982	0.889	0.891	0.891	0.891
3	5	1.000	0.990	0.906	0.909	0.909	0.909
3	6	1.000	0.988	0.842	0.842	0.842	0.842
3	7	1.000	0.986	0.894	0.895	0.895	0.895
4	5	1.000	0.985	0.866	0.868	0.868	0.868
4	6	0.999	0.979	0.843	0.843	0.843	0.843
4	7	1.000	0.991	0.882	0.882	0.882	0.882
5	6	0.999	0.983	0.889	0.889	0.889	0.889
5	7	1.000	0.989	0.908	0.907	0.907	0.907
6	7	0.999	0.983	0.893	0.893	0.893	0.893
Average		1.000	0.987	0.865	0.866	0.866	0.866

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took 30-40 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- The operator stopped working between runs 6 and 7 for a phone call.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-14, 11:50 – 13:14

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.681	0.554
Long (elev.)	0.999	0.998
Medium (elev.)	0.824	0.715
Short (elev.)	0.245	0.146
Long (slope)	0.999	0.997
Medium (slope)	0.612	0.473
Short (slope)	0.394	0.131

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	11:49	12:08	—	—	—	—
2	12:12	12:20	84.43	39.35	142.680	0.02
3	12:23	12:30	84.87	40.07	142.682	0.02
4	12:35	12:41	87.92	45.11	142.684	0.02
5	12:47	12:53	84.00	38.64	142.682	0.02
6	12:57	13:03	87.11	43.77	142.681	0.02
7	13:08	13:13	88.34	45.80	142.680	0.02

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.567	0.997	0.490	0.180	0.180	0.098	0.098
3	0.569	0.998	0.486	0.186	0.186	0.128	0.128
4	0.541	0.997	0.464	0.178	0.178	0.116	0.116
5	0.572	0.995	0.484	0.174	0.174	0.116	0.116
6	0.527	0.996	0.452	0.123	0.123	0.103	0.103
7	0.546	0.996	0.461	0.085	0.085	0.078	0.085
Ave.	0.554	0.997	0.473	0.154	0.154	0.107	0.108

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.998	0.785	0.127	0.127	0.127	0.127
3	1.000	0.752	0.157	0.157	0.157	0.157
4	0.999	0.715	0.148	0.147	0.147	0.147
5	0.998	0.703	0.171	0.171	0.171	0.171
6	0.997	0.668	0.157	0.157	0.157	0.157
7	0.999	0.669	0.116	0.116	0.116	0.116
Ave.	0.998	0.715	0.146	0.146	0.146	0.146

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	0.721	0.999	0.638	0.387	0.387	0.221	0.387
2	4	0.665	0.999	0.586	0.467	0.467	0.467	0.467
2	5	0.715	0.999	0.623	0.344	0.344	0.344	0.344
2	6	0.689	0.999	0.605	0.361	0.361	0.361	0.361
2	7	0.632	0.999	0.552	0.332	0.332	0.332	0.332
3	4	0.674	0.999	0.612	0.521	0.521	0.521	0.521
3	5	0.720	0.998	0.635	0.357	0.357	0.357	0.357
3	6	0.612	0.998	0.537	0.383	0.383	0.383	0.383
3	7	0.724	0.999	0.661	0.358	0.358	0.358	0.358
4	5	0.740	0.999	0.676	0.456	0.456	0.456	0.456
4	6	0.662	0.999	0.613	0.404	0.404	0.404	0.404
4	7	0.693	0.999	0.647	0.465	0.465	0.465	0.465
5	6	0.634	0.999	0.570	0.357	0.357	0.357	0.357
5	7	0.653	0.999	0.588	0.316	0.316	0.316	0.316
6	7	0.680	0.998	0.635	0.442	0.442	0.442	0.442
Average		0.681	0.999	0.612	0.397	0.397	0.386	0.397

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	0.998	0.856	0.256	0.254	0.254	0.254
2	4	1.000	0.803	0.266	0.260	0.260	0.260
2	5	1.000	0.791	0.315	0.315	0.315	0.315
2	6	0.999	0.759	0.253	0.261	0.261	0.261
2	7	0.999	0.734	0.121	0.120	0.301	0.301
3	4	0.999	0.845	0.394	0.393	0.393	0.393
3	5	0.998	0.835	0.148	0.154	0.153	0.151
3	6	0.997	0.769	0.233	0.231	0.231	0.231
3	7	0.999	0.800	0.270	0.265	0.265	0.265
4	5	0.999	0.897	0.349	0.346	0.346	0.346
4	6	0.999	0.833	0.229	0.229	0.229	0.229
4	7	1.000	0.832	0.261	0.261	0.261	0.261
5	6	1.000	0.858	0.165	0.163	0.163	0.163
5	7	0.999	0.857	0.105	0.101	0.101	0.101
6	7	0.998	0.898	0.214	0.227	0.227	0.227
Average		0.999	0.824	0.239	0.239	0.251	0.250

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- A three person crew set up the test section.
- Set up included placement of a chalk line (11:10-11:20), placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end (11:25-11:38).
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures in the mid 80s and sunny.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-15, 05:46 – 07:06

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.452	0.413
Long (elev.)	0.999	0.994
Medium (elev.)	0.539	0.356
Short (elev.)	0.224	0.109
Long (slope)	0.998	0.992
Medium (slope)	0.249	0.205
Short (slope)	0.318	0.127

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from 0.02 to 0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	05:46	06:06	—	—	—	—
2	06:09	06:16	70.99	17.16	142.696	0.03
3	06:20	06:26	66.63	9.97	142.696	0.03
4	06:29	06:36	73.86	21.90	142.695	0.03
5	06:40	06:47	81.68	34.81	142.693	0.02
6	06:49	06:56	77.35	27.66	142.695	0.03
7	06:58	07:06	76.16	25.70	142.696	0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.471	0.995	0.337	0.191	0.189	0.189	0.189
3	0.500	0.996	0.325	0.147	0.148	0.148	0.148
4	0.406	0.997	0.345	0.094	0.092	0.092	0.092
5	0.374	0.994	0.386	0.100	0.100	0.100	0.100
6	0.346	0.987	0.364	0.050	0.050	0.050	0.050
7	0.377	0.992	0.377	0.073	0.071	0.071	0.071
Ave.	0.413	0.992	0.205	0.152	0.133	0.095	0.129

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.992	0.250	0.223	0.223	0.129	0.223
3	0.991	0.252	0.211	0.211	0.119	0.211
4	0.993	0.201	0.164	0.072	0.098	0.072
5	0.995	0.197	0.107	0.081	0.081	0.107
6	0.991	0.149	0.077	0.077	0.062	0.077
7	0.991	0.180	0.133	0.133	0.083	0.083
Ave.	0.994	0.356	0.109	0.108	0.108	0.108

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	0.573	1.000	0.328	0.305	0.305	0.151	0.305
2	4	0.551	1.000	0.350	0.356	0.356	0.356	0.356
2	5	0.399	0.998	0.182	0.279	0.279	0.145	0.279
2	6	0.355	0.998	0.145	0.172	0.172	0.134	0.134
2	7	0.419	0.999	0.180	0.216	0.216	0.125	0.216
3	4	0.517	1.000	0.311	0.367	0.367	0.367	0.367
3	5	0.392	0.997	0.201	0.334	0.334	0.334	0.334
3	6	0.398	0.997	0.191	0.232	0.232	0.232	0.232
3	7	0.442	0.999	0.199	0.341	0.341	0.341	0.341
4	5	0.462	0.998	0.267	0.406	0.406	0.406	0.406
4	6	0.438	0.997	0.203	0.322	0.322	0.322	0.322
4	7	0.477	0.999	0.285	0.422	0.422	0.422	0.422
5	6	0.442	0.998	0.273	0.350	0.350	0.350	0.350
5	7	0.466	0.998	0.316	0.422	0.422	0.422	0.422
6	7	0.453	0.999	0.306	0.353	0.353	0.353	0.353
Average		0.452	0.998	0.249	0.325	0.325	0.297	0.323

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	0.662	0.132	0.131	0.131	0.131
2	4	1.000	0.635	0.142	0.147	0.147	0.147
2	5	1.000	0.491	0.135	0.133	0.133	0.133
2	6	0.997	0.452	0.164	0.162	0.162	0.162
2	7	1.000	0.511	0.200	0.203	0.203	0.091
3	4	1.000	0.614	0.312	0.316	0.242	0.316
3	5	0.999	0.478	0.303	0.180	0.114	0.181
3	6	0.996	0.447	0.147	0.146	0.142	0.146
3	7	0.999	0.520	0.231	0.217	0.217	0.217
4	5	0.999	0.529	0.322	0.315	0.315	0.315
4	6	0.996	0.493	0.239	0.233	0.233	0.233
4	7	0.999	0.524	0.352	0.338	0.338	0.338
5	6	0.998	0.567	0.278	0.289	0.289	0.289
5	7	1.000	0.580	0.322	0.321	0.286	0.286
6	7	0.999	0.578	0.269	0.272	0.272	0.272
Average		0.999	0.539	0.237	0.227	0.215	0.217

Notes:

- This was a return visit to the section over concerns about curling.
- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 30 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- The crew added additional sand to fill a wide crack prior to testing.
- Temperatures near 50 F and clear.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-15, 08:13 – 09:28

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.859	0.653
Long (elev.)	0.997	0.987
Medium (elev.)	0.952	0.730
Short (elev.)	0.690	0.512
Long (slope)	0.998	0.957
Medium (slope)	0.851	0.648
Short (slope)	0.731	0.326

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.02 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	08:13	08:29	—	—	—	—
2	08:32	08:38	135.49	38.95	138.211	-0.02
3	08:41	08:48	130.68	34.02	138.215	-0.02
4	08:54	09:02	131.63	34.99	138.213	-0.02
5	09:04	09:10	125.96	29.18	138.212	-0.02
6	09:14	09:20	127.15	30.40	138.214	-0.02
7	09:22	09:28	134.03	37.45	138.212	-0.02

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.631	0.958	0.624	0.323	0.323	0.323	0.315
3	0.658	0.954	0.653	0.349	0.349	0.349	0.349
4	0.639	0.956	0.639	0.328	0.328	0.328	0.329
5	0.678	0.959	0.668	0.362	0.362	0.362	0.362
6	0.675	0.957	0.669	0.317	0.317	0.317	0.313
7	0.635	0.961	0.635	0.277	0.277	0.277	0.277
Ave.	0.653	0.957	0.648	0.326	0.326	0.326	0.324

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.992	0.709	0.497	0.497	0.497	0.497
3	0.989	0.726	0.537	0.537	0.537	0.537
4	0.982	0.727	0.485	0.485	0.485	0.485
5	0.987	0.737	0.552	0.552	0.552	0.552
6	0.987	0.743	0.524	0.524	0.524	0.524
7	0.986	0.736	0.478	0.478	0.478	0.478
Ave.	0.987	0.730	0.512	0.512	0.512	0.512

