Texas A&M Transportation Institute
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135
979-317-2315
http://tti.tamu.edu

TECHNICAL MEMORANDUM

Task 4 Report: Investigation of Ride Quality Measurement Errors under Stop & Go Driving Conditions (Revision #1)

DATE: February 4, 2020

TO: Jenny Li, P.E., Ph.D., Texas Department of Transportation (TxDOT)
Todd Copenhaver, TxDOT

COPY TO: Erlinda Olivarez, Research Development Office, Texas A&M Trans. Inst. (TTI)

FROM: Emmanuel Fernando, TTI

FOR MORE INFORMATION:

Name: Emmanuel Fernando
Phone: (979) 317-2310
Email: e-fernando@tti.tamu.edu

TASK REPORT DISCLAIMER:

INTRODUCTION

The Texas Department of Transportation uses inertial profilers to monitor ride quality over the state highway network. These devices use accelerometers to establish an inertial reference for profile measurements. Accelerometers by design work best when used under constant speed driving conditions. While gradual changes in test speed do not significantly influence the profile measurements, sudden acceleration or deceleration, and in particular, stop and go driving in urban environments will affect the measured profiles and the resulting ride quality statistics computed from these measurements. Consequently, it becomes necessary to assess the effect of stop and go driving conditions on ride quality data collected in urban environments.

Since contractors and service providers are required to submit profile measurements in TxDOT's PRO format, engineers can use the GPS data in the PRO file to determine the route and the test speeds at which the operator collected profile data. Given the findings from these inspections of data quality, decisions can be made on the need for re-testing certain segments, or for flagging ride quality statistics computed from suspect measurements in pavement condition reports. In years past, TxDOT collected network wide ride quality data in-house, using its own staff and profiling equipment. With the transition to using the services of automated pavement condition data collection providers, the makes and models of inertial profiling systems used on TxDOT's network level surveys could vary from one contract to the next.

The effect of stop and go driving on inertial profile measurements is not considered in Tex-1001-S or AASHTO R 56, which test profilers based on data collected under operating conditions consistent with their design. Nor is this effect considered in the specifications used by TxDOT for automated pavement distress data collection contracts. Understanding the effect of stop and go driving is important to identify measures for minimizing errors in ride quality measurements collected in stop and go driving environments. In addition, new applicable technology for collecting ride quality data under these conditions should be investigated.

TASK SCOPE

This task conducted a preliminary investigation of ride quality measurement errors under stop and go driving conditions. To accomplish this investigation, TTI collected data with three profiling systems, and compared the differences between international roughness indices (IRIs) determined from test profiles collected under normal (constant speed) operating conditions versus stop and go driving. Two of the systems tested are commercially available and are among the makes and models used by contractors for ride quality assurance testing on TxDOT projects. Both systems have passed Tex-1001-S equipment certification in Texas.

For reporting purposes, the two commercially available inertial profilers are generically referred to as System A and System B in this report. System A has Gocator line lasers while System B has Selcom wide spot lasers. The third system, referred to herein as System C, is a test version of a profiler that is specifically designed to accommodate stop and go driving conditions. System C was not yet commercially available at the time of this evaluation, but a developmental version was loaned out by the manufacturer. To permit direct comparisons with a conventional inertial profiler, TTI installed System A and System C on one of its test vehicles for the purpose of data collection. System C has auxiliary sensors used with the system software to correct profile measurement errors under stop and go driving based on a proprietary algorithm developed by the equipment manufacturer. For data collection, separate distance encoders were used for System A and System C on the test vehicle. Note that System C has additional sensors not found on the conventional System A and System B inertial profilers. System B was installed on a separate test vehicle.

IRI COMPARISONS ON IN-SERVICE PAVEMENT SECTIONS

To compare the different profiling systems, TTI established a test route consisting of the north and south bound outside lanes of SH 47 where test data from the three systems were collected under the normal (constant speed) operating condition, and under stop and go driving. For each system, three runs were made at constant speed, followed by another set of three runs where the operator stopped at designated locations along the route. Table 1 identifies these stopping locations. Note that SH 47 is a four-lane divided highway with no traffic lights or stop signs along both directions. SH 47 presented a good test route for this evaluation since it covered sections classifying as smooth, medium smooth, and medium rough, and had an inside lane in each direction that allowed motorists to pass the test vehicle. To further minimize traffic disruptions, testing was conducted at night. The stop and go runs simulated driving conditions in an urban area with stop signs and/or traffic lights at intersections.

Table 1. Designated Stopping Locations along SH 47.

No.	North Bound (NB) Outside Lane	No.	South Bound (SB) Outside Lane
1	Yellow sign for merging traffic	1	Street sign for Goodson Bend road
2	SH 47 highway sign just south of Turkey Creek bridge	2	South end of Thompson Creek bridge at concrete barrier
3	Start of bridge over Villa Maria	3	Cross-over at Ford Ranch
4	“Intersection Ahead” yellow sign	4	Silver Hill road junction
5	Brazos County Expo sign just south of Leonard road	5	Cross-over south of Silver Hill road
6	“Left Lane for Passing Only” sign north of Leonard road	6	Brazos County Expo sign north of Leonard road
7	“Do Not Enter” sign at cross-over	7	75 mph speed limit sign at Leonard road junction
8	“Do Not Enter” sign south of Silver Hill road	8	Cross-over north of Villa Maria exit
9	“End Road Work” sign just north of Silver Hill road	9	SH 47 highway sign north of Villa Maria/Jones exit
10	“Bridge May Ice in Cold Weather” sign south of Thompson Creek bridge	10	“Bridge May Ice in Cold Weather” sign north of Villa Maria bridge
		11	FM 60 West/HSC Parkway exit sign
		12	17’6” vertical clearance sign north of HSC overpass

Figure 1 and Figure 2 show, respectively, the stopping locations along the north and south bound outside lanes of the test route. These figures show Google Earth maps drawn from the GPS data included in the PRO files from System A. The maps are color coded according to test speed. The red areas identify the stopping locations. Altogether, there are 22 stops in each loop, 10 going north bound and 12 going south bound. Table 2 and Table 3 identify the limits of the deceleration and acceleration zones at each designated stopping location on the north and south bound outside lanes, respectively. In this report, the deceleration zone is defined as the interval within which the test speed diminished from 30 to 0 mph. Conversely, the acceleration zone is the interval within which the test speed increased from 0 to 30 mph. Thus, the stopping location is the end point of the deceleration zone or the start point of the acceleration zone in Table 2 and Table 3. The zone limits were established from the GPS data and are referred to the start tape used to auto-trigger the profile measurements on each test lane.

