Preliminary Comparison of City of London and South-Western Ontario Road Surface Conditions

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Gorski Consulting has developed a methodology for obtaining objective data of road conditions through the use of multiple video cameras, gyro and accelerometer sensors and other instruments that are combined in an effective, inexpensive, data acquisition system. Details of the system have recently been reported in an article posted on the Gorski Consulting website entitled "Video Eyeglasses, iPhone and Multiple Video Cameras - An Effective Data Acquisition System For Motor Vehicle Accident Analysis and Reconstruction". This system was recently used in preliminary testing that was reported in another website article entitled "iPhone Gyro Function Generates Detailed Data Of Road Conditions For Accident Analysis" .

The system relies on the accelerometer and gyro sensors of an Apple iPhone to capture information about a road's characteristics. The iPhone is anchored to the centre-of-gravity of a test vehicle which is driven along a test site. Data is stored in a file which is sent via e-mail to a host computer to be analyzed in typical spreadsheet software such as Excel.

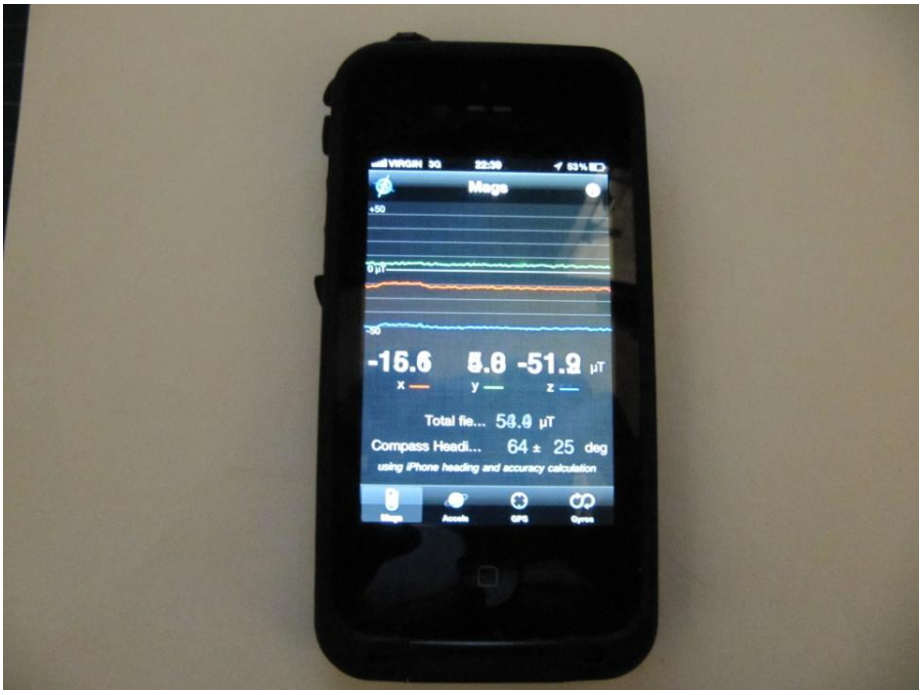

Figure 1: View of Apple iPhone opened in an app that stores the sensed data.

In early 2014 testing was performed on a variety of roads. The results of some of this testing were reported as shown in the table below.

Site	Standard Deviation in Rate- Of-Change in Lateral Motion	Standard Deviation in rate-of-change in Longitudinal Motion
Highway 401	0.0103	0.0093
Veterans Memorial Parkway	0.0131	0.0110
Sunningdale Road (1st 30 seconds)	0.0454	0.0617
Sunningdale Road (20 to 40.5 seconds)	0.0362	0.0537
Sunningdale Road (40.5 to 50 seconds)	0.0234	0.0223

The purpose of presenting this data was to demonstrate that our data acquisition system could reliably detect and differentiate between "good" and "bad" roads. Thus we selected a road (Sunningdale Road) which was known to contain a surface that was in poor condition and we compared the results to two other roads (Veterans Memorial Parkway and Highway 401). The results showed that the Sunningdale site produced substantially greater lateral and longitudinal motions of the test vehicle as a result of travelling over the noted poor road surface. In conclusion we suggested that the data from the Sunningdale site was exceptional and that our analysis of data from additional sites would indicate so.