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	0.860	0.998	0.849	0.694	0.694	0.694	0.694
2	4	0.852	0.999	0.846	0.681	0.681	0.681	0.681
2	5	0.821	0.999	0.814	0.665	0.665	0.665	0.665
2	6	0.803	0.999	0.784	0.660	0.660	0.660	0.660
2	7	0.821	0.998	0.796	0.686	0.686	0.686	0.686
3	4	0.921	0.999	0.912	0.804	0.804	0.804	0.804
3	5	0.876	0.998	0.874	0.819	0.819	0.819	0.819
3	6	0.893	0.999	0.891	0.746	0.746	0.746	0.746
3	7	0.896	0.995	0.887	0.771	0.771	0.771	0.771
4	5	0.838	0.999	0.829	0.727	0.727	0.727	0.727
4	6	0.844	0.999	0.832	0.739	0.739	0.739	0.739
4	7	0.859	0.997	0.841	0.767	0.767	0.767	0.767
5	6	0.887	0.999	0.884	0.755	0.755	0.755	0.755
5	7	0.866	0.999	0.869	0.700	0.700	0.700	0.700
6	7	0.854	0.997	0.860	0.755	0.755	0.755	0.755
Average		0.859	0.998	0.851	0.731	0.731	0.731	0.731

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	0.999	0.952	0.705	0.705	0.705	0.705
2	4	0.991	0.944	0.683	0.683	0.683	0.683
2	5	0.997	0.936	0.675	0.675	0.675	0.675
2	6	0.996	0.922	0.551	0.552	0.552	0.552
2	7	0.995	0.919	0.564	0.564	0.564	0.564
3	4	0.992	0.975	0.742	0.741	0.742	0.742
3	5	0.998	0.963	0.849	0.849	0.849	0.849
3	6	0.998	0.958	0.706	0.706	0.706	0.706
3	7	0.996	0.949	0.769	0.768	0.769	0.769
4	5	0.996	0.960	0.634	0.634	0.634	0.634
4	6	0.995	0.952	0.578	0.578	0.578	0.578
4	7	0.997	0.947	0.717	0.717	0.717	0.717
5	6	1.000	0.967	0.790	0.790	0.790	0.790
5	7	0.999	0.968	0.724	0.724	0.724	0.724
6	7	0.999	0.969	0.668	0.668	0.668	0.668
Average		0.997	0.952	0.690	0.690	0.690	0.690

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 45 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 60 F, partly cloudy.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-14, 15:52 – 16:31

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.979	0.922
Long (elev.)	0.997	0.984
Medium (elev.)	0.985	0.967
Short (elev.)	0.824	0.602
Long (slope)	0.997	0.992
Medium (slope)	0.970	0.923
Short (slope)	0.665	0.228

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.03 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	15:52	16:00	—	—	—	—
2	16:03	16:06	133.59	2.45	56.667	-0.03
3	16:08	16:12	136.02	4.32	56.670	-0.03
4	16:15	16:17	133.90	2.69	56.670	-0.03
5	16:21	16:23	133.56	2.43	56.669	-0.03
6	16:25	16:27	136.55	4.72	56.667	-0.03
7	16:29	16:31	134.90	3.46	56.672	-0.03

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
2	0.931	0.995	0.930	0.258
3	0.915	0.991	0.914	0.224
4	0.931	0.994	0.927	0.277
5	0.930	0.994	0.937	0.246
6	0.905	0.990	0.900	0.191
7	0.922	0.986	0.930	0.174
Ave.	0.922	0.992	0.923	0.228

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
2	0.982	0.972	0.621
3	0.980	0.966	0.592
4	0.988	0.961	0.630
5	0.985	0.975	0.610
6	0.985	0.954	0.589
7	0.981	0.973	0.568
Ave.	0.984	0.967	0.602

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short
2	3	0.981	0.997	0.978	0.754
2	4	0.987	0.999	0.977	0.712
2	5	0.991	1.000	0.981	0.701
2	6	0.970	0.997	0.961	0.706
2	7	0.983	0.993	0.985	0.549
3	4	0.970	0.998	0.961	0.571
3	5	0.982	0.999	0.974	0.787
3	6	0.980	1.000	0.968	0.782
3	7	0.986	0.997	0.974	0.674
4	5	0.985	1.000	0.968	0.538
4	6	0.965	0.998	0.953	0.609
4	7	0.979	0.993	0.972	0.447
5	6	0.971	0.998	0.957	0.734
5	7	0.984	0.994	0.982	0.669
6	7	0.979	0.997	0.963	0.737
Average		0.979	0.997	0.970	0.665

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short
2	3	0.999	0.994	0.836
2	4	0.995	0.983	0.851
2	5	0.999	0.994	0.811
2	6	0.998	0.981	0.854
2	7	1.000	0.991	0.770
3	4	0.993	0.982	0.738
3	5	0.997	0.990	0.878
3	6	0.997	0.984	0.891
3	7	1.000	0.988	0.866
4	5	0.998	0.979	0.726
4	6	0.998	0.988	0.800
4	7	0.993	0.976	0.707
5	6	1.000	0.978	0.887
5	7	0.997	0.995	0.894
6	7	0.997	0.977	0.857
Average		0.997	0.985	0.824

Notes:

- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Processing time to get longitudinal distance to report the value verbally was about 1.5 minutes after each run.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-15, 10:56 – 12:09

Device: SurPRO 4000L, Unit #91

Operator(s): Darel Mesher

Recording Interval: 5.08 mm

Use Moving Average: No

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

Up-Sampling: Not needed.

Results for Profile:

Waveband	Repeatability Score	Accuracy Score
IRI	0.988	0.933
Long (elev.)	0.993	0.994
Medium (elev.)	0.981	0.923
Short (elev.)	0.920	0.621
Long (slope)	0.998	0.996
Medium (slope)	0.981	0.914
Short (slope)	0.868	0.228

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was -0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (m)	Percent Error
1	10:56	11:11	—	—	—	—
2	11:16	11:22	79.33	2.69	164.111	-0.05
3	11:25	11:31	79.88	3.40	164.115	-0.05
4	11:36	11:42	79.70	3.17	164.115	-0.05
5	11:45	11:51	79.21	2.54	164.114	-0.05
6	11:54	12:00	80.02	3.59	164.112	-0.05
7	12:03	12:09	80.25	3.88	164.112	-0.05

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.941	0.997	0.927	0.245	0.247	0.247	0.247
3	0.931	0.999	0.912	0.247	0.248	0.248	0.163
4	0.933	0.990	0.919	0.208	0.209	0.209	0.209
5	0.938	0.997	0.920	0.224	0.224	0.224	0.224
6	0.929	0.998	0.909	0.231	0.232	0.232	0.232
7	0.924	0.998	0.898	0.229	0.230	0.230	0.230
Ave.	0.933	0.996	0.914	0.231	0.232	0.232	0.217

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.997	0.942	0.629	0.622	0.622	0.622
3	0.992	0.922	0.631	0.625	0.625	0.625
4	0.990	0.930	0.603	0.596	0.596	0.596
5	0.997	0.925	0.636	0.628	0.628	0.628
6	0.994	0.918	0.629	0.622	0.622	0.622
7	0.994	0.901	0.626	0.620	0.620	0.620
Ave.	0.994	0.923	0.626	0.619	0.619	0.619

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	0.985	0.998	0.978	0.888	0.887	0.887	0.887
2	4	0.987	0.997	0.986	0.826	0.829	0.829	0.829
2	5	0.991	0.999	0.987	0.848	0.849	0.849	0.849
2	6	0.986	1.000	0.978	0.854	0.855	0.855	0.855
2	7	0.978	0.999	0.965	0.855	0.858	0.858	0.858
3	4	0.991	0.991	0.983	0.821	0.823	0.823	0.823
3	5	0.987	0.998	0.982	0.875	0.875	0.875	0.875
3	6	0.994	0.999	0.991	0.881	0.880	0.880	0.880
3	7	0.988	0.999	0.980	0.881	0.883	0.883	0.883
4	5	0.990	0.996	0.991	0.850	0.854	0.854	0.854
4	6	0.991	0.995	0.981	0.867	0.870	0.870	0.870
4	7	0.986	0.996	0.972	0.845	0.845	0.845	0.845
5	6	0.989	1.000	0.983	0.912	0.915	0.915	0.915
5	7	0.981	1.000	0.970	0.898	0.898	0.898	0.898
6	7	0.988	1.000	0.982	0.897	0.898	0.898	0.898
Average		0.988	0.998	0.981	0.867	0.868	0.868	0.868

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	0.991	0.977	0.925	0.928	0.928	0.928
2	4	0.993	0.986	0.924	0.921	0.921	0.921
2	5	0.996	0.980	0.892	0.898	0.898	0.898
2	6	0.994	0.975	0.924	0.924	0.924	0.924
2	7	0.993	0.956	0.907	0.907	0.907	0.907
3	4	0.985	0.988	0.920	0.913	0.913	0.913
3	5	0.995	0.993	0.899	0.911	0.911	0.911
3	6	0.997	0.996	0.943	0.940	0.940	0.940
3	7	0.998	0.977	0.918	0.921	0.920	0.921
4	5	0.989	0.992	0.892	0.893	0.894	0.893
4	6	0.987	0.986	0.947	0.943	0.943	0.943
4	7	0.987	0.968	0.911	0.906	0.906	0.906
5	6	0.998	0.992	0.912	0.921	0.921	0.921
5	7	0.997	0.972	0.931	0.939	0.940	0.939
6	7	0.999	0.978	0.933	0.935	0.934	0.935
Average		0.993	0.981	0.919	0.920	0.920	0.920

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Set up included placement of a chalk line, placement of optical distance targets every 100 ft and 3 ft ahead of the test section start and behind the test section end. This process took about 15 minutes.
- The time for run 1 includes measurement in the upstream direction for loop closure.
- A calibration factor from the run 1 loop closure is applied to all other runs.
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- Temperatures near 70 F, sunny with some clouds.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-14, 08:15 – 11:44

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.901
Long (elev.)	0.964	0.978
Medium (elev.)	0.970	0.935
Short (elev.)	0.849	0.630
Long (slope)	0.968	0.978
Medium (slope)	0.972	0.870
Short (slope)	0.314	0.166

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.04 to 0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:15	08:46	70.95	-8.21	1037.6	-0.04
2	08:47	09:24	72.13	-6.69	1038.2	0.02
3	09:28	09:59	70.95	-8.21	1037.7	-0.03
4	10:03	10:36	71.07	-8.06	1038.1	0.01
5	10:41	11:13	71.15	-7.96	1037.9	-0.01
6	11:19	11:58	72.02	-6.83	1038.5	0.05

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.900	0.985	0.873	0.187	0.179	0.179	0.174
2	0.900	0.956	0.871	0.157	0.147	0.147	0.146
3	0.905	0.985	0.872	0.179	0.170	0.170	0.173
4	0.890	0.973	0.861	0.181	0.176	0.176	0.172
5	0.907	0.985	0.881	0.160	0.147	0.147	0.163
6	0.903	0.984	0.863	0.171	0.160	0.160	0.165
Ave.	0.901	0.978	0.870	0.173	0.163	0.163	0.166

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.997	0.943	0.655	0.650	0.650	0.655
2	0.930	0.942	0.636	0.635	0.635	0.641
3	0.997	0.923	0.635	0.632	0.632	0.637
4	0.965	0.925	0.635	0.636	0.636	0.639
5	0.990	0.940	0.635	0.628	0.628	0.632
6	0.988	0.937	0.590	0.588	0.588	0.596
Ave.	0.978	0.935	0.631	0.628	0.628	0.633