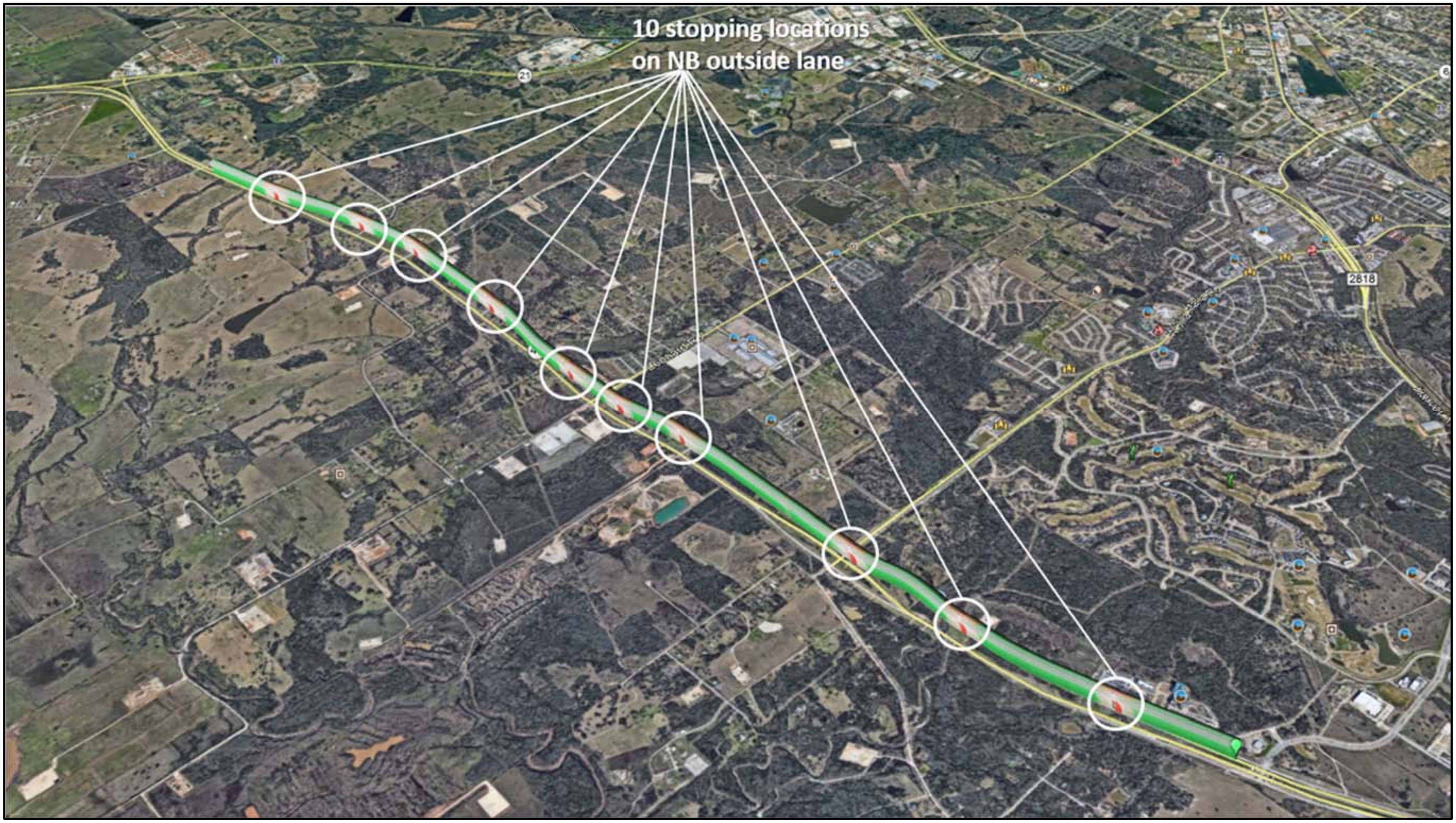

Figure 1. Google Earth Map showing Stopping Locations along North Bound Outside Lane of SH 47.

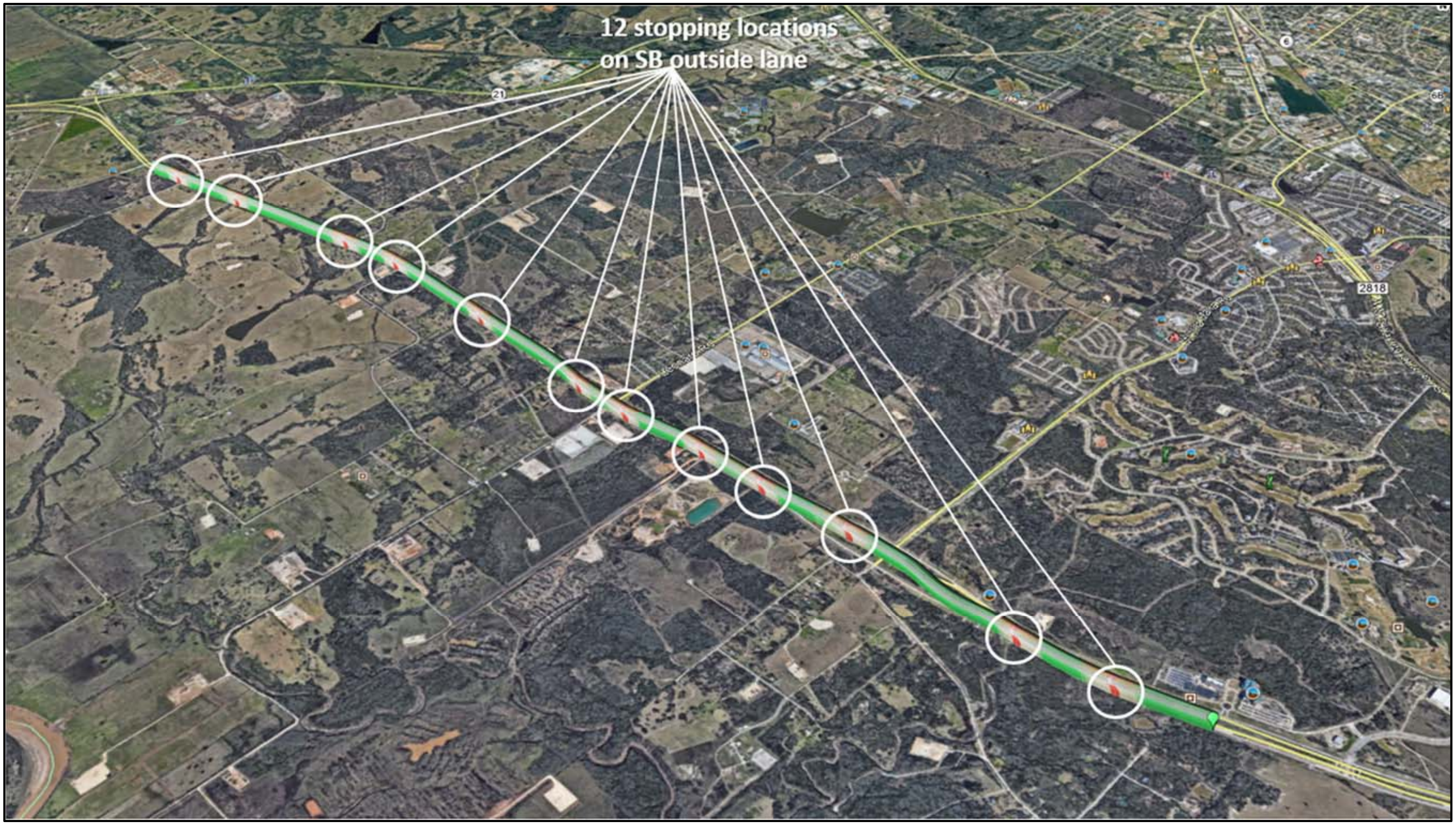

Figure 2. Google Earth Map showing Stopping Locations along South Bound Outside Lane of SH 47.

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Table 2. Limits of Deceleration and Acceleration Zones along SH 47 NB Outside Lane*.

Deceleration limits (ft)		Deceleration distance (ft)	Acceleration limits (ft)		Acceleration distance (ft)
Begin	End		Begin	End	
1556	1777	221	1777	2082	305
4199	4539	340	4539	4855	316
6588	6846	258	6846	7211	365
10,582	11,108	526	11,108	11,460	352
12,289	12,582	293	12,582	13,069	487
13,532	14,029	497	14,029	14,401	372
16,426	16,847	421	16,847	17,307	460
19,187	19,503	316	19,503	19,946	443
20,886	21,188	302	21,188	21,535	347
23,367	23,748	381	23,748	24,081	333
Average (ft)		356			379
Minimum (ft)		221			305
Maximum (ft)		526			487

* Based on System A GPS data.

Table 3. Limits of Deceleration and Acceleration Zones along SH 47 SB Outside Lane*.

Deceleration limits (ft)		Deceleration distance (ft)	Acceleration limits (ft)		Acceleration distance (ft)
Begin	End		Begin	End	
465	774	309	774	1182	408
2326	2596	270	2596	2976	380
5499	5870	371	5870	6279	409
6926	7292	366	7292	7656	364
9572	10,005	433	10,005	10,341	336
12,774	13,001	227	13,001	13,358	357
13,966	14,271	305	14,271	14,581	310
15,674	16,011	337	16,011	16,360	349
17,083	17,421	338	17,421	17,758	337
18,975	19,229	254	19,229	19,555	326
22,249	22,564	315	22,564	22,995	431
23,855	24,213	358	24,213	24,569	356
Average (ft)		324			364
Minimum (ft)		227			310
Maximum (ft)		433			431

* Based on System A GPS data.

Using the test profiles, the author computed the IRIs at 0.1-mile intervals from each run, consistent with the current practice for evaluating ride quality in TxDOT network and project level applications. For the initial assessment, this report compares the 0.1-mile section IRIs from System A and System C as determined from profiles collected along SH 47 under the normal (constant speed) operating condition. Herein, the section IRI is the average of the left and right wheel path IRIs for the given 0.1-mile section. Note that the data from constant speed runs are consistent with the way conventional inertial profilers are to be used in practice. Since System A and System C were installed on the same vehicle, the effects of wheel path variability are minimized given that the lasers were set to track the same wheel paths.

Figure 3 and Figure 4 compare the average section IRIs between System A and System C as determined using profiles collected from constant speed runs along SH 47. It is observed that the two systems give very comparable section IRIs under the constant speed operating condition. Along the north bound outside lane, the average of the IRI differences between System A and System C is 0.24 in/mile, while on the south bound outside lane, the average IRI difference is 0.10 in/mile. A two-tailed paired *t*-test of the differences between section IRIs on each lane resulted in *p*-values of 0.200 and 0.614, respectively, on the north and south bound test lanes, indicating that the IRIs from both systems are not significantly different at $\alpha = 0.05$. This finding suggests that System C can function like a conventional inertial profiler when operated at constant speed.