The present article has been prepared to reveal the results of analysis that was conducted on additional sites in the vicinity of the City of London and nearby highways. The results from twelve additional sites will be presented and compared to the data in the above table. Data still needs to be analyzed from more sites where testing has already been conducted and these are expected to be presented in a future article.

Review of Testing and Results of Analysis

Combining the multiple video cameras of the DAS and iPhone data logging, we performed a variety of test drives on various roads within the City of London, Ontario, Canada as well as highways outside of the City within about a 1 hour radius. Charts were prepared to provide a graphic view of the data. For example, as shown in a previous article, the two charts (below) show the data from the Highway 401 and Sunningdale Road site to illustrate the stark difference in the two sites.

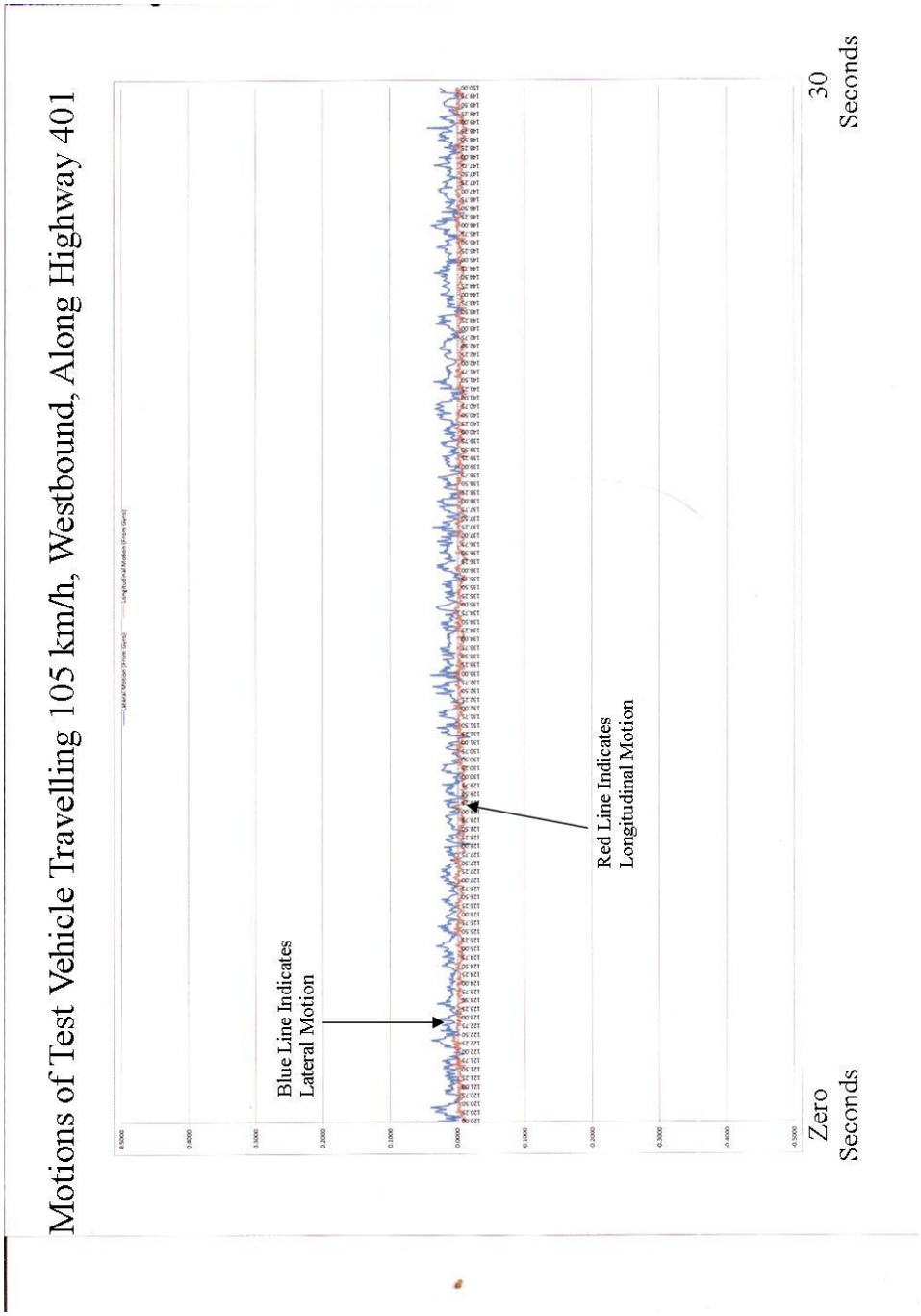

Figure 2: iPhone data from WB Highway 401

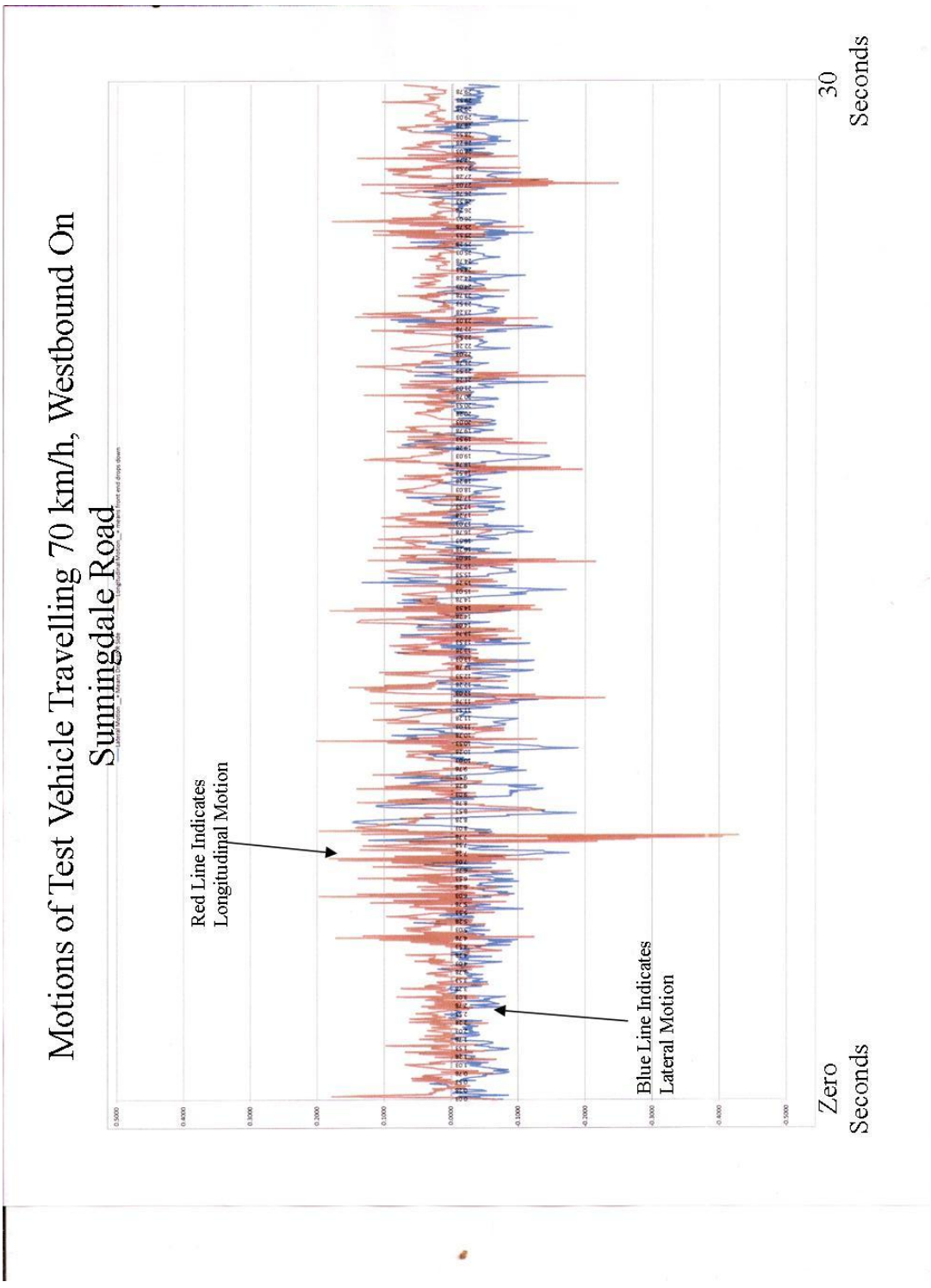

Figure 3: iPhone data from Sunningdale Road Site (1st 30 seconds of testing)

The figure below indicates the location of the sites of the additional testing. The data from Sites 1 through 5 are those that were previously reported and shown in the above table.