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	0.968	0.950	0.978	0.260	0.301	0.301	0.307
1	3	0.989	0.997	0.973	0.441	0.430	0.430	0.428
1	4	0.972	0.964	0.960	0.301	0.293	0.293	0.286
1	5	0.988	0.998	0.980	0.414	0.405	0.405	0.412
1	6	0.972	0.974	0.967	0.292	0.283	0.283	0.281
2	3	0.969	0.949	0.969	0.312	0.303	0.303	0.304
2	4	0.952	0.939	0.955	0.266	0.252	0.252	0.243
2	5	0.967	0.952	0.974	0.289	0.298	0.298	0.298
2	6	0.973	0.969	0.964	0.311	0.301	0.301	0.300
3	4	0.978	0.965	0.979	0.301	0.298	0.298	0.299
3	5	0.995	0.998	0.984	0.495	0.487	0.487	0.483
3	6	0.978	0.973	0.979	0.201	0.188	0.188	0.208
4	5	0.978	0.962	0.972	0.309	0.303	0.303	0.306
4	6	0.962	0.961	0.966	0.307	0.301	0.301	0.298
5	6	0.977	0.974	0.977	0.253	0.244	0.244	0.245
Average		0.975	0.968	0.972	0.317	0.312	0.312	0.313

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	0.936	0.976	0.887	0.876	0.876	0.874
1	3	0.997	0.967	0.926	0.920	0.920	0.919
1	4	0.968	0.968	0.839	0.829	0.829	0.829
1	5	0.986	0.984	0.904	0.897	0.897	0.899
1	6	0.994	0.983	0.842	0.838	0.838	0.839
2	3	0.932	0.950	0.892	0.884	0.884	0.884
2	4	0.932	0.955	0.843	0.833	0.833	0.831
2	5	0.924	0.966	0.840	0.825	0.825	0.825
2	6	0.942	0.969	0.810	0.800	0.800	0.800
3	4	0.967	0.972	0.832	0.826	0.826	0.827
3	5	0.987	0.978	0.900	0.891	0.891	0.892
3	6	0.989	0.960	0.820	0.815	0.815	0.814
4	5	0.954	0.981	0.824	0.814	0.814	0.815
4	6	0.963	0.962	0.822	0.815	0.815	0.819
5	6	0.980	0.977	0.839	0.839	0.839	0.840
Average		0.964	0.970	0.855	0.847	0.847	0.847

Notes:

- Section length is 1038.0 ft, measured by a tensioned nylon-coated 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 (10-13 minutes).
- Typically, 1-4 minutes were spent between runs for processing to report the section length.
- Brent operated for odd numbered runs and Flint operated for even numbered runs.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The temperature was 61-72 F throughout the testing.
- The sky was clear at the start of the testing, but it became cloudy through the middle runs and was sunny and windy at the end of the set.
- The crew changed the laptop battery at 11:17.
- The crew transferred data to a thumb drive at 12:03 and finalized processing inside a vehicle. Provided data at 12:21.
- The crew used a chalk line for lateral reference.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-14 (3 runs), 2013-May-16 (3 runs, 12:11 to 14:08)

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.972	0.905
Long (elev.)	0.964	0.975
Medium (elev.)	0.970	0.939
Short (elev.)	0.836	0.632
Long (slope)	0.970	0.981
Medium (slope)	0.964	0.874
Short (slope)	0.321	0.168

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from –0.06 to 0.05 percent.

Run Log, DMI Results:

Run	Date	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
2	14-May	08:47	09:24	72.13	-6.69	1038.2	0.02
4	14-May	10:03	10:36	71.07	-8.06	1038.1	0.01
6	14-May	11:19	11:58	72.02	-6.83	1038.5	0.05
7	16-May	12:11	12:49	72.13	-6.69	1037.5	-0.05
8	16-May	12:54	13:29	72.10	-6.73	1037.4	-0.06
9	16-May	13:36	14:08	72.19	-6.61	1037.4	-0.06

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.900	0.956	0.871	0.157	0.147	0.147	0.146
4	0.890	0.973	0.861	0.181	0.176	0.176	0.172
6	0.903	0.984	0.863	0.171	0.160	0.160	0.165
7	0.915	0.993	0.883	0.182	0.168	0.168	0.168
8	0.914	0.988	0.886	0.178	0.171	0.171	0.163
9	0.911	0.994	0.880	0.190	0.179	0.179	0.169
Ave.	0.905	0.981	0.874	0.177	0.167	0.167	0.164

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.930	0.942	0.636	0.635	0.635	0.641
4	0.965	0.925	0.635	0.636	0.636	0.639
6	0.988	0.937	0.590	0.588	0.588	0.596
7	0.979	0.934	0.638	0.634	0.634	0.639
8	0.992	0.945	0.642	0.643	0.643	0.646
9	0.993	0.950	0.651	0.647	0.647	0.651
Ave.	0.975	0.939	0.632	0.630	0.630	0.635

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	4	0.952	0.939	0.955	0.266	0.252	0.252	0.243
2	6	0.973	0.969	0.964	0.311	0.301	0.301	0.300
2	7	0.976	0.965	0.974	0.340	0.334	0.334	0.331
2	8	0.976	0.952	0.970	0.268	0.265	0.265	0.276
2	9	0.971	0.958	0.963	0.356	0.344	0.344	0.339
4	6	0.962	0.961	0.966	0.307	0.301	0.301	0.298
4	7	0.961	0.970	0.960	0.299	0.289	0.289	0.290
4	8	0.960	0.962	0.953	0.361	0.354	0.354	0.335
4	9	0.951	0.971	0.942	0.342	0.331	0.331	0.322
6	7	0.980	0.986	0.968	0.248	0.236	0.236	0.237
6	8	0.981	0.975	0.963	0.202	0.211	0.211	0.208
6	9	0.972	0.980	0.951	0.268	0.260	0.260	0.259
7	8	0.993	0.985	0.985	0.405	0.401	0.401	0.405
7	9	0.984	0.993	0.973	0.545	0.529	0.531	0.525
8	9	0.984	0.991	0.978	0.430	0.342	0.416	0.398
Average		0.972	0.970	0.964	0.330	0.317	0.322	0.318

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	4	0.932	0.955	0.843	0.833	0.833	0.831
2	6	0.942	0.969	0.810	0.800	0.800	0.800
2	7	0.955	0.961	0.865	0.857	0.857	0.859
2	8	0.925	0.973	0.824	0.819	0.819	0.819
2	9	0.938	0.976	0.836	0.824	0.824	0.827
4	6	0.963	0.962	0.822	0.815	0.815	0.819
4	7	0.978	0.976	0.792	0.783	0.783	0.786
4	8	0.952	0.965	0.857	0.856	0.856	0.856
4	9	0.971	0.953	0.855	0.846	0.846	0.849
6	7	0.982	0.973	0.803	0.797	0.797	0.798
6	8	0.981	0.984	0.812	0.808	0.808	0.814
6	9	0.991	0.970	0.798	0.798	0.798	0.805
7	8	0.971	0.982	0.866	0.860	0.860	0.863
7	9	0.987	0.969	0.887	0.886	0.886	0.888
8	9	0.985	0.980	0.924	0.926	0.926	0.927
Average		0.964	0.970	0.840	0.834	0.834	0.836

Notes:

- Section length is 1038.0 ft, measured by a tensioned nylon-coated 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 (10-13 minutes).
- Typically, 1-4 minutes were spent between runs for processing to report the section length.
- Brent operated for all six runs. This series includes three runs from a previous visit, and three subsequent runs by Bryent only.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The crew used a chalk line for lateral reference.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-13, 10:47 – 15:42

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.982	0.942
Long (elev.)	0.992	0.961
Medium (elev.)	0.980	0.969
Short (elev.)	0.921	0.660
Long (slope)	0.993	0.972
Medium (slope)	0.981	0.926
Short (slope)	0.694	0.128

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.11 to 0.17 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	10:47	10:59	86.65	-5.39	502.0	0.15
2	11:02	11:17	86.69	-5.35	502.0	0.15
3	11:21	11:36	87.19	-4.80	502.1	0.17
4	11:39	11:55	—	—	—	—
5	13:49	14:03	87.97	-3.95	502.0	0.15
6	14:07	14:22	87.10	-4.90	501.8	0.11
7	14:26	15:42	87.67	-4.28	501.9	0.13

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.941	0.971	0.930	0.135	0.135	0.135	0.135
2	0.937	0.965	0.926	0.120	0.121	0.121	0.121
3	0.943	0.974	0.930	0.124	0.125	0.125	0.125
5	0.947	0.971	0.927	0.132	0.132	0.132	0.132
6	0.939	0.985	0.912	0.129	0.131	0.131	0.131
7	0.943	0.968	0.928	0.124	0.126	0.126	0.126
Ave.	0.942	0.972	0.926	0.127	0.128	0.128	0.128

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.956	0.967	0.670	0.672	0.672	0.672
2	0.949	0.972	0.631	0.633	0.641	0.633
3	0.962	0.971	0.667	0.669	0.669	0.669
5	0.960	0.970	0.657	0.658	0.658	0.658
6	0.971	0.958	0.678	0.677	0.677	0.677
7	0.969	0.979	0.650	0.652	0.652	0.652
Ave.	0.961	0.969	0.659	0.660	0.661	0.660

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	0.992	0.998	0.988	0.735	0.737	0.737	0.737
1	3	0.981	0.996	0.979	0.684	0.687	0.687	0.687
1	5	0.979	0.997	0.987	0.716	0.719	0.719	0.719
1	6	0.980	0.988	0.982	0.692	0.694	0.694	0.694
1	7	0.993	0.998	0.987	0.736	0.739	0.739	0.739
2	3	0.978	0.995	0.973	0.649	0.650	0.650	0.650
2	5	0.976	0.995	0.981	0.683	0.689	0.689	0.689
2	6	0.975	0.983	0.981	0.705	0.704	0.704	0.704
2	7	0.988	0.996	0.985	0.707	0.710	0.710	0.710
3	5	0.985	0.997	0.980	0.692	0.694	0.694	0.694
3	6	0.983	0.991	0.970	0.687	0.688	0.688	0.688
3	7	0.979	0.995	0.974	0.681	0.684	0.684	0.684
5	5	0.988	0.989	0.978	0.659	0.664	0.664	0.664
5	6	0.978	0.996	0.982	0.720	0.729	0.729	0.729
6	6	0.978	0.986	0.986	0.632	0.639	0.639	0.639
Average		0.982	0.993	0.981	0.692	0.695	0.695	0.695

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	0.980	0.911	0.912	0.912	0.912
1	3	0.995	0.976	0.923	0.924	0.924	0.924
1	5	0.996	0.974	0.927	0.927	0.927	0.927
1	6	0.986	0.986	0.926	0.928	0.928	0.928
1	7	0.990	0.979	0.936	0.937	0.937	0.937
2	3	0.988	0.982	0.910	0.910	0.910	0.910
2	5	0.990	0.985	0.935	0.937	0.937	0.937
2	6	0.979	0.974	0.900	0.900	0.900	0.900
2	7	0.983	0.986	0.935	0.935	0.935	0.935
3	5	0.998	0.984	0.938	0.938	0.938	0.938
3	6	0.994	0.976	0.951	0.951	0.951	0.951
3	7	0.997	0.984	0.893	0.894	0.894	0.894
5	5	0.992	0.976	0.925	0.925	0.925	0.925
5	6	0.995	0.987	0.912	0.915	0.915	0.915
6	6	0.998	0.974	0.885	0.886	0.886	0.886
Average		0.992	0.980	0.920	0.921	0.921	0.921

