Test Data to Document Road Surface Conditions On Wonderland Road South of Highway 401, London, Ontario

Posting Date: 17-Nov-2016

1.0 Background

The character of a road segment that may have been a causal factor in a collision can be retrieved from testing conducted by an instrumented vehicle travelling through the accident site. Gorski Consulting has used an Apple iPhone attached to a test vehicle to sense vehicle motions and to store that data. This data is then sent to our remote computer where it is imported into an Excel spreadsheet and then analyzed. These procedures have resulted in the development of a database of road characteristics which has been unloaded to the Road Data page of the Gorski Consulting website. Over the years our process of study has been documented in a number of articles posted to the Articles page of the Gorski Consulting website. Some of those relevant articles are noted below:

1. *Multiple Video Cameras & iPhone Accelerometers in Braking and Vehicle Motion Testing, February 7, 2013*

2. *Comparison of City of London And South-Western Ontario Road Surface Conditions, February 28, 2014*

3. *Further Differentiation Between Good and Bad Road Surface Characteristics From Instrumented Vehicle Testing, March 3, 2014*

4. *Guidelines For Interpretation of Gorski Consulting Road Data From iPhone Testing, March 17, 2104*

5. *iPhone Gyro Function Generates Detailed Data On Road Conditions For Accident Analysis, February 25, 2014*

6. *Rough Roads Increasing Speed and Change in Test Vehicle Motion, March, 2014 (2 Articles)*

7. *Video Eyeglasses iPhone and Multiple Video Cameras - An Effective Data Acquisition System For Motor Vehicle Accident Reconstruction Analysis, February 11, 2014*

8. *Rough Roads Increasing Speed and Change in Test Vehicle Motion - Additional Data, March & April, 2015 (2 Articles)*

The Road Data files are broken down into locations in South-Western Ontario where testing was conducted along specific road segments. The tested roads existing in the City of London are located under one category. Other categories were created according to highways/roads existing in Counties such as Middlesex, Lambton, Oxford and Perth.

Reference 4 above (*Guidelines For Interpretation of Gorski Consulting Road Data...etc)* provides a summary of how the Road Data was generated and we provide a quote from that article below:

> *Because of the large amount of data that was collected by the iPhone it became impractical to display it all in the database. Therefore it was necessary to select parameters that would be most useful in differentiating between the sites.*
>
> *It was decided that the rate-of-change in the angle of the vehicle might best differentiate the sites. The app used to obtain this data stores the rates of lateral and longitudinal rotation in radians. Members of the public are often not used to working with radians and are more familiar with degrees. There are 57.3 degrees in one radian.*
>
> *The iPhone senses the angle of the vehicle along its three axes, x, y and z. The X-axis is often described as a pole that punctures the side doors of a vehicle such that the vehicle then revolves around this pole. Similarly, the Y-axis is a pole that punctures the front and rear license plates and the vehicle rotates around that pole. Finally, the Z-axis is a pole that punctures the roof and floor of the vehicle so that the vehicle rotates around that pole.*
>
> *Rotation around the Z-axis is a motion called "yaw" and this is the most common indicator of a vehicle's loss-of-control because it produces curved "yaw" tire marks on a road surface before it crashes. However we decided not to report this value because, by the time such yaw marks become visible on a roadway, it is almost guaranteed that most vehicles on public roads will be involved in a collision. In other words, there would to be little yaw rotation expected in the motion data during the normal travel performed by the test vehicle and it would be difficult to use this parameter to differentiate one road from another. For this reason only the lateral (rotation about the X axis) and longitudinal (rotation about the Y axis) motions of the test vehicle were reported in the database.*
>
> *Because the test vehicle could rotate clockwise or counter-clockwise on any axis, the reported radian data alternated between positive and negative values and reporting an average of these values would not reveal the different magnitudes of motion in the test vehicle. Therefore the standard deviation of the rate-of-rotation was taken as the final value that would be displayed in the database. Thus when the standard deviation is high it indicates that, on average, the rate of rotation, whether clockwise or counter clockwise, is high and vise versa. So if the values displayed in the "Lateral Motion" or "Longitudinal Motion" are high it indicates that the magnitude of the*

vehicle's displacement from a "perfectly level" condition is also large and that the vehicle's interaction with the road surface is causing that motion.