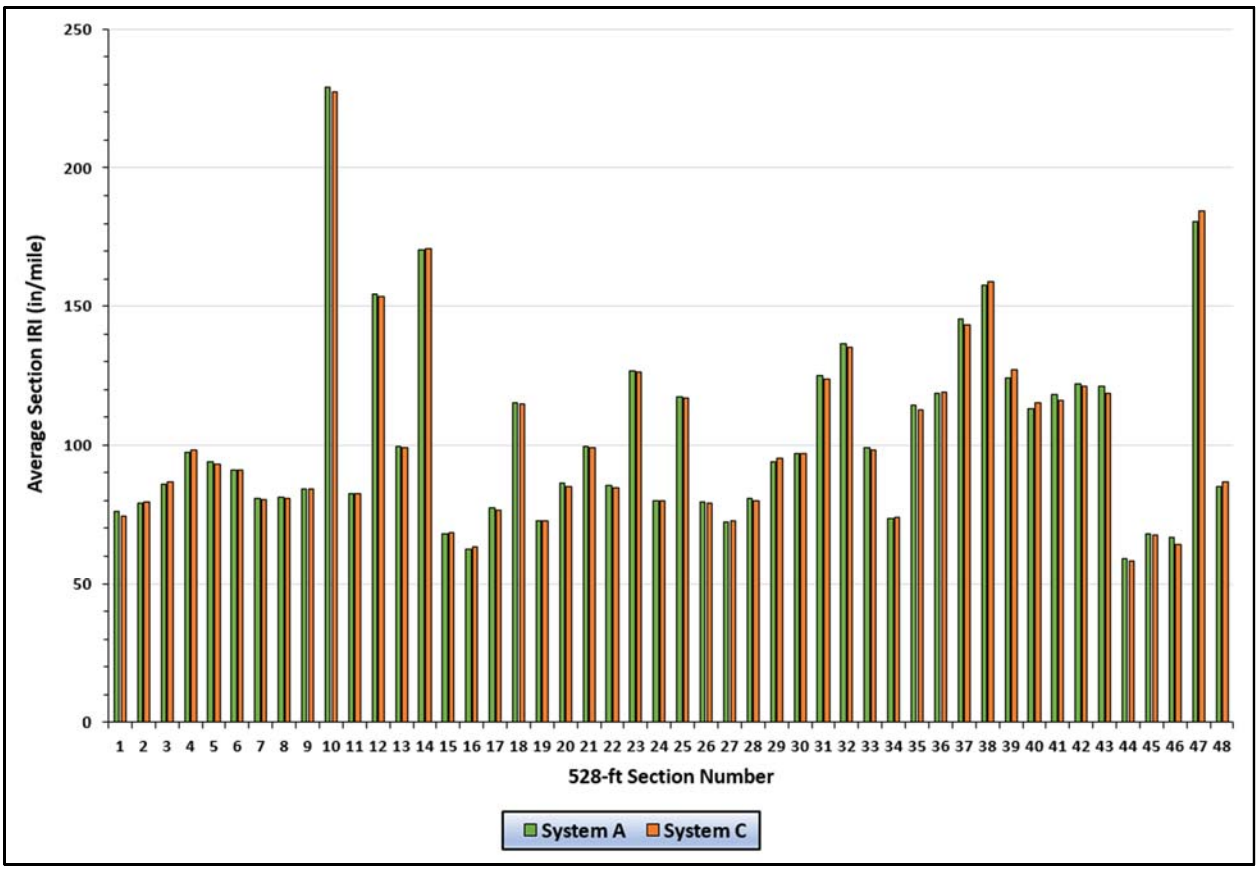

Figure 3. System A vs. System C Section IRIs from Constant Speed Runs (SH 47 NB).

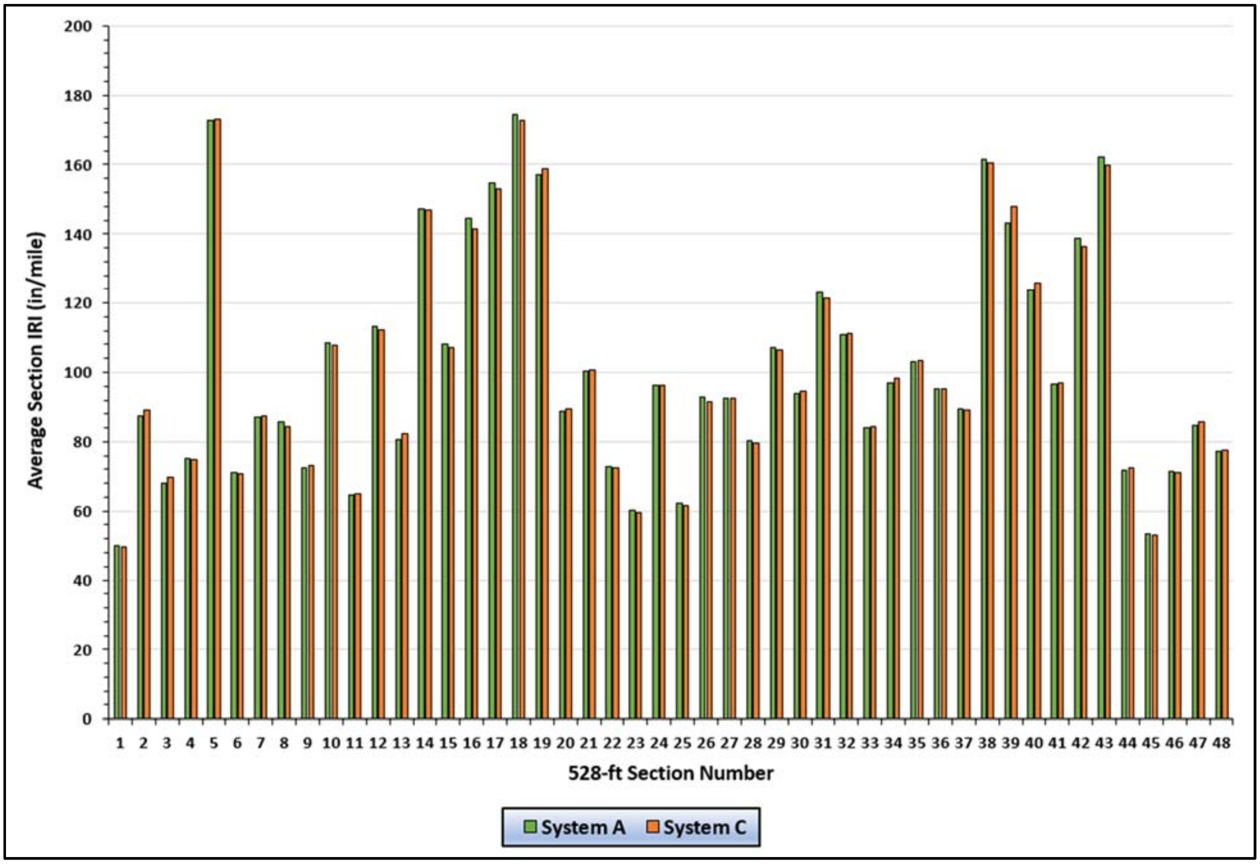

Figure 4. System A vs. System C Section IRIs from Constant Speed Runs (SH 47 SB).

The next assessment compares the section IRIs from System A and System C under stop and go driving. In this regard, stop and go effects are evaluated as follows:

1. Compare constant speed with stop and go section IRIs from System A using data from non-concurrent test runs.
2. Compare System A and System C based on section IRIs determined from stop and go data from concurrent test runs.

Figure 5 and Figure 6 compare the IRIs between constant speed and stop and go runs made with System A. The effect of stop and go driving on the IRIs determined from System A profiles is highly significant. On sections where the test vehicle stopped, the IRIs are significantly much higher compared to the IRIs determined when System A is operated consistent with its design.

In practice, the results shown in Figure 5 and Figure 6 strongly suggest using police escorts to stop traffic at intersections and collecting data during off-peak traffic hours. The significantly high IRI errors stem from artificial bumps and dips induced by profile measurement errors caused by stopping. Figure 7 shows an example from test data collected at the first stopping point along the SH 47 north bound outside lane. From Table 2, this location is 1777 ft from the start of the test run on this lane (within the 4th 0.1-mile section).

The artificial bumps and dips in the wheel path profiles generate an average section IRI of about 805 in/mile compared to the IRI of about 98 in/mile using the wheel path profiles from the constant speed runs. Depending on the locations of these artificial bumps and dips, profile measurement errors can spill over into the adjacent sections. Note from Figure 7 that the length of the profile distortion spans from about 1600 to 2050 ft. In this case, the distortion ends just before the start of section 5 (at 2112 ft).