Notes:

- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values were reported verbally in the field.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- DMI calibrated just before measuring this section.
- Run 4 eliminated at the operator's request because of the influence of the rain.
- Brent operated for runs 1, 2, 3, and 6 and Flint operated run 5.
- The battery died at the end of run 7, so the return (loop closure) was performed much later.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-13, 15:38 – 17:56

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.927	0.937
Long (elev.)	0.993	0.992
Medium (elev.)	0.903	0.915
Short (elev.)	0.685	0.425
Long (slope)	0.979	0.986
Medium (slope)	0.900	0.910
Short (slope)	0.234	0.077

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.07 to 0.08 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	15:38	15:54	60.72	0.21	468.1	0.01
2	15:58	16:15	61.11	0.86	468.4	0.08
3	16:24	16:39	61.18	0.97	468.0	-0.01
4	16:42	17:00	59.87	-1.19	468.0	-0.01
5	17:22	17:38	57.21	-5.58	468.1	0.01
6	17:41	17:55	56.27	-7.13	467.7	-0.07

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.962	0.988	0.931	0.081	0.081	0.081	0.081
2	0.933	0.959	0.882	0.087	0.068	0.073	0.087
3	0.952	0.997	0.926	0.074	0.074	0.089	0.089
4	0.965	0.995	0.952	0.063	0.063	0.073	0.073
5	0.894	0.989	0.881	0.091	0.091	0.091	0.091
6	0.916	0.991	0.888	0.060	0.060	0.067	0.067
Ave.	0.937	0.986	0.910	0.076	0.073	0.079	0.081

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.983	0.920	0.446	0.443	0.443	0.443
2	0.989	0.870	0.427	0.426	0.426	0.426
3	0.993	0.909	0.431	0.429	0.429	0.429
4	0.998	0.936	0.436	0.434	0.434	0.434
5	0.994	0.915	0.405	0.405	0.405	0.405
6	0.992	0.938	0.410	0.407	0.407	0.407
Ave.	0.992	0.915	0.426	0.424	0.424	0.424

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	0.948	0.973	0.923	0.199	0.199	0.199	0.199
1	3	0.960	0.986	0.958	0.244	0.244	0.244	0.244
1	4	0.971	0.976	0.948	0.202	0.202	0.202	0.202
1	5	0.906	0.992	0.885	0.224	0.224	0.224	0.224
1	6	0.916	0.996	0.873	0.219	0.220	0.219	0.219
2	3	0.943	0.954	0.936	0.212	0.212	0.212	0.212
2	4	0.939	0.944	0.896	0.175	0.175	0.175	0.175
2	5	0.870	0.966	0.828	0.236	0.236	0.236	0.236
2	6	0.891	0.974	0.831	0.235	0.235	0.235	0.235
3	4	0.956	0.993	0.938	0.358	0.358	0.358	0.358
3	5	0.886	0.989	0.862	0.236	0.236	0.236	0.236
3	6	0.908	0.991	0.869	0.337	0.337	0.337	0.337
4	5	0.912	0.980	0.899	0.182	0.182	0.119	0.182
4	6	0.932	0.982	0.903	0.253	0.253	0.334	0.334
5	6	0.969	0.994	0.946	0.180	0.180	0.180	0.180
Average		0.927	0.979	0.900	0.233	0.233	0.234	0.238

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	0.987	0.912	0.676	0.677	0.678	0.678
1	3	0.997	0.944	0.750	0.752	0.752	0.752
1	4	0.983	0.953	0.786	0.781	0.781	0.781
1	5	0.993	0.897	0.638	0.639	0.653	0.653
1	6	0.997	0.896	0.646	0.645	0.645	0.645
2	3	0.990	0.941	0.653	0.657	0.657	0.657
2	4	0.988	0.890	0.658	0.655	0.655	0.655
2	5	0.989	0.827	0.697	0.695	0.695	0.695
2	6	0.991	0.846	0.696	0.695	0.695	0.695
3	4	0.993	0.929	0.771	0.761	0.761	0.761
3	5	0.998	0.858	0.591	0.593	0.593	0.593
3	6	0.999	0.879	0.674	0.666	0.666	0.666
4	5	0.994	0.897	0.663	0.656	0.656	0.656
4	6	0.993	0.918	0.727	0.726	0.726	0.726
5	6	0.997	0.963	0.670	0.667	0.667	0.667
Average		0.993	0.903	0.686	0.684	0.685	0.685

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Flint operated the device in runs 1-5 and Brent operated the device in run 6.
- A run was attempted and aborted before run 1.
- A run was attempted and aborted between runs 4 and 5.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-14, 17:12 – 19:23

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.927	0.923
Long (elev.)	0.993	0.984
Medium (elev.)	0.877	0.864
Short (elev.)	0.734	0.430
Long (slope)	0.989	0.987
Medium (slope)	0.881	0.868
Short (slope)	0.265	0.080

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	17:12	17:30	65.92	8.80	468.1	0.01
2	17:36	17:54	65.31	7.79	468.2	0.03
3	18:00	18:17	63.13	4.19	468.2	0.03
4	18:22	18:39	61.24	1.07	468.2	0.03
5	18:42	19:00	60.12	-0.78	468.0	-0.01
6	19:06	19:23	58.26	-3.85	468.0	-0.01

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.886	0.967	0.803	0.082	0.082	0.066	0.082
2	0.891	0.994	0.818	0.063	0.063	0.086	0.086
3	0.922	0.996	0.856	0.082	0.082	0.084	0.084
4	0.945	0.992	0.897	0.085	0.085	0.085	0.085
5	0.967	0.990	0.939	0.088	0.088	0.088	0.084
6	0.925	0.986	0.897	0.069	0.069	0.069	0.098
Ave.	0.923	0.987	0.868	0.078	0.078	0.080	0.086

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.963	0.795	0.443	0.442	0.442	0.442
2	0.992	0.804	0.450	0.446	0.446	0.446
3	0.994	0.847	0.428	0.426	0.426	0.426
4	0.983	0.894	0.432	0.431	0.431	0.431
5	0.989	0.924	0.427	0.424	0.424	0.424
6	0.983	0.921	0.409	0.407	0.407	0.407
Ave.	0.984	0.864	0.432	0.429	0.429	0.429

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	0.980	0.971	0.962	0.287	0.287	0.287	0.287
1	3	0.953	0.975	0.922	0.378	0.379	0.378	0.378
1	4	0.928	0.981	0.879	0.278	0.277	0.278	0.278
1	5	0.900	0.982	0.829	0.250	0.250	0.250	0.250
1	6	0.859	0.987	0.769	0.313	0.313	0.313	0.313
2	3	0.956	0.995	0.941	0.267	0.267	0.267	0.267
2	4	0.934	0.995	0.900	0.375	0.375	0.375	0.375
2	5	0.906	0.992	0.850	0.190	0.190	0.190	0.190
2	6	0.863	0.989	0.785	0.181	0.181	0.180	0.180
3	4	0.966	0.997	0.943	0.264	0.264	0.264	0.264
3	5	0.939	0.995	0.892	0.319	0.319	0.319	0.319
3	6	0.894	0.991	0.825	0.207	0.207	0.207	0.207
4	5	0.963	0.996	0.935	0.218	0.218	0.218	0.218
4	6	0.922	0.994	0.868	0.212	0.212	0.212	0.212
5	6	0.946	0.995	0.912	0.230	0.230	0.230	0.230
Average		0.927	0.989	0.881	0.265	0.265	0.265	0.265

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	0.980	0.970	0.787	0.789	0.789	0.789
1	3	0.978	0.924	0.746	0.749	0.749	0.748
1	4	0.988	0.874	0.738	0.739	0.739	0.739
1	5	0.984	0.832	0.717	0.719	0.719	0.719
1	6	0.990	0.764	0.737	0.739	0.739	0.739
2	3	0.998	0.933	0.744	0.746	0.746	0.746
2	4	0.996	0.885	0.762	0.760	0.760	0.760
2	5	0.997	0.846	0.742	0.743	0.743	0.743
2	6	0.995	0.772	0.676	0.678	0.678	0.678
3	4	0.996	0.936	0.734	0.734	0.734	0.734
3	5	0.998	0.894	0.780	0.779	0.779	0.779
3	6	0.995	0.815	0.697	0.699	0.700	0.700
4	5	0.998	0.943	0.705	0.704	0.704	0.704
4	6	0.998	0.863	0.748	0.747	0.747	0.747
5	6	0.998	0.900	0.684	0.684	0.684	0.684
Average		0.993	0.877	0.733	0.734	0.734	0.734

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- This was a return visit to the section requested because of excessive wind during the previous visit.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (7-8 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- Temperatures in the 90s and winds up to 20 mph.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing in runs 3-6 and Bob Orthmeyer observed the testing in runs 1 and 2.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-14, 13:54 – 15:48

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.892
Long (elev.)	0.977	0.980
Medium (elev.)	0.982	0.889
Short (elev.)	0.973	0.761
Long (slope)	0.982	0.970
Medium (slope)	0.988	0.888
Short (slope)	0.783	0.329

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	13:54	14:09	91.17	-6.50	453.4	-0.03
2	14:12	14:28	90.32	-7.37	453.3	-0.05
3	14:33	14:48	90.48	-7.21	453.3	-0.05
4	14:53	15:09	91.48	-6.18	453.3	-0.05
5	15:14	15:30	91.37	-6.30	453.3	-0.05
6	15:39	15:54	92.17	-5.48	453.2	-0.07

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.892	0.961	0.886	0.332	0.332	0.332	0.332
2	0.885	0.963	0.881	0.330	0.332	0.330	0.332
3	0.885	0.961	0.884	0.331	0.331	0.331	0.331
4	0.894	0.972	0.889	0.323	0.323	0.323	0.323
5	0.895	0.985	0.890	0.334	0.334	0.334	0.334
6	0.903	0.981	0.899	0.324	0.324	0.324	0.324
Ave.	0.892	0.970	0.888	0.329	0.329	0.329	0.329

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.967	0.887	0.770	0.770	0.771	0.771
2	0.983	0.878	0.764	0.764	0.764	0.764
3	0.984	0.879	0.769	0.769	0.769	0.769
4	0.987	0.891	0.754	0.754	0.755	0.755
5	0.970	0.892	0.760	0.760	0.761	0.761
6	0.989	0.904	0.749	0.749	0.749	0.749
Ave.	0.980	0.889	0.761	0.761	0.761	0.761