2. 0 Testing On Wonderland Road, London, Ontario

Wonderland Road is a major, north/south arterial road in west London, Ontario. Near the north end of the City Wonderland is perhaps the busiest arterial road in the area. This high traffic volume continues southward up to the southern edges of the built up area approaching Exeter Road. However, beyond Exeter Road Wonderland receives progressively less traffic.

As Wonderland approached the high-volume expressway of Highway 401 the road was essentially a low-volume, rural road without any connection to the Highway 401 expressway. However, as time passed the south portion of Wonderland Road came into increasing commercial development such that traffic volume was expected to increase dramatically. Thus a new interchange was constructed at Highway 401 to connect with Wonderland. However, little was done to the several kilometers of Wonderland Road north and south of the interchange to upgrade it for the increased traffic volume. Figures 1 through 5 provide some general views of the area.

Figure 1: View of South-Western Ontario showing the City of London and the testing site on Wonderland Road near Highway 401.

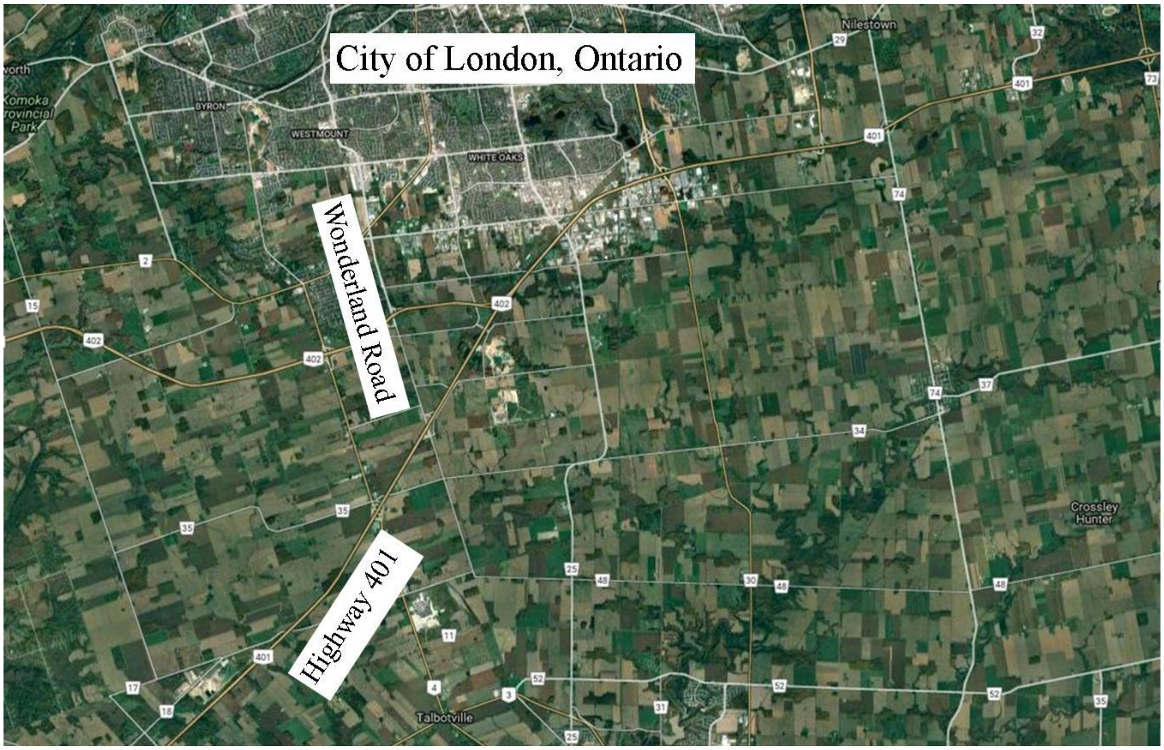

Figure 2: Relationship between London, Wonderland Road and Highway 401.

Figure 3: Relationship between the City of London, Wonderland Road and Highway 401.

Figure 4: View of the new interchange being built at the junction of Wonderland Road and Highway 401.

Figure 5: View of the south end of the construction zone on Wonderland Road, south of Highway 401 where the new construction terminated and the aged road surface remained further to the south.

On occasions when Gorski Consulting happened to pass through that portion of Wonderland it became clear that the road surface and its edges were deteriorating. As the new interchange was completed in November of 2015 and the road experienced a sudden upsurge in traffic volume problems became apparent.