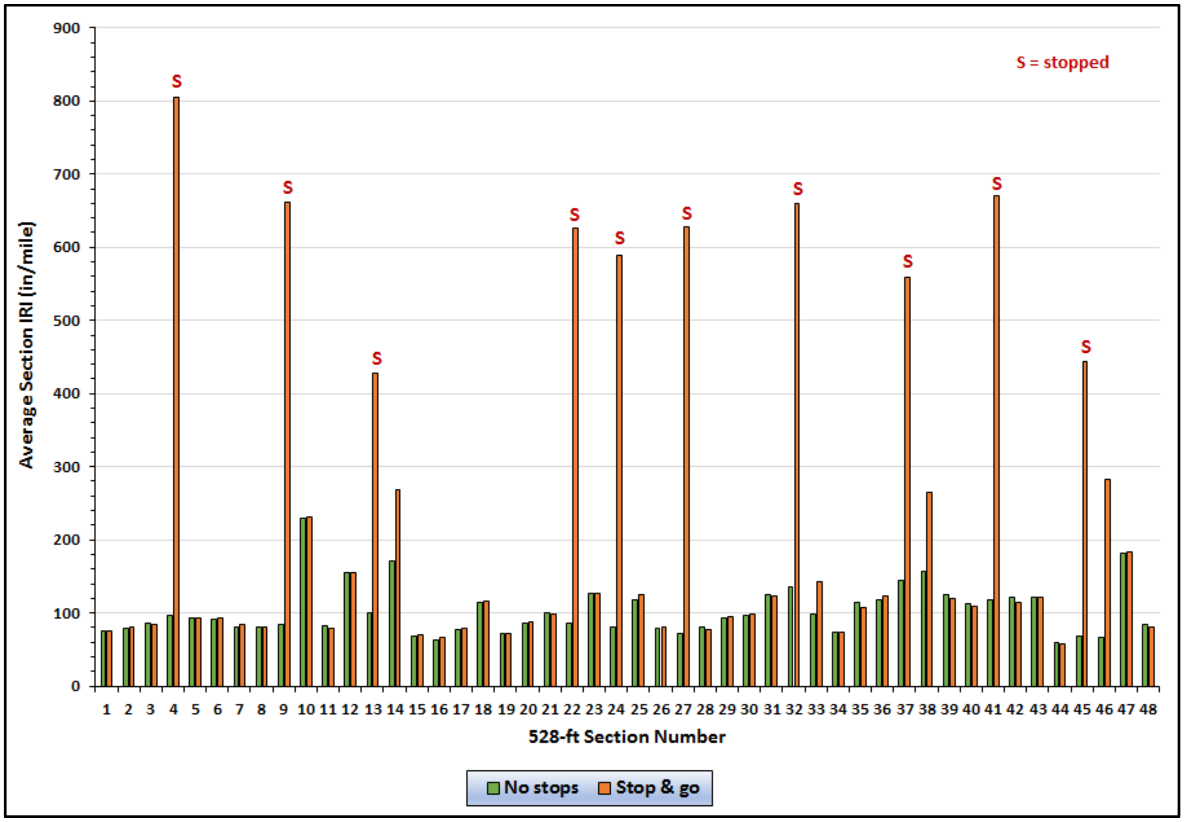

Figure 5. Comparison of Section IRIs from System A Test Profiles on SH 47 NB runs.

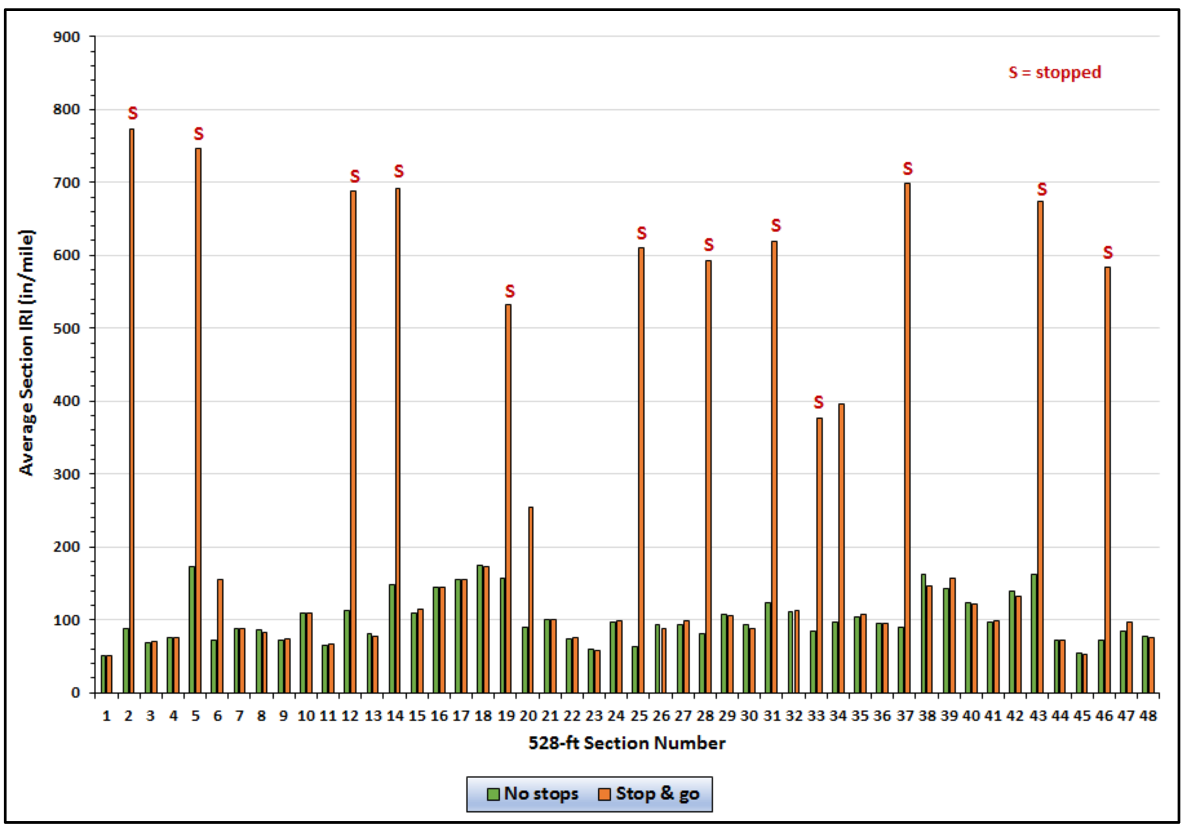

Figure 6. Comparison of Section IRIs from System A Test Profiles on SH 47 SB runs.

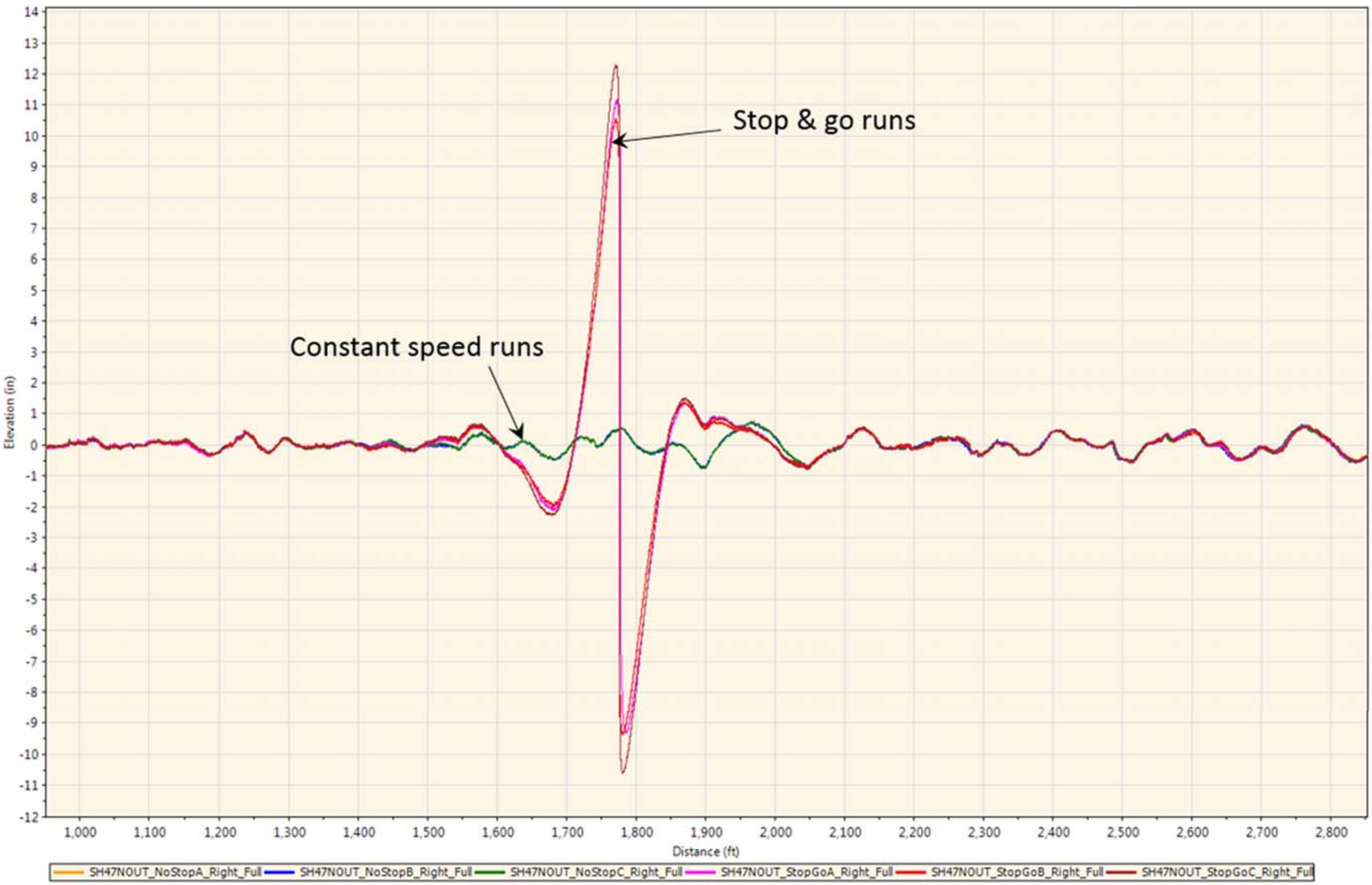

Figure 7. Artificial Bump and Dip on Right Wheel Path Profiles from Stop and Go Runs of System A on SH 47 NB Test Lane.