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	0.992	0.995	0.992	0.784	0.784	0.784	0.784
1	3	0.991	0.996	0.995	0.808	0.809	0.808	0.808
1	4	0.990	0.984	0.990	0.741	0.741	0.741	0.741
1	5	0.990	0.971	0.990	0.805	0.805	0.805	0.805
1	6	0.982	0.969	0.981	0.792	0.792	0.792	0.792
2	3	0.995	0.997	0.995	0.791	0.791	0.791	0.791
2	4	0.986	0.988	0.986	0.762	0.762	0.762	0.762
2	5	0.987	0.976	0.986	0.801	0.801	0.801	0.801
2	6	0.978	0.971	0.977	0.790	0.791	0.790	0.790
3	4	0.984	0.986	0.988	0.818	0.818	0.818	0.818
3	5	0.985	0.974	0.989	0.752	0.752	0.752	0.752
3	6	0.977	0.970	0.980	0.782	0.782	0.782	0.782
4	5	0.994	0.986	0.995	0.780	0.780	0.780	0.780
4	6	0.989	0.982	0.988	0.791	0.791	0.791	0.791
5	6	0.986	0.991	0.986	0.753	0.753	0.753	0.753
Average		0.987	0.982	0.988	0.783	0.783	0.783	0.783

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	0.984	0.989	0.974	0.974	0.974	0.974
1	3	0.980	0.989	0.985	0.985	0.985	0.985
1	4	0.977	0.988	0.964	0.964	0.964	0.964
1	5	0.944	0.987	0.974	0.974	0.974	0.974
1	6	0.964	0.973	0.957	0.957	0.957	0.957
2	3	0.997	0.995	0.981	0.981	0.981	0.981
2	4	0.994	0.983	0.971	0.971	0.971	0.971
2	5	0.961	0.982	0.978	0.978	0.978	0.978
2	6	0.980	0.967	0.971	0.971	0.971	0.971
3	4	0.997	0.981	0.973	0.973	0.973	0.973
3	5	0.964	0.981	0.975	0.975	0.975	0.975
3	6	0.983	0.967	0.961	0.961	0.961	0.961
4	5	0.966	0.993	0.980	0.980	0.980	0.980
4	6	0.986	0.981	0.981	0.981	0.981	0.981
5	6	0.979	0.977	0.975	0.975	0.975	0.975
Average		0.977	0.982	0.973	0.973	0.973	0.973

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- At the start of the visit to this section, the temperature was 84 F and it was windy. At the end, the temperature was 92 F and it was still.
- The crew used a chalk line for lateral reference.
- Bob Orthmeyer observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-13, 09:18 – 10:22

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.936
Long (elev.)	0.968	0.961
Medium (elev.)	0.943	0.902
Short (elev.)	0.948	0.683
Long (slope)	0.966	0.946
Medium (slope)	0.976	0.935
Short (slope)	0.631	0.108

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.06 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	09:18	09:27	124.34	-4.64	186.1	0.06
2	09:30	09:38	121.76	-6.62	186.1	0.06
3	09:40	09:47	126.29	-3.14	186.1	0.06
4	09:54	10:01	120.55	-7.55	186.1	0.06
5	10:03	10:11	125.75	-3.56	186.1	0.06
6	10:13	10:22	124.28	-4.69	186.1	0.06

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
1	0.939	0.950	0.937	0.104
2	0.922	0.935	0.922	0.111
3	0.953	0.958	0.955	0.112
4	0.915	0.898	0.923	0.110
5	0.949	0.981	0.943	0.108
6	0.938	0.956	0.930	0.106
Ave.	0.936	0.946	0.935	0.108

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
1	0.947	0.905	0.672
2	0.926	0.908	0.686
3	0.945	0.943	0.671
4	0.970	0.833	0.694
5	0.992	0.934	0.683
6	0.983	0.887	0.692
Ave.	0.961	0.902	0.683

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1
1	2	0.982	0.984	0.981	0.565
1	3	0.979	0.991	0.970	0.667
1	4	0.971	0.945	0.978	0.676
1	5	0.986	0.968	0.989	0.669
1	6	0.996	0.995	0.988	0.689
2	3	0.965	0.977	0.958	0.482
2	4	0.982	0.960	0.986	0.517
2	5	0.970	0.951	0.974	0.510
2	6	0.981	0.977	0.984	0.484
3	4	0.955	0.938	0.956	0.688
3	5	0.990	0.975	0.977	0.695
3	6	0.978	0.996	0.963	0.724
4	5	0.959	0.912	0.973	0.647
4	6	0.972	0.942	0.983	0.658
5	6	0.985	0.973	0.981	0.787
Average		0.977	0.966	0.976	0.631

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short, Seg. 1
1	2	0.974	0.988	0.952
1	3	0.995	0.949	0.955
1	4	0.976	0.916	0.949
1	5	0.959	0.964	0.960
1	6	0.966	0.978	0.930
2	3	0.979	0.954	0.930
2	4	0.956	0.909	0.957
2	5	0.935	0.965	0.960
2	6	0.942	0.968	0.936
3	4	0.975	0.881	0.933
3	5	0.955	0.980	0.949
3	6	0.962	0.935	0.952
4	5	0.970	0.883	0.954
4	6	0.981	0.931	0.956
5	6	0.991	0.947	0.955
Average		0.968	0.943	0.948

Notes:

- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (3-4 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-16, 08:24 – 11:17

Device: SSI CS8800 Walking Profiler

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.941
Long (elev.)	0.972	0.957
Medium (elev.)	0.927	0.949
Short (elev.)	0.852	0.538
Long (slope)	0.990	0.988
Medium (slope)	0.934	0.937
Short (slope)	0.383	0.053

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.12 to –0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:24	08:44	71.52	-7.42	538.4	-0.05
2	08:47	09:09	72.60	-6.02	538.2	-0.08
3	09:10	09:32	73.11	-5.36	538.0	-0.10
4	09:38	09:59	73.29	-5.13	538.3	-0.07
5	10:00	10:23	74.44	-3.64	538.1	-0.12
7	10:57	11:17	75.78	-1.90	538.4	-0.05

Detailed Accuracy Scores:

		Cross Correlation to Benchmark Profile, Slope					
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.914	0.985	0.892	0.056	0.057	0.057	0.057
2	0.933	0.991	0.927	0.060	0.059	0.048	0.059
3	0.938	0.996	0.934	0.055	0.052	0.044	0.044
4	0.943	0.976	0.953	0.055	0.055	0.040	0.055
5	0.955	0.996	0.965	0.051	0.050	0.050	0.050
7	0.962	0.985	0.953	0.064	0.061	0.049	0.049
Ave.	0.941	0.988	0.937	0.057	0.056	0.048	0.052

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.952	0.900	0.533	0.520	0.520	0.520
2	0.963	0.941	0.543	0.524	0.526	0.528
3	0.975	0.952	0.535	0.526	0.527	0.529
4	0.930	0.980	0.534	0.523	0.524	0.519
5	0.980	0.983	0.555	0.548	0.545	0.548
7	0.940	0.940	0.580	0.572	0.572	0.570
Ave.	0.957	0.949	0.547	0.535	0.536	0.536

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	0.978	0.997	0.962	0.335	0.333	0.333	0.333
1	3	0.963	0.991	0.941	0.456	0.455	0.455	0.455
1	4	0.952	0.996	0.914	0.234	0.227	0.174	0.227
1	5	0.933	0.983	0.890	0.323	0.321	0.321	0.321
1	7	0.904	0.997	0.841	0.493	0.497	0.499	0.499
2	3	0.984	0.994	0.980	0.276	0.277	0.277	0.277
2	4	0.977	0.991	0.957	0.603	0.600	0.600	0.600
2	5	0.960	0.988	0.938	0.468	0.464	0.464	0.464
2	7	0.936	0.996	0.893	0.367	0.350	0.351	0.351
3	4	0.984	0.982	0.966	0.258	0.259	0.220	0.259
3	5	0.970	0.994	0.951	0.303	0.322	0.322	0.322
3	7	0.948	0.991	0.908	0.443	0.435	0.435	0.435
4	5	0.980	0.975	0.975	0.410	0.406	0.406	0.406
4	7	0.961	0.994	0.937	0.381	0.386	0.386	0.386
5	7	0.977	0.983	0.957	0.432	0.430	0.430	0.430
Average		0.987	0.990	0.934	0.386	0.384	0.378	0.384

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	0.987	0.955	0.806	0.802	0.802	0.802
1	3	0.970	0.933	0.908	0.904	0.904	0.904
1	4	0.977	0.897	0.803	0.799	0.799	0.799
1	5	0.967	0.881	0.855	0.851	0.851	0.851
1	7	0.986	0.836	0.859	0.858	0.858	0.858
2	3	0.983	0.976	0.807	0.805	0.805	0.805
2	4	0.965	0.943	0.935	0.933	0.933	0.933
2	5	0.980	0.930	0.857	0.855	0.855	0.855
2	7	0.975	0.888	0.837	0.828	0.828	0.828
3	4	0.950	0.955	0.816	0.813	0.813	0.813
3	5	0.992	0.944	0.862	0.859	0.859	0.859
3	7	0.960	0.903	0.855	0.851	0.851	0.851
4	5	0.947	0.978	0.869	0.861	0.861	0.861
4	7	0.987	0.938	0.851	0.845	0.845	0.845
5	7	0.957	0.955	0.907	0.908	0.908	0.908
Average		0.972	0.927	0.855	0.852	0.852	0.852

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values and measurement times extracted from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The crew used a chalk line for lateral reference.
- Computer crashed during run 6. A replacement run was made.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-14, 08:15 – 11:44

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.962
Long (elev.)	0.984	0.939
Medium (elev.)	0.973	0.927
Short (elev.)	0.891	0.753
Long (slope)	0.980	0.958
Medium (slope)	0.967	0.952
Short (slope)	0.385	0.172

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.04 to 0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:15	08:46	76.88	-0.54	1037.6	-0.04
2	08:47	09:24	76.82	-0.62	1038.2	0.02
3	09:28	09:59	76.92	-0.49	1037.7	-0.03
4	10:03	10:36	77.48	0.23	1038.1	0.01
5	10:41	11:13	77.55	0.32	1037.9	-0.01
6	11:19	11:58	78.02	0.93	1038.5	0.05

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.956	0.961	0.946	0.167	0.162	0.162	0.167
2	0.958	0.960	0.952	0.199	0.202	0.202	0.171
3	0.967	0.959	0.962	0.173	0.177	0.177	0.177
4	0.963	0.940	0.957	0.166	0.161	0.161	0.156
5	0.971	0.963	0.961	0.168	0.166	0.166	0.164
6	0.954	0.965	0.935	0.174	0.171	0.171	0.173
Ave.	0.962	0.958	0.952	0.175	0.173	0.173	0.168

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.938	0.933	0.742	0.735	0.735	0.744
2	0.956	0.931	0.758	0.750	0.750	0.759
3	0.935	0.921	0.723	0.718	0.718	0.729
4	0.928	0.928	0.789	0.782	0.782	0.794
5	0.931	0.931	0.755	0.753	0.753	0.762
6	0.945	0.916	0.766	0.759	0.759	0.761
Ave.	0.939	0.927	0.756	0.750	0.750	0.758