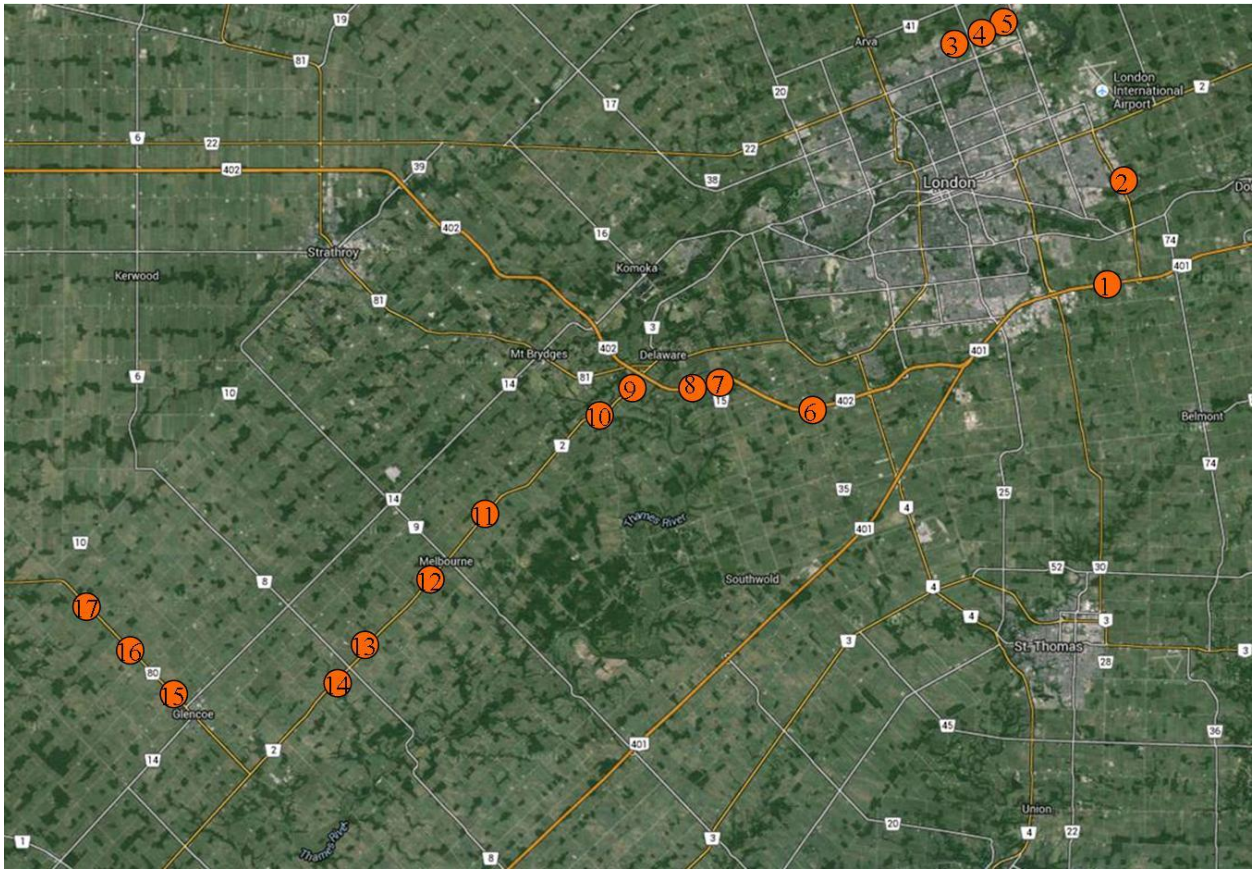

Figure 4: View of location of test sites. The City of London Ontario is located in the upper right of the figure.

Generally, the additional 12 sites are located to the south-west of London. The additional sites are located along Highway 402, Longwoods Road and Dundonald Road.