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However, Figure 5 shows four indications along the NB lane where profile measurement errors due to stopping spill over into the next section (sections 13-14, 32-33, 37-38, and 45-46). Likewise, Figure 6, shows three similar cases along the SB lane (sections 5-6, 19-20, and 33-34). Table 4 shows that the stopping location for each of these cases is within 50 ft of the next section, suggesting that the profile distortion extends into this section thereby artificially inflating its IRI as well.

Table 4. Cases where Effect of Stopping on IRI Spills over into Adjacent Section.

Test lane	Stopping location (ft)*	0.1-mile section of stoppage			Distance from stop location to end of section (ft)
		No.	Begin (ft)*	End (ft)*	
SH47 NB	6846	13	6336	6864	18
	16847	32	16368	16896	49
	19503	37	19008	19536	33
	23748	45	23232	23760	12
SH47 SB	2596	5	2112	2640	44
	10005	19	9504	10032	27
	17421	33	16896	17424	3

* Referred from start of profile measurements along test lane.

Relative to IRI, the previous comparisons established that System A is significantly affected by stop and go driving conditions. Since earlier comparisons showed that System A and System C give very comparable IRIs under constant speed testing, an analogous comparison is made between section IRIs to check whether System C is similarly affected by stop and go driving as System A. Figure 8 and Figure 9 compare the average section IRIs between System A and System C as determined using profiles collected from stop and go test runs along SH 47. These figures are like mirror images of Figure 5 and Figure 6 except that stop and go IRIs from System C are plotted and compared with corresponding values from System A.

The preceding results give a clear indication that System C is not as significantly affected by stop and go driving as System A. Thus, while System C behaves like a conventional inertial profiler when used under constant speed, the same system with its auxiliary sensors can correct profile measurement errors that arise when operated under stop and go driving conditions. Along the north bound outside lane, the average of the stop and go IRI differences between System A and System C is 116 in/mile, while on the south bound outside lane, the average IRI difference is 141 in/mile. The positive sign of the average IRI differences indicates higher IRIs from System A compared to System C under stop and go driving conditions. A one-tailed paired t-test of the differences between section IRIs on each lane resulted in p-values of 2.18×10^{-4} and 5.18×10^{-5}, respectively, on the north and south bound test lanes indicating that the stop and go IRIs from System A are significantly greater than those from System C at $\alpha = 0.05$. As can be inferred from Figure 8 and Figure 9, much of the IRI differences are observed at the stopping locations, where the average of the IRI differences between System A and System C is 509 in/mile on the NB lane and 518 in/mile on the SB lane. Excluding the stopping locations, the average IRI differences are 12.7 and 15.6 in/mile, respectively, on the NB and SB test lanes. Again, the positive IRI differences indicate higher IRIs from System A compared to System C under stop and go driving conditions.

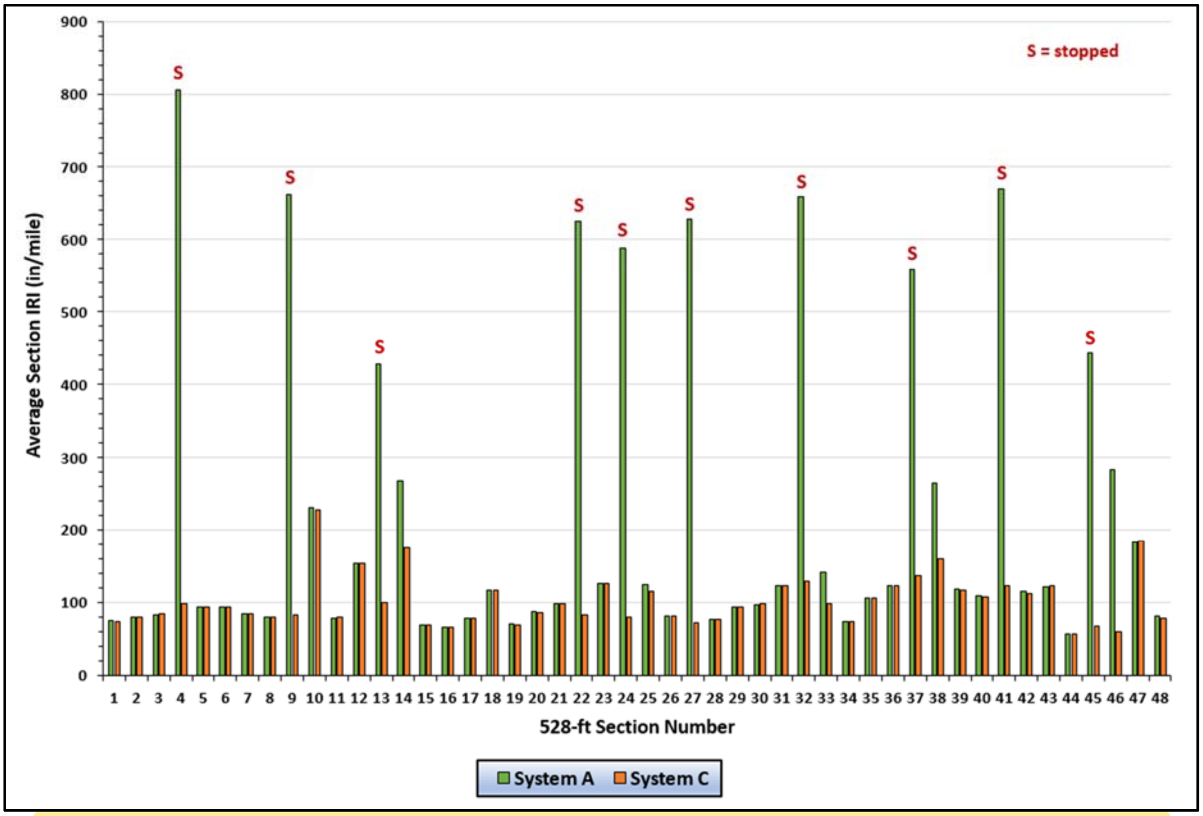

Figure 8. System A vs. System C Section IRIs from Stop and Go Runs (SH 47 NB).