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	0.981	0.981	0.978	0.335	0.369	0.369	0.372
1	3	0.984	0.996	0.970	0.523	0.503	0.503	0.507
1	4	0.969	0.975	0.966	0.396	0.386	0.386	0.381
1	5	0.977	0.994	0.965	0.496	0.351	0.479	0.482
1	6	0.962	0.987	0.942	0.362	0.350	0.350	0.350
2	3	0.982	0.981	0.974	0.364	0.340	0.358	0.341
2	4	0.965	0.965	0.968	0.371	0.357	0.357	0.359
2	5	0.975	0.977	0.970	0.338	0.269	0.322	0.268
2	6	0.961	0.972	0.948	0.390	0.378	0.378	0.378
3	4	0.977	0.978	0.981	0.392	0.390	0.390	0.393
3	5	0.987	0.993	0.986	0.570	0.561	0.561	0.564
3	6	0.969	0.984	0.959	0.299	0.284	0.284	0.260
4	5	0.982	0.972	0.979	0.394	0.390	0.390	0.395
4	6	0.970	0.961	0.951	0.381	0.373	0.373	0.372
5	6	0.975	0.990	0.963	0.326	0.321	0.321	0.320
Average		0.975	0.980	0.967	0.396	0.375	0.388	0.383

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	0.973	0.982	0.914	0.913	0.913	0.910
1	3	0.998	0.972	0.929	0.927	0.927	0.930
1	4	0.991	0.978	0.864	0.862	0.862	0.859
1	5	0.995	0.980	0.930	0.930	0.930	0.926
1	6	0.991	0.959	0.889	0.888	0.888	0.890
2	3	0.971	0.972	0.895	0.893	0.893	0.894
2	4	0.965	0.974	0.876	0.873	0.873	0.870
2	5	0.968	0.978	0.913	0.909	0.909	0.908
2	6	0.979	0.959	0.902	0.901	0.901	0.903
3	4	0.994	0.973	0.845	0.842	0.842	0.843
3	5	0.996	0.982	0.915	0.915	0.915	0.914
3	6	0.988	0.975	0.863	0.861	0.861	0.865
4	5	0.990	0.982	0.868	0.865	0.865	0.864
4	6	0.982	0.959	0.896	0.895	0.895	0.889
5	6	0.984	0.969	0.890	0.887	0.887	0.891
Average		0.984	0.973	0.893	0.891	0.891	0.890

Notes:

- Section length is 1038.0 ft, measured by a tensioned nylon-coated 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 (10-13 minutes).
- Typically, 1-4 minutes were spent between runs for processing to report the section length.
- Brent operated for odd numbered runs and Flint operated for even numbered runs.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The temperature was 61-72 F throughout the testing.
- The sky was clear at the start of the testing, but it became cloudy through the middle runs and was sunny and windy at the end of the set.
- The crew changed the laptop battery at 11:17.
- The crew transferred data to a thumb drive at 12:03 and finalized processing inside a vehicle. Provided data at 12:21.
- The crew used a chalk line for lateral reference.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Dense Graded Asphalt

Date: 2013-May-14 (3 runs), 2013-May-16 (3 runs, 12:11 to 14:08)

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.943
Long (elev.)	0.979	0.937
Medium (elev.)	0.963	0.912
Short (elev.)	0.901	0.781
Long (slope)	0.975	0.945
Medium (slope)	0.953	0.933
Short (slope)	0.393	0.178

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from –0.06 to 0.05 percent.

Run Log, DMI Results:

Run	Date	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
2	14-May	08:47	09:24	76.82	-0.62	1038.2	0.02
4	14-May	10:03	10:36	77.48	0.23	1038.1	0.01
6	14-May	11:19	11:58	78.02	0.93	1038.5	0.05
7	16-May	12:11	12:49	79.11	2.34	1037.5	-0.05
8	16-May	12:59	13:29	80.13	3.66	1037.4	-0.06
9	16-May	13:36	14:08	80.00	3.49	1037.4	-0.06

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.958	0.960	0.952	0.199	0.202	0.202	0.171
4	0.963	0.940	0.957	0.166	0.161	0.161	0.156
6	0.954	0.965	0.935	0.174	0.171	0.171	0.173
7	0.938	0.941	0.926	0.186	0.187	0.187	0.189
8	0.925	0.933	0.915	0.172	0.195	0.163	0.171
9	0.923	0.933	0.910	0.179	0.173	0.173	0.186
Ave.	0.943	0.945	0.933	0.179	0.181	0.176	0.174

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	0.956	0.931	0.758	0.750	0.750	0.759
4	0.928	0.928	0.789	0.782	0.782	0.794
6	0.945	0.916	0.766	0.759	0.759	0.761
7	0.941	0.901	0.805	0.802	0.802	0.812
8	0.933	0.896	0.788	0.784	0.784	0.800
9	0.918	0.899	0.787	0.784	0.784	0.796
Ave.	0.937	0.912	0.782	0.777	0.777	0.787

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	4	0.965	0.965	0.968	0.371	0.357	0.357	0.359
2	6	0.961	0.972	0.948	0.390	0.378	0.378	0.378
2	7	0.943	0.968	0.938	0.415	0.409	0.409	0.410
2	8	0.932	0.961	0.930	0.360	0.345	0.341	0.340
2	9	0.934	0.961	0.929	0.435	0.277	0.422	0.420
4	6	0.970	0.961	0.951	0.381	0.373	0.373	0.372
4	7	0.957	0.979	0.945	0.399	0.393	0.393	0.399
4	8	0.945	0.983	0.936	0.426	0.417	0.417	0.406
4	9	0.943	0.983	0.929	0.413	0.400	0.400	0.398
6	7	0.967	0.972	0.973	0.335	0.327	0.327	0.326
6	8	0.957	0.968	0.965	0.303	0.255	0.288	0.286
6	9	0.956	0.967	0.960	0.344	0.336	0.336	0.334
7	8	0.979	0.990	0.979	0.436	0.322	0.421	0.421
7	9	0.979	0.990	0.975	0.614	0.601	0.601	0.599
8	9	0.981	0.997	0.978	0.499	0.411	0.485	0.478
Average		0.958	0.975	0.953	0.408	0.373	0.397	0.395

Run 1	Run 2	Cross Correlation by Waveband, Elevation					
		Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
2	4	0.965	0.974	0.876	0.873	0.873	0.870
2	6	0.979	0.959	0.902	0.901	0.901	0.903
2	7	0.975	0.947	0.882	0.881	0.881	0.878
2	8	0.968	0.943	0.882	0.887	0.887	0.881
2	9	0.955	0.947	0.872	0.878	0.878	0.872
4	6	0.982	0.959	0.896	0.895	0.895	0.889
4	7	0.978	0.952	0.904	0.899	0.899	0.899
4	8	0.985	0.946	0.909	0.903	0.903	0.908
4	9	0.986	0.949	0.904	0.895	0.895	0.899
6	7	0.986	0.974	0.884	0.883	0.884	0.876
6	8	0.992	0.972	0.894	0.899	0.899	0.891
6	9	0.978	0.975	0.884	0.891	0.891	0.883
7	8	0.991	0.986	0.940	0.935	0.935	0.940
7	9	0.978	0.985	0.949	0.943	0.944	0.944
8	9	0.986	0.983	0.952	0.952	0.952	0.947
Average		0.979	0.963	0.902	0.901	0.901	0.899

Notes:

- Section length is 1038.0 ft, measured by a tensioned nylon-coated 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 (10-13 minutes).
- Typically, 1-4 minutes were spent between runs for processing to report the section length.
- Brent operated for all six runs. This series includes three runs from a previous visit, and three subsequent runs by Bryent only.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The crew used a chalk line for lateral reference.
- Scott Zielinski observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Chip Seal

Date: 2013-May-13, 10:47 – 15:42

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.972	0.882
Long (elev.)	0.988	0.911
Medium (elev.)	0.950	0.884
Short (elev.)	0.935	0.766
Long (slope)	0.985	0.909
Medium (slope)	0.966	0.905
Short (slope)	0.726	0.103

Result for Longitudinal Distance: Did not pass.

Error in longitudinal distance ranged from 0.11 to 0.17 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	10:47	10:59	99.18	8.29	502.0	0.15
2	11:02	11:17	100.55	9.78	502.0	0.15
3	11:21	11:36	102.85	12.29	502.1	0.17
4	11:39	11:55	—	—	—	—
5	13:49	14:03	102.53	11.94	502.0	0.15
6	14:07	14:22	100.80	10.06	501.8	0.11
7	14:26	15:42	100.94	10.21	501.9	0.13

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.899	0.914	0.920	0.105	0.107	0.108	0.107
2	0.884	0.908	0.911	0.106	0.108	0.108	0.108
3	0.864	0.899	0.885	0.103	0.106	0.106	0.106
5	0.875	0.900	0.903	0.097	0.100	0.100	0.100
6	0.887	0.926	0.906	0.095	0.097	0.097	0.097
7	0.881	0.904	0.903	0.098	0.099	0.099	0.099
Ave.	0.882	0.909	0.905	0.101	0.103	0.103	0.103

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.907	0.915	0.736	0.737	0.737	0.737
2	0.903	0.900	0.774	0.775	0.775	0.775
3	0.902	0.848	0.781	0.781	0.782	0.782
5	0.911	0.870	0.763	0.766	0.766	0.766
6	0.928	0.892	0.763	0.765	0.765	0.765
7	0.918	0.880	0.771	0.773	0.773	0.773
Ave.	0.911	0.884	0.765	0.766	0.766	0.766

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	0.977	0.993	0.975	0.773	0.773	0.773	0.773
1	3	0.957	0.987	0.946	0.705	0.707	0.707	0.707
1	5	0.957	0.977	0.954	0.742	0.744	0.744	0.744
1	6	0.977	0.987	0.971	0.728	0.730	0.730	0.730
1	7	0.970	0.986	0.964	0.746	0.745	0.745	0.745
2	3	0.969	0.994	0.957	0.680	0.680	0.680	0.680
2	5	0.968	0.987	0.965	0.714	0.720	0.720	0.720
2	6	0.985	0.980	0.979	0.730	0.729	0.729	0.729
2	7	0.980	0.994	0.971	0.760	0.760	0.760	0.760
3	5	0.979	0.990	0.962	0.711	0.713	0.713	0.713
3	6	0.967	0.974	0.958	0.707	0.707	0.707	0.707
3	7	0.972	0.993	0.963	0.735	0.736	0.736	0.736
5	5	0.968	0.965	0.970	0.686	0.691	0.691	0.691
5	6	0.976	0.991	0.977	0.780	0.787	0.787	0.787
6	6	0.979	0.974	0.975	0.680	0.681	0.681	0.681
Average		0.972	0.985	0.966	0.725	0.727	0.727	0.727

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	0.969	0.929	0.928	0.928	0.928
1	3	0.996	0.918	0.889	0.889	0.889	0.889
1	5	0.995	0.930	0.928	0.929	0.929	0.929
1	6	0.980	0.957	0.928	0.928	0.928	0.928
1	7	0.991	0.950	0.923	0.923	0.923	0.923
2	3	0.998	0.930	0.927	0.927	0.927	0.927
2	5	0.995	0.934	0.950	0.950	0.950	0.950
2	6	0.974	0.963	0.956	0.956	0.956	0.956
2	7	0.985	0.953	0.963	0.963	0.963	0.963
3	5	0.996	0.958	0.921	0.921	0.921	0.921
3	6	0.975	0.943	0.922	0.922	0.922	0.922
3	7	0.986	0.949	0.935	0.935	0.935	0.935
5	5	0.976	0.957	0.957	0.957	0.957	0.957
5	6	0.988	0.965	0.952	0.953	0.953	0.953
6	6	0.991	0.971	0.950	0.951	0.951	0.951
Average		0.988	0.950	0.935	0.935	0.935	0.935

Notes:

- Section length is 501.26 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values were reported verbally in the field.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- DMI calibrated just before measuring this section.
- Run 4 eliminated at the operator's request because of the influence of the rain.
- Brent operated for runs 1, 2, 3, and 6 and Flint operated run 5.
- The battery died at the end of run 7, so the return (loop closure) was performed much later.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, first visit

Date: 2013-May-13, 15:38 – 17:56

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.934	0.888
Long (elev.)	0.991	0.966
Medium (elev.)	0.905	0.875
Short (elev.)	0.819	0.556
Long (slope)	0.979	0.946
Medium (slope)	0.912	0.875
Short (slope)	0.250	0.083

Result for Longitudinal Distance: Passed.