For the three sites located on Highway 402 the test vehicle's cruise control was set to 106 km/h. For the six sites along Longwoods Road and the three sites on Dundonald Road the cruise control was set to 90 km/h.

To be consistent with the previous methodology a segment of 30 seconds of data was selected for evaluation at each site. Thus at the speed of 106 km/h (29.44 metres per second) the documented segment of road was about 833 metres long. For the travel speed of 90 km/h (25.00 metres per second) the documented segment of road was about 750 metres.

Figure 5 shows the table of results from all 17 sites. Figure 6 shows that data in the form of an Excel chart.

Comparison of City of London & South-Western Ontario Road Surface Conditions

Test #	Road Segment Description	Standard Deviation of Motion Data	
		Lateral Motion	Longitudinal Motion
1	Highway 401, WB, at 105 km/h, Between Veterans Memorial Parkway & Highbury Ave	0.0103	0.0093
2	Veterans Memorial Parkway, SB, at 80 km/h, On Approach to Bradley Ave	0.0131	0.0110
3	Sunningdale Road, WB, at 70 km/h, East of Clarke Road; 1st 30 Seconds of Test	0.0454	0.0617
4	Sunningdale Road, WB, at 70 km/h, East of Clarke Road; 20 to 40.5 Seconds of Test	0.0362	0.0537
5	Sunningdale Road, WB, at 70 km/h, East of Clarke Road; 40.5 to 50 Seconds of Test	0.0234	0.0223
6	Highway 402, WB, at 106 km/h, Commencing from West of Westdel Bourne Overpass	0.0153	0.0102
7	Highway 402, WB, at 106 km/h, Commencing from Springer Road Over-pass	0.0135	0.0091
8	Highway 402, WB, at 106 km/h, Commencing from Miller Road Over-pass	0.0135	0.0150
9	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from Cooks Road	0.0136	0.0123
10	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from Christina Road	0.0114	0.0112
11	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from Glen Oak Road	0.0105	0.0139
12	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from West Limit of Melbourne, Ont.	0.0166	0.0153
13	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from Just East of Mayfair Road	0.0213	0.0185
14	Longwoods Road (Hwy 2), WB, at 90 km/h, Commencing from Just West of Thames Road	0.0180	0.0197
15	Highway 80 (Dundonald Road), NB, at 90 km/h, Commencing from Coltsfoot Drive	0.0117	0.0112
16	Highway 80 (Dundonald Road), NB, at 90 km/h, Commencing from Knapdale Drive	0.0098	0.0111
17	Highway 80 (Dundonald Road), NB, at 90 km/h, Commencing from Argyll Drive	0.0127	0.0113

Figure 5: Table of data from 17 sites.

The chart (below) provides the quickest way to recognize that the data from Sunningdale Road truly is exceptional, as we expected. As discussed in the previous article, the Sunningdale data was separated into three "sites" so that that we could demonstrate the difference between the eastern portion of the road which was in worse condition and the portion further to the west which had been re-paved and was in better condition.

So the site numbered "3" is that portion that contains the first 30 seconds of data along the worst portion of the road. The site numbered "4" is the portion from 20 to 40.5 seconds which contains slightly better conditions. At 40.5 seconds the test vehicle crossed over to the newly paved section of the road so that the site numbered "5" shows about 9.5 seconds of data on that newer section of road.

Obviously, the Sunningdale site contains a surface which causes much more lateral and longitudinal motion than any of the other 14 remaining sites.