Within a few months two serious collisions occurred at the intersection of Wonderland Road and Glanworth Drive located just south of the Highway 401 interchange. Previously Glanworth had been a higher volume roadway and therefore drivers on Wonderland had to stop at a stop sign before proceeding through the that intersection. However, with the increased volume on Wonderland the number of vehicles on Wonderland became substantially more than those on Glanworth. This development should have been foreseeable as the development of the interchange would naturally bring more traffic onto Wonderland as a means to enter onto the Highway 401 expressway.

While the remaining aged portions of Wonderland were in poor condition the problem became much more intense when, on a day in June of 2016, we came across a major road surface failure as shown in Figures 6 and 7.

Figure 6: View, looking north on Wonderland Road and showing a major collapse of the surface of the southbound lane.

Figure 7: View of an asphalt patch in the failure indicating that roads personnel had tried to make a repair but this was unsuccessful.

Figure 8: An edge of Wonderland Road that has been milled out resulting in a steep edge drop off.

In another portion of Wonderland Road it was apparent that the road edge had been milled out thus exposing the public to a deep edge drop off as shown in Figure 8. In other areas the road exhibited major depressions and undulations causing our vehicle to be displaced in random directions.

As a result of these observations Gorski Consulting decided to conduct testing along Wonderland Road to provide some objective data on the extent of its defects. Figure 9 shows the general area along Wonderland where the testing was conducted.

Figure 9: An oblong circle shows the general area along Wonderland road where the testing was conducted.

As can be seen in Figure 10 the testing began at a driveway just north of Highway 401. The test vehicle was driven southward where a stop had to be made at the intersection with Glanworth Drive (Figure 11). The vehicle then continued further south where it crossed a small bridge as shown in Figure 12. As the vehicle reached the intersection with Ferguson Line (See Figure 13) the driver made a U-turn and the testing continued in a northward direction, retracing the southbound path, back to the driveway. Upon reaching the driveway the vehicle was stopped and the driver accessed the iPhone to send the data to an e-mail address for eventual export an Excel spreadsheet at the office computer. Then two additional tests were performed before the testing was completed.