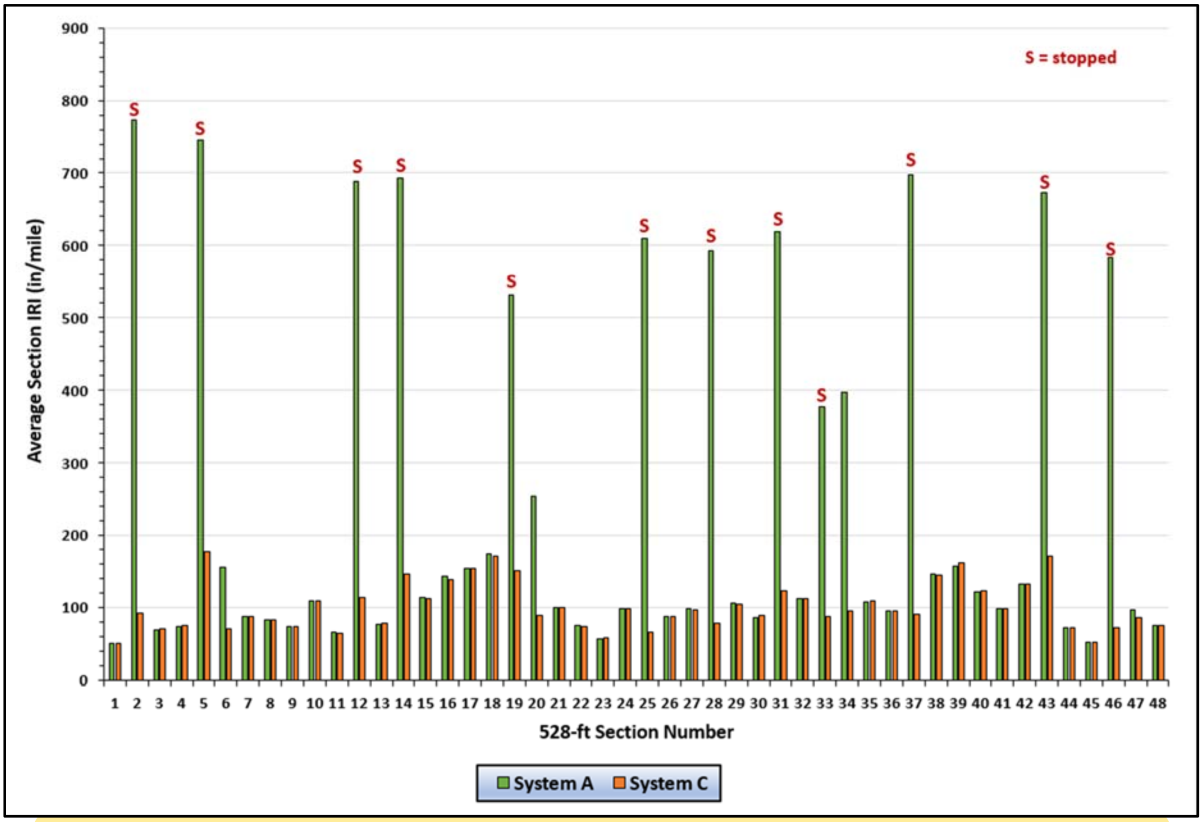

Figure 9. System A vs. System C Section IRIs from Stop and Go Runs (SH 47 SB).

The previous comparison suggests that System C is not as affected by stop and go driving as System A. To further assess the effect of stop and go driving on the IRIs determined from test runs along SH 47, the paired *t*-test is used to evaluate the significance of the differences in IRIs between constant speed and stop and go runs with each of the systems tested in this report. The null (H_0) and alternate (H_a) hypotheses used for significance testing are:

H_0: $(\mu_{stop\&go} - \mu_{const.\ speed})_j = 0$
H_a: $(\mu_{stop\&go} - \mu_{const.\ speed})_j > 0$

where $(\mu_{stop\&go} - \mu_{const.\ speed})_j$ is the difference in average section IRIs between stop and go and constant speed tests conducted using system *j*. Table 5 summarizes the results from the statistical tests of significance.

Table 5. Results of Statistical Significance Testing of IRI Differences.

System	SH 47 NB Test Lane		SH 47 SB Test Lane	
	Average IRI difference (in/mile)	*p*-value*	Average IRI difference (in/mile)	*p*-value*
A	115.48	0.000231	141.54	5.25×10^{-5}
B	-0.29	0.358989	0.72	0.171670
C	-0.34	0.259101	0.46	0.235154

**p*-value shown in red indicates statistically significant section IRI difference at $\alpha = 0.05$.

Table 5 shows that System A is significantly affected by stop and go driving, giving significantly higher section IRIs when operated under these conditions as opposed to constant speed data collection. Figure 5 and Figure 6 illustrate this effect. In contrast, the section IRIs are not significantly different between stop and go and constant speed tests with System B and System C. It is noted that System B is a conventional inertial profiler with none of the auxiliary sensors found in System C. From an earlier communication, the equipment manufacturer noted that System B is designed to reduce errors associated with stop and go data collection. Thus, System B was included in the test program for this evaluation.

Figure 10 to Figure 13 show the average section IRIs determined from constant speed and stop and go tests done with System B and System C. To better show the differences between constant speed and stop and go IRIs, the vertical axes in these figures are drawn to a different scale compared to Figure 5 and Figure 6. Overall, the effect of stop and go data collection on the computed IRIs is significantly less with System B and System C compared to System A. However, Figure 10 to Figure 13 do show sections where the IRI differences are relatively higher compared to the rest of the data. In particular, there are stopping locations where the section IRI differences are higher than 6.0 in/mile in magnitude. Under TxDOT's Item 585 ride specification, referee testing is triggered when the overall average IRI difference between the department's and contractor's data is more than 6.0 in/mile on a given project.

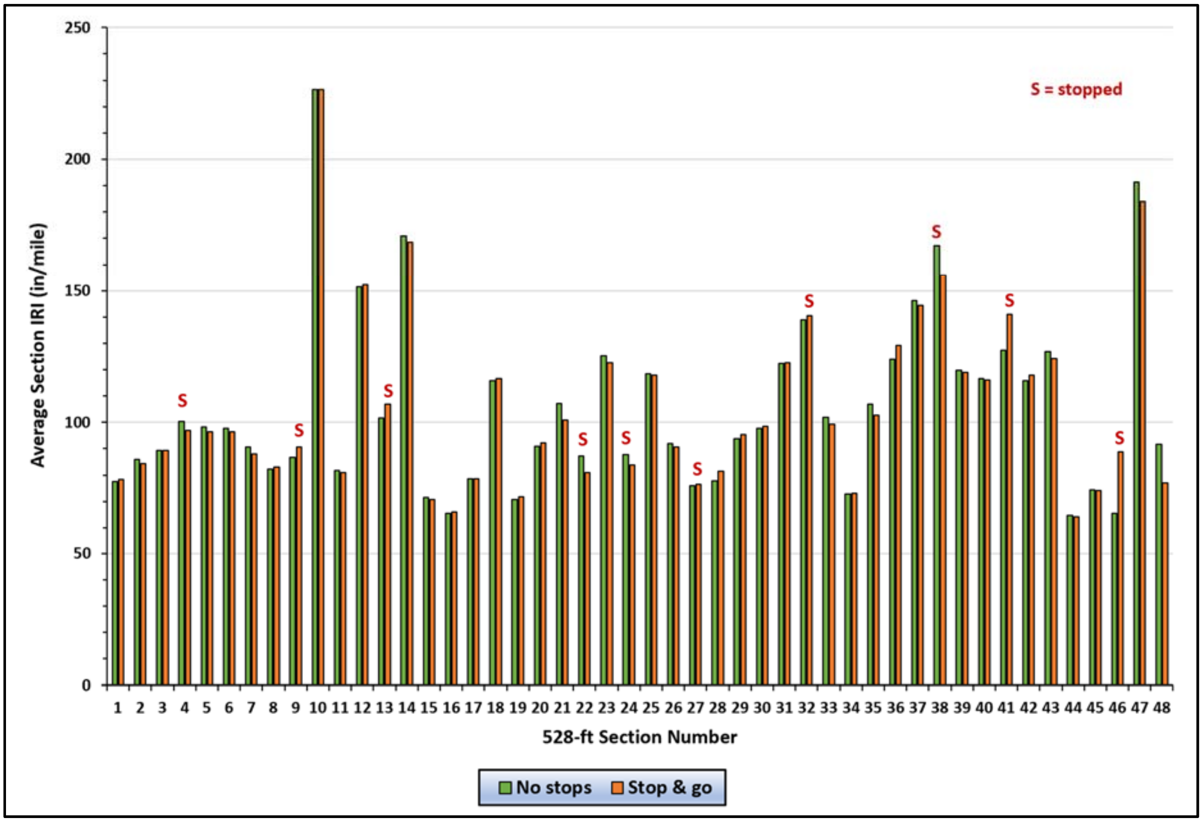

Figure 10. Comparison of Section IRIs from System B Test Profiles on SH 47 NB runs.