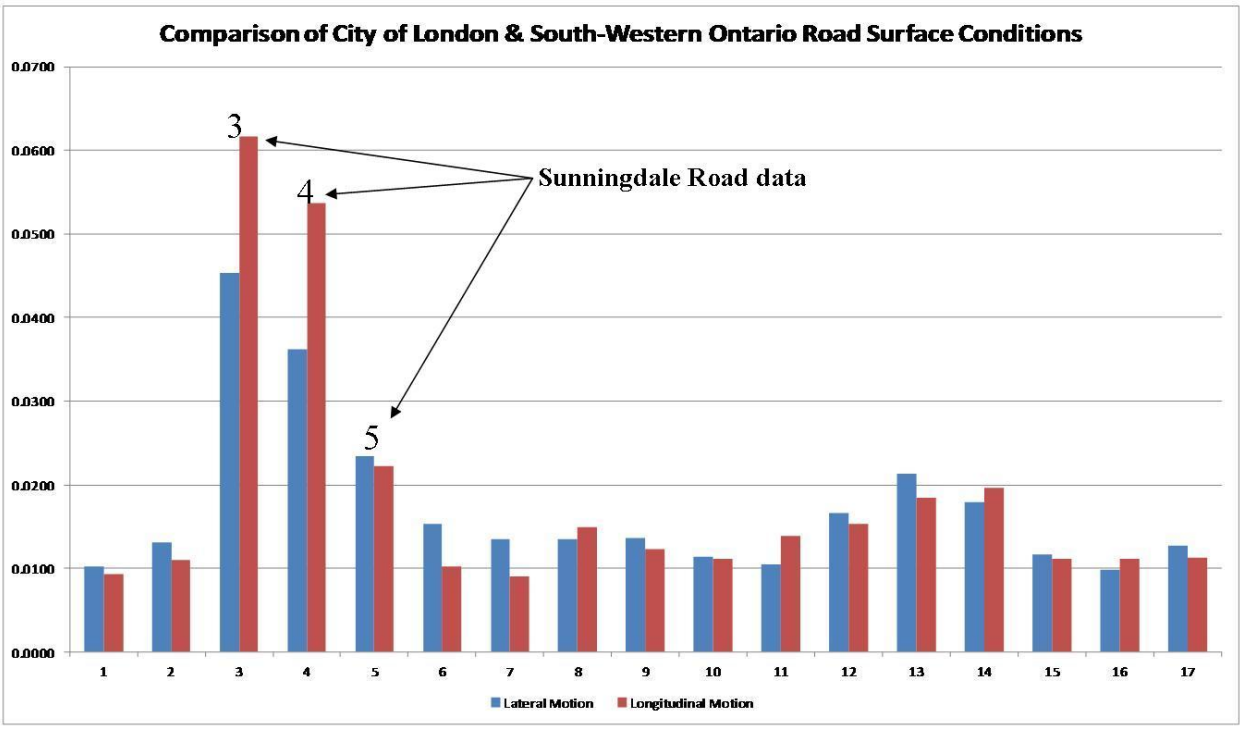

Figure 6: Chart comparing the data from all the sites.

In particular, the longitudinal motion of the test vehicle was much more pronounced at the Sunningdale site. The red columns of longitudinal motion are much taller than the blue columns of the lateral motion and this difference is starkly greater than any of the other sites.

Site "5" was the portion of Sunningdale Road which contained the re-paved surface. It can be seen that the height of the red column has been greatly reduced and the relationship between the longitudinal motion and lateral motion (relationship between red and blue columns) is similar to the other sites. Yet the overall motion on the re-paved surface is still higher than any of the other sites. This is unusual because the other sites contain aged surfaces that would be expected to cause greater motion that the newer surface of Sunningdale Road. As we alluded to in our previous article, we suspect there are problems in the road bed of Sunningdale Road which is causing the upheaval of the newly paved road which is evident from the data.

These results confirm that our data acquisition system can reliable differentiate between "good" and "bad" road surfaces. More generally, the system can be used to study other features of a road. In fact any geometric condition that might be of concern can be evaluated through the recording of objective data and comparison to other sites.

Concerns may not only be with respect to the roughness of a surface. For example collisions might occur due to the slipperiness of a surface. This can be evaluated with our system by conducting braking tests and observing how the rate of deceleration afforded by the road might change from one area to another.

Concerns may be with respect to horizontal or vertical curves or the combination of the two. Such geometric characteristics might affect the travel of vehicles around such curves and may lead to an unsafe condition. Again, our system can document the tri-axial accelerations of the vehicle passing through such features, but additionally, the angle of the vehicle can documented and, even more importantly, a driver's actions or reactions to those accelerations and motions of the vehicle can be observed from the videotape footage. So actions such as braking or steering inputs and their magnitudes or timing are all capable of being documented by video. Furthermore the driver's head and eye motions can also be tracked.

Therefore the issue of road surface character that has been the focus of the present articles is only a part of the many issues that can be objectively examined with our system.

Future articles will continue to expand the list of sites where the road surface has been tested and this data will make it more obvious that certain sites are quite unusual, substandard and could be a safety hazard.

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