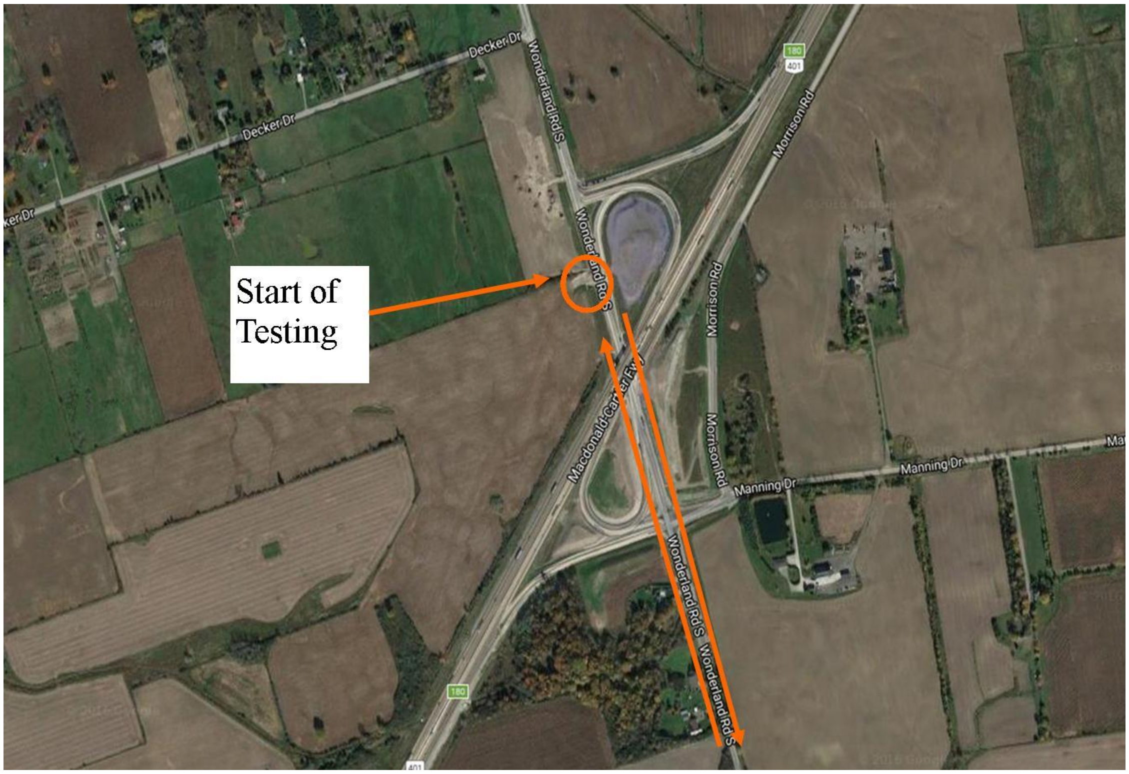

Figure 10: View of the location of a driveway on the west side of Wonderland Road where the testing commenced.

Figure 11: View of the intersection of Wonderland Road with Glanworth Drive. At the time of the testing traffic on Wonderland was still required to stop at a stop sign before proceeding through the intersection.

Figure 12: Travelling further south the test vehicle had to cross a small bridge over a creek as seen in this figure.

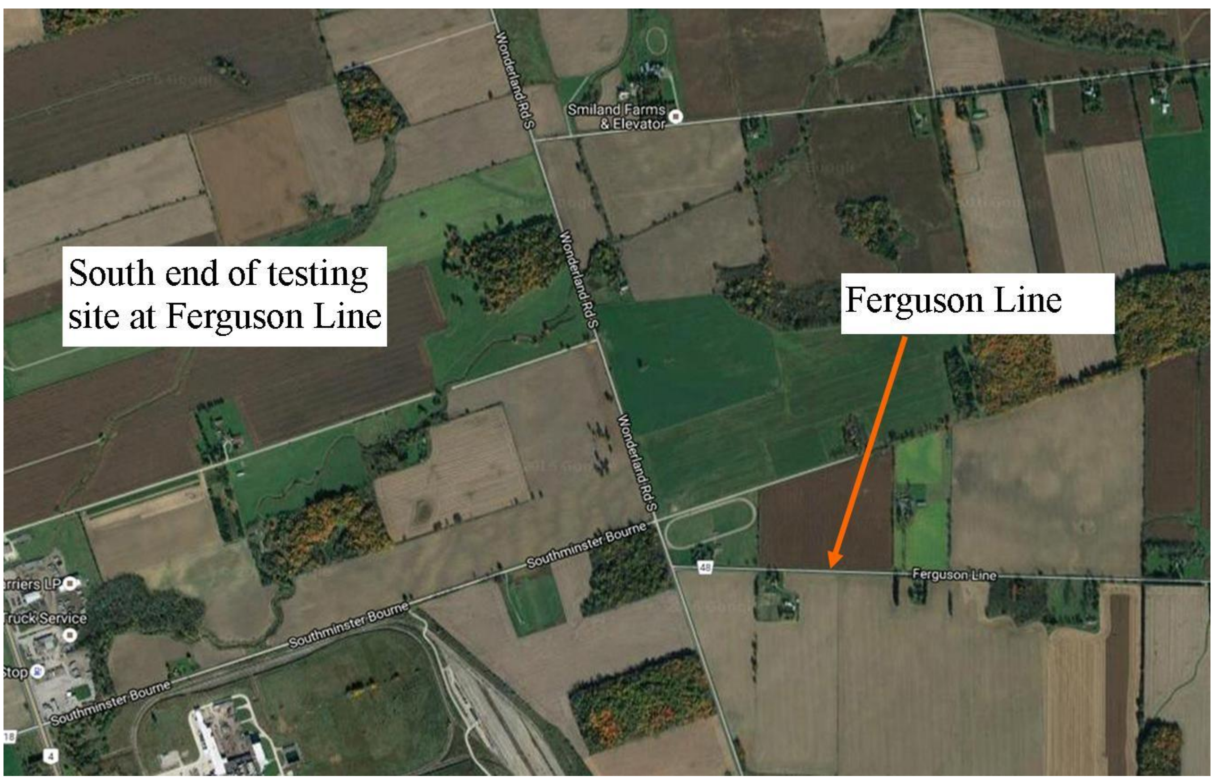

Figure 13: View of the area of Ferguson Line where the test driver made a U-turn to continue the testing in a northbound direction.