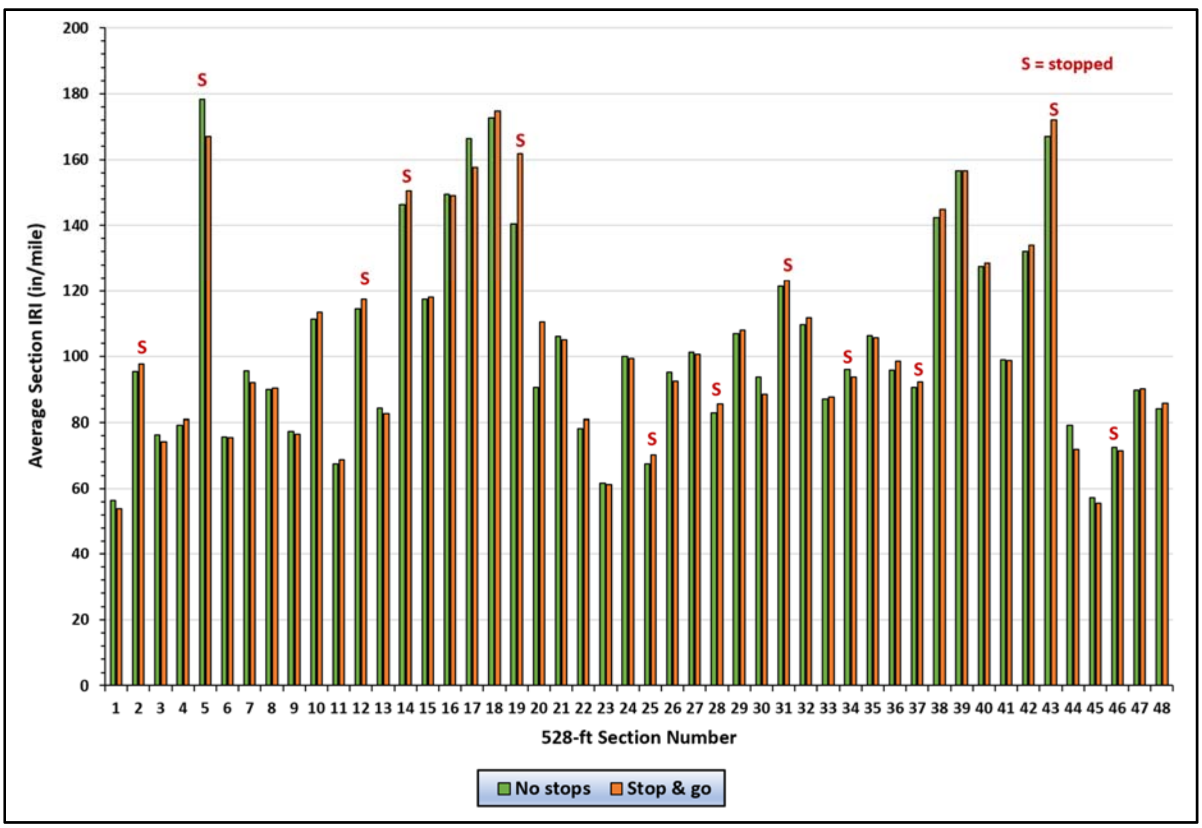

Figure 11. Comparison of Section IRIs from System B Test Profiles on SH 47 SB runs.

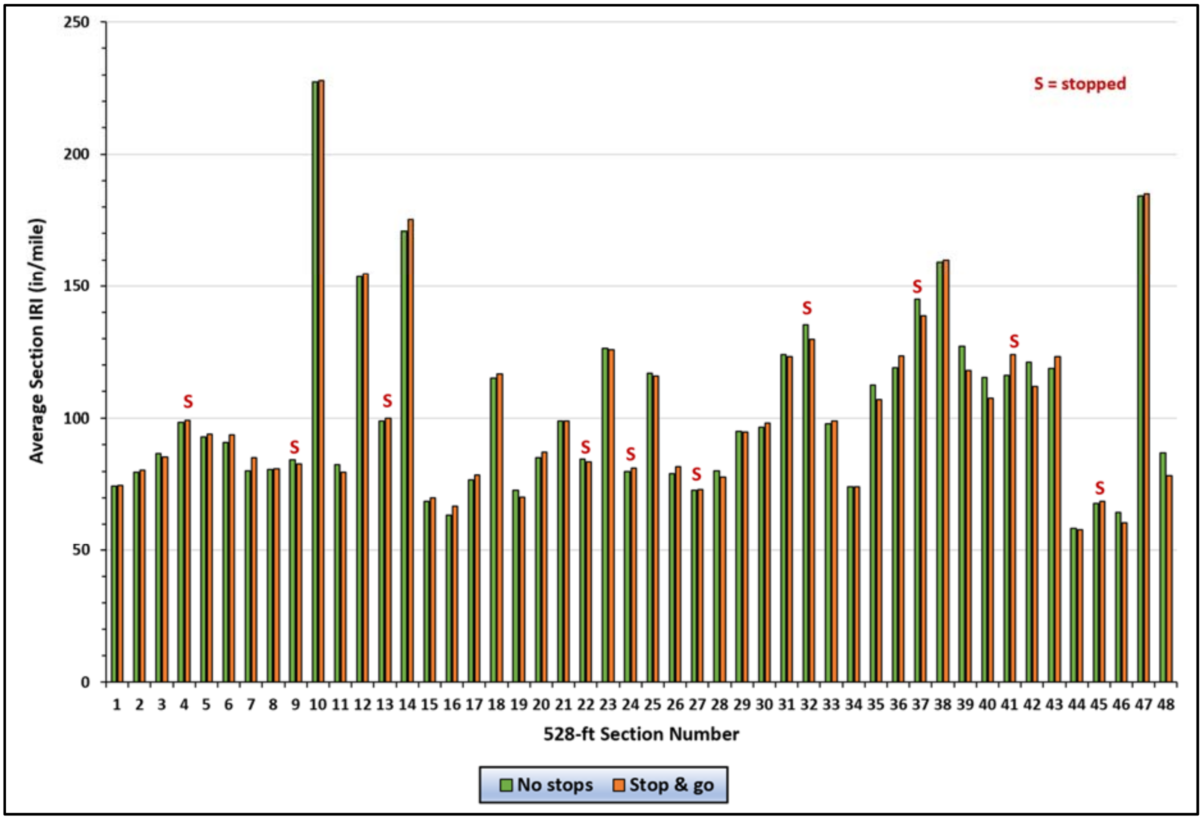

Figure 12. Comparison of Section IRIs from System C Test Profiles on SH 47 NB runs.

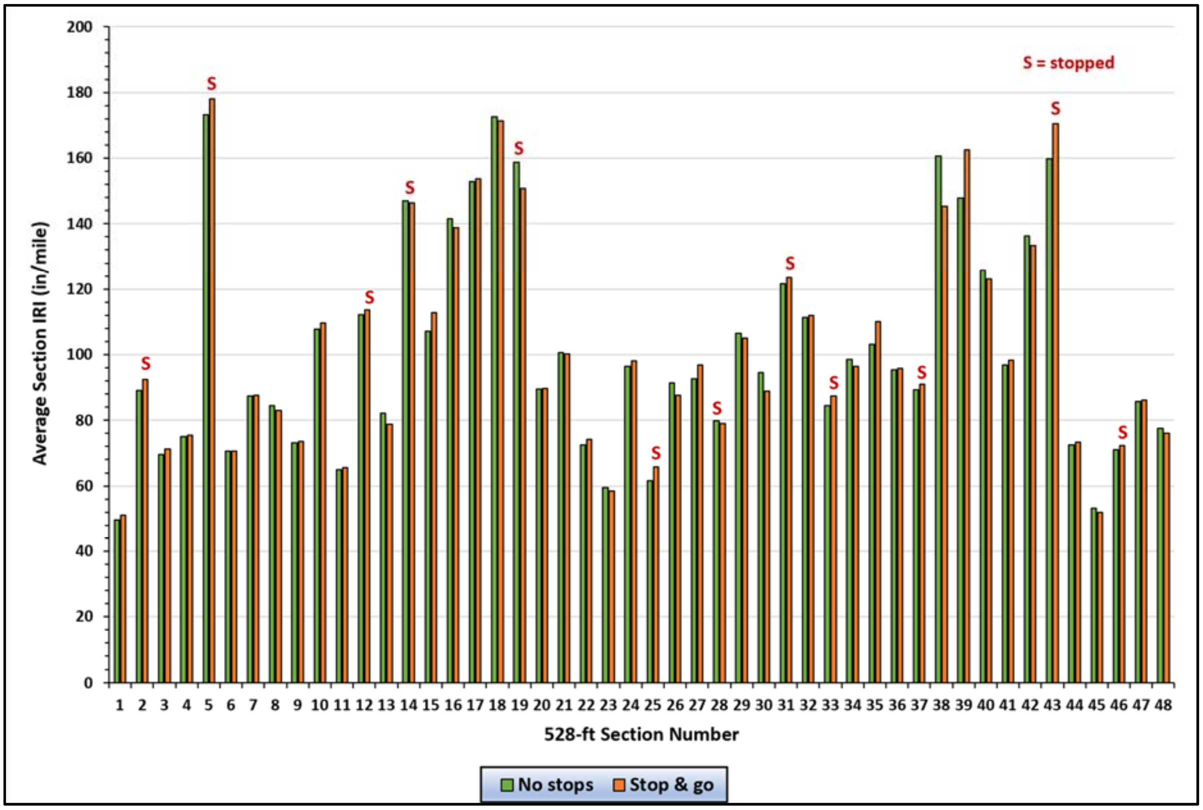

Figure 13. Comparison of Section IRIs from System C Test Profiles on SH 47 SB runs.

At a few stopping locations, the constant speed IRIs are higher than the corresponding stop and go IRIs. These cases counterbalance those observations where the IRI difference is in the opposite direction at these locations. Since constant speed and stop and go runs were made at different times, the IRI differences are influenced by wheel path tracking variability. One-tailed paired *t*-tests of the IRI differences at the stopping locations showed that the differences between stop and go and constant speed section IRIs are not statistically signficant at $\alpha = 0.05$ for System B and System C. Table 6 summarizes the results from these statistical tests.

Table 6. Results from Paired *t*-tests of IRI Differences at Stopping Locations.