Error in longitudinal distance ranged from -0.07 to 0.08 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	15:38	15:54	66.30	9.42	468.1	0.01
2	15:58	16:15	69.32	14.41	468.4	0.08
3	16:24	16:39	64.98	7.25	468.0	-0.01
4	16:42	17:00	66.78	10.22	468.0	-0.01
5	17:22	17:38	64.84	7.01	468.1	0.01
6	17:41	17:55	63.61	4.98	467.7	-0.07

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.876	0.953	0.854	0.085	0.085	0.085	0.085
2	0.838	0.903	0.824	0.082	0.082	0.076	0.076
3	0.903	0.961	0.868	0.090	0.090	0.081	0.081
4	0.882	0.953	0.863	0.078	0.078	0.075	0.075
5	0.901	0.956	0.908	0.101	0.101	0.074	0.101
6	0.928	0.947	0.931	0.079	0.079	0.079	0.079
Ave.	0.888	0.946	0.875	0.086	0.086	0.078	0.083

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.975	0.858	0.564	0.561	0.561	0.561
2	0.946	0.828	0.547	0.546	0.546	0.546
3	0.970	0.868	0.589	0.585	0.585	0.585
4	0.966	0.865	0.551	0.548	0.548	0.548
5	0.982	0.913	0.538	0.536	0.536	0.536
6	0.959	0.921	0.557	0.555	0.555	0.555
Ave.	0.966	0.875	0.558	0.555	0.555	0.555

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	0.926	0.952	0.928	0.236	0.236	0.238	0.238
1	3	0.948	0.991	0.960	0.287	0.287	0.287	0.287
1	4	0.971	0.993	0.960	0.248	0.248	0.248	0.248
1	5	0.948	0.990	0.906	0.275	0.275	0.275	0.275
1	6	0.927	0.993	0.888	0.243	0.243	0.243	0.182
2	3	0.903	0.948	0.922	0.262	0.262	0.168	0.262
2	4	0.929	0.958	0.930	0.192	0.146	0.126	0.126
2	5	0.902	0.943	0.872	0.252	0.252	0.148	0.252
2	6	0.879	0.963	0.847	0.274	0.274	0.274	0.274
3	4	0.949	0.992	0.959	0.407	0.407	0.407	0.407
3	5	0.965	0.993	0.901	0.249	0.249	0.179	0.249
3	6	0.946	0.992	0.884	0.326	0.326	0.265	0.326
4	5	0.942	0.991	0.894	0.201	0.158	0.157	0.201
4	6	0.927	0.995	0.884	0.360	0.360	0.218	0.360
5	6	0.949	0.989	0.940	0.139	0.139	0.123	0.139
Average		0.934	0.979	0.912	0.263	0.257	0.224	0.255

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	0.979	0.914	0.835	0.835	0.835	0.835
1	3	0.997	0.951	0.848	0.846	0.846	0.846
1	4	0.996	0.952	0.841	0.838	0.838	0.838
1	5	0.993	0.903	0.754	0.751	0.776	0.776
1	6	0.992	0.882	0.816	0.815	0.815	0.815
2	3	0.988	0.922	0.840	0.839	0.839	0.839
2	4	0.992	0.919	0.799	0.796	0.796	0.796
2	5	0.973	0.863	0.778	0.775	0.776	0.775
2	6	0.995	0.830	0.815	0.814	0.814	0.814
3	4	0.998	0.956	0.836	0.834	0.834	0.834
3	5	0.993	0.897	0.784	0.782	0.782	0.782
3	6	0.997	0.874	0.836	0.833	0.833	0.833
4	5	0.990	0.891	0.802	0.801	0.801	0.801
4	6	0.998	0.880	0.885	0.885	0.885	0.885
5	6	0.984	0.937	0.818	0.819	0.819	0.819
Average		0.991	0.905	0.819	0.818	0.819	0.819

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Flint operated the device in runs 1-5 and Brent operated the device in run 6.
- A run was attempted and aborted before run 1.
- A run was attempted and aborted between runs 4 and 5.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Conventional Diamond Grinding, second visit

Date: 2013-May-14, 17:12 – 19:23

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.889	0.829
Long (elev.)	0.968	0.961
Medium (elev.)	0.816	0.794
Short (elev.)	0.688	0.545
Long (slope)	0.976	0.950
Medium (slope)	0.831	0.781
Short (slope)	0.267	0.081

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	17:12	17:30	73.15	20.73	468.1	0.01
2	17:36	17:54	71.47	17.96	468.2	0.03
3	18:00	18:17	68.19	12.54	468.2	0.03
4	18:22	18:39	68.70	13.39	468.2	0.03
5	18:42	19:00	67.13	10.79	468.0	-0.01
6	19:06	19:23	66.12	9.13	468.0	-0.01

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.795	0.939	0.732	0.084	0.084	0.111	0.111
2	0.815	0.965	0.753	0.091	0.091	0.082	0.082
3	0.854	0.966	0.804	0.086	0.086	0.066	0.066
4	0.860	0.962	0.810	0.085	0.085	0.069	0.070
5	0.876	0.957	0.844	0.083	0.083	0.083	0.083
6	0.771	0.913	0.745	0.068	0.068	0.068	0.068
Ave.	0.829	0.950	0.781	0.083	0.083	0.080	0.080

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.955	0.744	0.608	0.606	0.606	0.606
2	0.992	0.759	0.604	0.602	0.602	0.602
3	0.980	0.815	0.574	0.569	0.569	0.569
4	0.966	0.816	0.569	0.565	0.565	0.565
5	0.978	0.854	0.574	0.570	0.570	0.570
6	0.898	0.779	0.352	0.351	0.351	0.351
Ave.	0.961	0.794	0.547	0.544	0.544	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
1	2	0.954	0.977	0.946	0.335	0.335	0.335	0.335
1	3	0.918	0.980	0.890	0.374	0.375	0.374	0.374
1	4	0.911	0.985	0.890	0.278	0.277	0.278	0.278
1	5	0.886	0.988	0.837	0.245	0.245	0.245	0.245
1	6	0.757	0.960	0.627	0.245	0.245	0.245	0.245
2	3	0.938	0.996	0.909	0.297	0.297	0.297	0.297
2	4	0.933	0.994	0.912	0.421	0.421	0.421	0.421
2	5	0.910	0.992	0.864	0.240	0.240	0.240	0.240
2	6	0.774	0.943	0.643	0.173	0.173	0.173	0.173
3	4	0.979	0.996	0.979	0.292	0.292	0.292	0.292
3	5	0.954	0.995	0.924	0.349	0.349	0.349	0.349
3	6	0.809	0.943	0.686	0.209	0.209	0.209	0.209
4	5	0.965	0.996	0.935	0.203	0.203	0.203	0.203
4	6	0.813	0.950	0.693	0.153	0.152	0.153	0.153
5	6	0.833	0.954	0.728	0.192	0.192	0.192	0.192
Average		0.889	0.976	0.831	0.267	0.267	0.267	0.267

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	0.970	0.953	0.859	0.860	0.860	0.860
1	3	0.984	0.885	0.831	0.832	0.832	0.832
1	4	0.997	0.898	0.806	0.808	0.808	0.808
1	5	0.985	0.833	0.802	0.803	0.803	0.803
1	6	0.946	0.586	0.408	0.408	0.406	0.406
2	3	0.995	0.901	0.821	0.820	0.820	0.820
2	4	0.981	0.914	0.834	0.835	0.835	0.835
2	5	0.993	0.858	0.811	0.810	0.810	0.810
2	6	0.908	0.603	0.409	0.410	0.410	0.410
3	4	0.993	0.972	0.830	0.832	0.832	0.832
3	5	0.999	0.919	0.833	0.833	0.833	0.833
3	6	0.920	0.642	0.420	0.421	0.421	0.421
4	5	0.994	0.926	0.830	0.831	0.831	0.831
4	6	0.939	0.650	0.420	0.419	0.419	0.419
5	6	0.923	0.693	0.403	0.403	0.404	0.404
Average		0.968	0.816	0.688	0.688	0.688	0.688

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- This was a return visit to the section requested because of excessive wind during the previous visit.
- Section length is 468.04 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (7-8 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- Temperatures in the 90s and winds up to 20 mph.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing in runs 3-6 and Bob Orthmeyer observed the testing in runs 1 and 2.

Benchmark Test Evaluation Report

Test Section: MnROAD, Longitudinal Tining

Date: 2013-May-14, 13:54 – 15:48

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.989	0.940
Long (elev.)	0.965	0.963
Medium (elev.)	0.983	0.936
Short (elev.)	0.987	0.889
Long (slope)	0.974	0.970
Medium (slope)	0.988	0.934
Short (slope)	0.837	0.346

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	13:54	14:09	94.54	-3.05	453.4	-0.03
2	14:12	14:28	95.25	-2.32	453.3	-0.05
3	14:33	14:48	96.18	-1.36	453.3	-0.05
4	14:53	15:09	95.68	-1.88	453.3	-0.05
5	15:14	15:30	94.31	-3.28	453.3	-0.05
6	15:39	15:54	95.31	-2.26	453.2	-0.07

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.940	0.967	0.939	0.340	0.340	0.340	0.340
2	0.939	0.982	0.931	0.349	0.349	0.349	0.349
3	0.943	0.948	0.933	0.346	0.346	0.346	0.346
4	0.944	0.965	0.935	0.354	0.354	0.354	0.354
5	0.932	0.973	0.928	0.345	0.345	0.345	0.350
6	0.944	0.985	0.942	0.337	0.337	0.342	0.342
Ave.	0.940	0.970	0.934	0.345	0.345	0.346	0.347

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.952	0.946	0.883	0.883	0.883	0.883
2	0.962	0.930	0.884	0.887	0.887	0.887
3	0.941	0.934	0.888	0.888	0.888	0.888
4	0.962	0.934	0.897	0.897	0.897	0.897
5	0.974	0.930	0.887	0.890	0.890	0.890
6	0.984	0.945	0.887	0.890	0.890	0.890
Ave.	0.963	0.936	0.888	0.889	0.889	0.889