System	SH 47 NB Test Lane		SH 47 SB Test Lane	
	Average IRI difference (in/mile)	*p*-value*	Average IRI difference (in/mile)	*p*-value*
A	508.23	1.40×10^{-7}	519.52	1.11×10^{-9}
B	2.40	0.236794	2.54	0.126347
C	-0.20	0.438116	1.93	0.076149

**p*-value shown in red indicates statistically significant section IRI difference at $\alpha = 0.05$.

TEST RUNS ON SECTIONS WITH REFERENCE IRI VALUES

TTI also tested the three systems on the dense graded Type D hot-mix asphalt (HMA), and the Portland cement concrete (PCC) certification tracks located at the Texas A&M RELLIS Campus. Just like the test runs on SH 47, three full constant speed runs were made with each system on each track. Another set of three full runs were made under stop and go driving, where the operator stopped at about the midpoints of the designated sections on each track. While the constant speed and stop and go runs were made at different times, wheel path tracking variability is expected to have less effect on this experiment for the following reasons:

- The wheel paths on each track are delineated.
- The test runs are shorter.
- Data collection was done during daylight hours.

Researchers computed the IRIs from the test profiles and compared the test IRIs from each system with the corresponding reference values. Table 7 and Table 8 summarize the average IRI differences between corresponding test and reference values from the stop and go, and constant speed runs, respectively. The test results show similar trends with those obtained from the SH 47 runs. Specifically, the following observations are noted:

- System A is very much influenced by stop and go driving conditions with test IRIs that are much higher than the reference values compared with the IRIs obtained when this system is operated at constant speed (consistent with its design).
- System B is not as affected by stop and go driving as System A with test IRIs that are within the same order of magnitude as the corresponding reference values but exhibit more spread compared to IRI differences based on constant speed profiles. The range of the differences on each wheel path is wider than ±6.0 in/mile under stop and go driving as shown in Table 7. However, the IRI differences are within these limits under constant speed driving conditions as shown in Table 8.
- System C, a developmental version of a stop and go profiler at the time of this evaluation, gave IRIs comparable to the reference values for both stop and go, and constant speed operating conditions. The IRI differences are within ±6.0 in/mile for both test conditions.

Table 7. Average IRI Differences from Stop and Go Tests on RELLIS Sections.

Test Section Designation	Average IRI Difference (in/mile)[1]					
	System A		System B		System C	
	LWP	RWP	LWP	RWP	LWP	RWP
HMA Type D medium rough	352.87	373.47	-7.78	-8.60	0.39	1.97
HMA Type D medium smooth	346.69	338.13	5.64	4.17	-1.61	-3.01
HMA Type D smooth	339.98	322.02	5.42	5.33	-0.99	-0.81
Conventional Trans. Grooved PCC	489.87	203.72	-11.20	-11.84	-0.68	2.22
Variable Trans. Grooved PCC	361.85	228.02	6.68	7.29	-3.54	2.43
Longitudinally Grooved PCC	446.28	217.68	N/A[2]	N/A[2]	0.12	1.73

[1] Absolute difference not to exceed 6.0 inches/mile per TxDOT Test Method Tex-1001-S.
Positive difference indicates higher IRIs from test system relative to reference IRIs.
[2] Not available. No data collected on longitudinally grooved section with System B, which has wide spot lasers.

Table 8. Average IRI Differences from Constant Speed Tests on RELLIS Sections.

Test Section Designation	Average IRI Difference (in/mile)[1]					
	System A		System B		System C	
	LWP	RWP	LWP	RWP	LWP	RWP
HMA Type D medium rough	0.70	1.34	-4.24	-1.58	1.07	1.35
HMA Type D medium smooth	-1.61	-2.66	-3.31	-3.08	-0.86	-1.63
HMA Type D smooth	-1.05	-0.38	-0.31	0.83	-1.17	-0.34
Conventional Trans. Grooved PCC	-2.33	0.64	-1.34	-1.98	2.66	2.63
Variable Trans. Grooved PCC	-1.95	3.62	-3.52	1.91	-2.38	3.40
Longitudinally Grooved PCC	0.79	0.89	N/A[2]	N/A[2]	0.62	0.68

[1] Absolute difference not to exceed 6.0 inches/mile per TxDOT Test Method Tex-1001-S.
Positive difference indicates higher IRIs from test system relative to reference IRIs.
[2] Not available. No data collected on longitudinally grooved section with System B, which has wide spot lasers.

Table 9 and Table 10 compare the IRI accuracy between the three systems based on cross-correlations of the IRI filtered test profiles with the corresponding reference profiles (the method used in AASHTO R 56). It is found that the three systems meet the 90% threshold for IRI accuracy on all sections when tested under constant speed conditions (a finding also reflected in Table 8). However, under stop and go driving, only System C met the specified IRI accuracy thresholds in Tex-1001-S and AASHTO R 56.

It should be noted that these methods are applicable for certifying inertial profilers, which by design need to be operated above a specified minimum speed. Use of the existing IRI accuracy thresholds in these test methods was solely for the purpose of providing a reference with which to assess the effect of stop and go driving on the profiling systems evaluated in this report. Their use does not imply endorsement for certifying these systems under stop and go traffic conditions found in urban environments. There is currently no standard test method for this type of certification. The results presented in this report are tied to the specific test procedures used in this preliminary evaluation.

Table 9. Accuracy of IRI Filtered Profiles from RELLIS Stop and Go Tests.

Test Section Designation	Average Agreement Factor (%)[1]					
	System A		System B		System C	
	LWP	RWP	LWP	RWP	LWP	RWP
HMA Type D medium rough	2.63	13.16	91.68	89.72	93.73	92.06
HMA Type D medium smooth	0.87	3.81	83.39	74.45	96.47	93.96
HMA Type D smooth	0.38	0.67	59.19	53.24	91.65	90.21
Conventional Trans. Grooved PCC	1.23	17.62	82.95	86.24	98.13	96.79
Variable Trans. Grooved PCC	0.74	1.13	77.12	79.86	90.76	93.63
Longitudinally Grooved PCC	0.40	0.37	N/A[2]	N/A[2]	96.52	95.51

[1] Must be at least 90% per AASHTO R 56.
[2] Not available. No data collected on longitudinally grooved section with System B, which has wide spot lasers.

Table 10. Accuracy of IRI Filtered Profiles from RELLIS Constant Speed Tests.

Test Section Designation	Average Agreement Factor (%)[1]					
	System A		System B		System C	
	LWP	RWP	LWP	RWP	LWP	RWP
HMA Type D medium rough	98.71	98.45	95.56	95.79	98.74	98.19
HMA Type D medium smooth	97.95	96.48	97.17	95.07	98.39	97.17
HMA Type D smooth	96.07	95.25	95.79	92.56	95.67	95.40
Conventional Trans. Grooved PCC	98.17	97.45	96.06	96.68	97.51	97.60
Variable Trans. Grooved PCC	94.48	94.23	92.30	93.23	94.13	93.72
Longitudinally Grooved PCC	97.16	97.53	N/A[2]	N/A[2]	97.46	98.08

[1] Must be at least 90% per AASHTO R 56.
[2] Not available. No data collected on longitudinally grooved section with System B, which has wide spot lasers.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Based on the results from the tests conducted in this task, the following findings are noted:

- Differences in performance were found between two commercially available systems (A and B) when these systems are operated under stop and go driving conditions.
- Compared to the commercially available systems tested in this task, a developmental version of a stop and go profiler (System C) gave more consistent IRIs between normal (constant speed) and stop and go runs.

The above findings are of significance to the collection of network wide ride quality measurements. Given that TxDOT has transitioned to automated pavement condition data collection service contracts, these findings point to the importance of testing the performance of competing vendors' profiling systems under stop and go driving conditions when qualifying service providers for such contracts. The following recommendations are offered in this regard:

- In the procurement of services for collecting network wide pavement condition data, establish a test procedure with which to qualify profiling systems under stop and go driving conditions representative of urban environments.
- In addition to the current practice of certifying inertial profilers under Tex-1001-S, use the test procedure noted above in the procurement process for automated pavement condition data collection services.
- Establish a process within existing data quality control protocols to screen profile data for occurrences of stop and go driving during data collection. In this regard, use the GPS

data found in TxDOT's PRO files to flag and include such occurrences in the ride quality reports.
- Keep abreast of advances in profiling technology, particularly when improvements are made that address issues with existing inertial profilers. Evaluate new technology as appropriate.

FINAL NOTES

While the results obtained from the initial tests done on System C look very promising, there were a couple of times when glitches took place during testing that produced inconsistent profiles due to bad accelerometer readings. The system developer was aware of this glitch and was working on fixing this issue at the time of this evaluation. The developer provided software with which to view the sensor data, but TTI researchers could not get the software to work on the computer used with the test vehicle. As per the developer's guidance, TTI researchers rebooted the system when these glitches occurred. Researchers then collected data over a short distance, examined the profiles, and if the profiles looked consistent, proceeded with further testing.