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	0.987	0.991	0.864	0.863	0.864	0.864
1	3	0.989	0.963	0.994	0.853	0.854	0.853	0.853
1	4	0.989	0.972	0.992	0.813	0.814	0.813	0.813
1	5	0.989	0.976	0.987	0.866	0.866	0.866	0.866
1	6	0.987	0.987	0.987	0.828	0.828	0.828	0.828
2	3	0.992	0.962	0.990	0.857	0.857	0.857	0.857
2	4	0.992	0.974	0.993	0.789	0.789	0.789	0.789
2	5	0.987	0.982	0.992	0.858	0.858	0.858	0.858
2	6	0.991	0.996	0.983	0.832	0.832	0.832	0.832
3	4	0.994	0.986	0.991	0.865	0.864	0.865	0.865
3	5	0.984	0.949	0.986	0.817	0.817	0.816	0.816
3	6	0.993	0.960	0.987	0.824	0.824	0.824	0.824
4	5	0.984	0.960	0.988	0.834	0.834	0.834	0.834
4	6	0.993	0.975	0.984	0.843	0.843	0.843	0.843
5	6	0.984	0.983	0.980	0.809	0.809	0.809	0.809
Average		0.989	0.974	0.988	0.837	0.837	0.837	0.837

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	0.979	0.980	0.986	0.986	0.986	0.986
1	3	0.934	0.990	0.981	0.981	0.981	0.981
1	4	0.944	0.982	0.977	0.977	0.977	0.977
1	5	0.990	0.976	0.981	0.981	0.981	0.981
1	6	0.973	0.989	0.983	0.983	0.983	0.983
2	3	0.933	0.981	0.990	0.990	0.990	0.990
2	4	0.946	0.992	0.983	0.983	0.983	0.983
2	5	0.986	0.989	0.989	0.989	0.989	0.989
2	6	0.976	0.977	0.991	0.991	0.991	0.991
3	4	0.986	0.982	0.989	0.989	0.989	0.989
3	5	0.947	0.976	0.991	0.991	0.991	0.991
3	6	0.957	0.986	0.992	0.992	0.992	0.992
4	5	0.958	0.986	0.988	0.988	0.988	0.988
4	6	0.973	0.978	0.986	0.986	0.986	0.986
5	6	0.986	0.973	0.992	0.992	0.992	0.992
Average		0.965	0.983	0.987	0.987	0.987	0.987

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores may have been affected by slab curling because of changing conditions during the measurement series.
- Section length is 453.53 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (5-6 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- At the start of the visit to this section, the temperature was 84 F and it was windy. At the end, the temperature was 92 F and it was still.
- The crew used a chalk line for lateral reference.
- Bob Orthmeyer observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Pervious Hot Mix Asphalt

Date: 2013-May-13, 09:18 – 10:22

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman and Flint Hixon

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.980	0.942
Long (elev.)	0.958	0.852
Medium (elev.)	0.944	0.848
Short (elev.)	0.958	0.827
Long (slope)	0.988	0.948
Medium (slope)	0.970	0.910
Short (slope)	0.690	0.111

Result for Longitudinal Distance: Passed.

Error in longitudinal distance was 0.06 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	09:18	09:27	134.51	3.16	186.1	0.06
2	09:30	09:38	135.17	3.67	186.1	0.06
3	09:40	09:47	133.35	2.27	186.1	0.06
4	09:54	10:01	136.85	4.95	186.1	0.06
5	10:03	10:11	136.93	5.02	186.1	0.06
6	10:13	10:22	135.08	3.60	186.1	0.06

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope			
Run	IRI	Long	Medium	Short
1	0.944	0.944	0.909	0.099
2	0.941	0.939	0.920	0.118
3	0.958	0.968	0.931	0.114
4	0.938	0.934	0.904	0.113
5	0.925	0.939	0.892	0.114
6	0.944	0.965	0.905	0.109
Ave.	0.942	0.948	0.910	0.111

	Cross Correlation to Benchmark Profile, Elevation		
Run	Long	Medium	Short
1	0.823	0.816	0.813
2	0.813	0.881	0.835
3	0.872	0.889	0.809
4	0.865	0.837	0.837
5	0.845	0.834	0.833
6	0.896	0.831	0.837
Ave.	0.852	0.848	0.827

Detailed Repeatability Scores:

		Cross Correlation by Waveband, Slope			
Run 1	Run 2	IRI	Long	Medium	Short, Seg. 1
1	2	0.991	0.984	0.981	0.565
1	3	0.981	0.991	0.970	0.667
1	4	0.979	0.945	0.978	0.676
1	5	0.975	0.968	0.989	0.669
1	6	0.988	0.995	0.988	0.689
2	3	0.976	0.977	0.958	0.482
2	4	0.984	0.960	0.986	0.517
2	5	0.975	0.951	0.974	0.510
2	6	0.991	0.977	0.984	0.484
3	4	0.969	0.938	0.956	0.688
3	5	0.960	0.975	0.977	0.695
3	6	0.973	0.996	0.963	0.724
4	5	0.985	0.912	0.973	0.647
4	6	0.989	0.942	0.983	0.658
5	6	0.981	0.973	0.981	0.787
Average		0.980	0.988	0.970	0.690

		Cross Correlation by Waveband, Elevation		
Run 1	Run 2	Long	Medium	Short, Seg. 1
1	2	0.980	0.910	0.942
1	3	0.964	0.911	0.970
1	4	0.945	0.972	0.949
1	5	0.970	0.959	0.966
1	6	0.930	0.972	0.960
2	3	0.946	0.975	0.934
2	4	0.924	0.918	0.961
2	5	0.949	0.922	0.961
2	6	0.911	0.920	0.965
3	4	0.978	0.925	0.939
3	5	0.990	0.932	0.958
3	6	0.966	0.924	0.947
4	5	0.978	0.961	0.966
4	6	0.977	0.986	0.976
5	6	0.957	0.973	0.978
Average		0.958	0.944	0.958

Notes:

- Section length is 185.98 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All times include measurement in the upstream direction for loop closure (3-4 minutes).
- All length values reported verbally in the field.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- Brent operated the device in all runs.
- The crew used a chalk line for lateral reference.
- Rohan Perera observed the testing.

Benchmark Test Evaluation Report

Test Section: MnROAD, Transverse Tining

Date: 2013-May-16, 08:48 – 10:57

Device: SSI CS8800 Walking Profiler, Experimental Config.

Operator(s): SSI, Brent Bergman

Recording Interval: 1 inch

Use Moving Average: Yes

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	0.959	0.942
Long (elev.)	0.961	0.893
Medium (elev.)	0.921	0.920
Short (elev.)	0.883	0.634
Long (slope)	0.981	0.932
Medium (slope)	0.927	0.928
Short (slope)	0.434	0.051

Result for Longitudinal Distance:

Error in longitudinal distance ranged from -0.12 to –0.05 percent.

Run Log, DMI Results:

Run	Start Time	End Time	IRI (in/mi)	Percent Error	Length (ft)	Percent Error
1	08:24	08:44	77.59	0.44	538.4	-0.05
2	08:47	09:09	78.27	1.32	538.2	-0.08
3	09:10	09:32	78.71	1.89	538.0	-0.10
4	09:38	09:59	80.02	3.59	538.3	-0.07
5	10:00	10:23	81.04	4.91	538.1	-0.12
7	10:57	11:17	81.86	5.97	538.4	-0.05

Detailed Accuracy Scores:

	Cross Correlation to Benchmark Profile, Slope						
Run	IRI	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.963	0.929	0.954	0.059	0.058	0.058	0.058
2	0.967	0.926	0.973	0.060	0.060	0.049	0.049
3	0.948	0.922	0.944	0.051	0.049	0.041	0.049
4	0.942	0.924	0.925	0.046	0.046	0.046	0.046
5	0.925	0.963	0.901	0.051	0.051	0.050	0.051
7	0.908	0.929	0.872	0.047	0.046	0.046	0.045
Ave.	0.942	0.932	0.928	0.052	0.052	0.049	0.050

	Cross Correlation to Benchmark Profile, Elevation					
Run	Long	Medium	Short, Seg. 1	Short, Seg. 2	Short, Seg. 3	Short, Seg. 4
1	0.887	0.955	0.617	0.603	0.604	0.605
2	0.885	0.970	0.618	0.610	0.611	0.608
3	0.887	0.932	0.647	0.633	0.633	0.633
4	0.863	0.915	0.641	0.631	0.632	0.627
5	0.954	0.887	0.658	0.645	0.645	0.645
7	0.880	0.864	0.674	0.662	0.662	0.662
Ave.	0.893	0.920	0.643	0.631	0.631	0.630

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	0.990	0.995	0.968	0.383	0.384	0.384	0.384
1	3	0.966	0.992	0.933	0.498	0.497	0.497	0.497
1	4	0.952	0.992	0.903	0.297	0.292	0.229	0.292
1	5	0.933	0.962	0.877	0.368	0.367	0.368	0.368
1	7	0.909	0.994	0.838	0.530	0.532	0.537	0.537
2	3	0.974	0.994	0.961	0.355	0.355	0.355	0.355
2	4	0.963	0.993	0.937	0.615	0.620	0.620	0.620
2	5	0.947	0.960	0.910	0.506	0.505	0.505	0.505
2	7	0.927	0.993	0.877	0.414	0.418	0.418	0.418
3	4	0.981	0.995	0.967	0.332	0.335	0.335	0.335
3	5	0.967	0.953	0.943	0.360	0.355	0.355	0.355
3	7	0.949	0.986	0.912	0.496	0.490	0.490	0.490
4	5	0.980	0.953	0.967	0.453	0.450	0.450	0.450
4	7	0.965	0.985	0.940	0.432	0.438	0.438	0.438
5	7	0.981	0.965	0.966	0.481	0.478	0.478	0.478
Average		0.959	0.981	0.927	0.435	0.434	0.431	0.435

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	0.992	0.973	0.914	0.913	0.913	0.913
1	3	0.992	0.929	0.895	0.896	0.896	0.896
1	4	0.968	0.899	0.870	0.865	0.865	0.865
1	5	0.925	0.875	0.850	0.847	0.847	0.847
1	7	0.994	0.839	0.846	0.843	0.843	0.843
2	3	0.988	0.949	0.878	0.880	0.880	0.880
2	4	0.962	0.925	0.908	0.908	0.908	0.908
2	5	0.929	0.894	0.860	0.860	0.860	0.860
2	7	0.995	0.866	0.830	0.828	0.828	0.828
3	4	0.970	0.966	0.912	0.912	0.913	0.913
3	5	0.922	0.938	0.908	0.904	0.904	0.904
3	7	0.987	0.911	0.897	0.891	0.891	0.891
4	5	0.898	0.960	0.895	0.893	0.893	0.893
4	7	0.965	0.934	0.878	0.875	0.875	0.875
5	7	0.924	0.966	0.923	0.921	0.921	0.921
Average		0.961	0.921	0.884	0.882	0.882	0.882

Notes:

- Accuracy scores were affected by slab curling because the benchmark profiles and reference profiles were made during different weather conditions.
- Repeatability scores were affected by slab curling because of changing conditions during the measurement series.
- Section length is 538.68 ft, measured by a tensioned nylon-coated steel tape and corrected for temperature.
- All length values and measurement times extracted from data files.
- Each cross correlation value was derived using the optimal offset and DMI correction for that comparison.
- The crew used a chalk line for lateral reference.
- Computer crashed during run 6. A replacement run was made.
- Scott Zielinski observed the testing.