Figures 14 through 17 provide 4 portions of the table summarizing the results of the testing.

Wonderland Road iPhone Rotation Testing - Oct 23, 2016

Test #1						
Samples	Location	Speed (km/h)	Sampling Rate (Hertz)	Length of Recording (Sec)	Stan Dev in Longitudinal Rotation (Rad/Sec)	Stan Dev in Lateral Rotation (Rad/Sec)
0 to 3000	SB From Driveway N of Hwy 401 on approach to underpass of Hwy 401	Accelerating from 0 to 80	90	33	0.0214	0.0408
3000 to 6000	SB from underpass of Hwy 401 and passing onto old rough road surface	Cruise set at 80	90	33	0.0209	0.0424
6000 to 9000	SB along old rough surface before braking for Glanworth Road	Cruise set at 80	90	33	0.0351	0.0680
9000 to 12000	Start light braking for stop at Glanworth, @ 2 seconds from start of segment; rolling stop at 20 seconds into segment & commence acceleration reaching 80 km/h at 27 seonds into segment.	Cruise set at 80	90	33	0.0338	0.0525
12000 to 15000	Travelling SB on straight segment at constant speed south of Glanworth, end at @ timecode 00;07;43;00	Cruise set at 80	90	33	0.0297	0.0632
15000 to 18000	SB passing Harry White Drive at @ timecode 00;07;58;00 @ 15 seconds into segment; observation made that approaching a SB slow-moving farm vehicle; end segment at @ timecode of 00;08;16;00	Cruise set at 80	90	33	0.0355	0.0731

Figure 14: 1st Portion of Summary of Results

A video project was created that accompanied the recorded data. A video camera was pointed at the speedometer/tachometer cluster, another camera was placed pointing forward through the windshield. Another camera was positioned on a pole extending to the left from a bicycle rack thus capturing the rear and left side of the vehicle also capturing the road condition to the left of the vehicle. A video camera was also positioned behind and between the two front seats, pointing forward at the driver and steering wheel. All these camera views were incorporated in a synchronized display of a computer screen. The timecode of the video project was matched to the samples of the iPhone data and these landmarks are mentioned in the comments of the figures.

As shown above, the data was divided into segments of 3000 samples. At 90 samples per second this comprises a time of about 33 seconds of data for each segment of road. While the attempt was to travel through the site at the maximum posted speed of 80 km/h, that was not possible at several instances. For example at the start of the testing the vehicle had to be accelerated from its stopped position and then the cruise was set at 80 once the vehicle reached a speed of 60 km/h. Similarly, shortly after 9000 samples braking was begun to bring the vehicle to a stop at the stop sign at Glanworth

Drive. Also, in the time before 12000 samples, the vehicle was being accelerated again once it passed the Glanworth intersection. In this zone the lateral rotation is reduced, understandably because of the slower speed of the test vehicle.

It can be noted in the comments that, upon approaching 18000 samples, the test driver observed that there was a slow-moving farm vehicle ahead travelling southbound and therefore the test vehicle would have to be slowed. Shortly after 18000 samples the test vehicle was braked and the speed was reduced to about 30 km/h. Before this braking Figure 14 shows the very large values of lateral rotation that occurred while the test vehicle was travelling at a constant speed of 80 km/h.

Samples	Location	Speed (km/h)	Sampling Rate (Hertz)	Length of Re-cording (Sec)	Stan Dev in Lon-gitudinal Rota-tion (Rad/Sec)	Stan Dev in Lat-eral Rotation (Rad/Sec)
18000 to 21000	Start braking for slow-moving farm vehicle @ 4 seconds into segment or at timecode 00;08;20;00 while crossing small bridge over creek, speed reduced to 40 km/h @ 10 seconds onto segment or @ time-code of 00;08;26;00; following slow-moving farm vehicle at @30 km/h to end of segment at 00;08;49;00	Braking from 80 km/h to 30 km/h	90	33	0.0279	0.0536
21000 to 24000	SB continue to follow slow-moving farm vehicle at @ speed of 30 km/h up to end of segment at timecode of 00;09;22;00	30 km/h	90	33	0.0162	0.0382
24000 to 27000	SB continue to follow slow-moving farm vehicle at @ speed of 30 km/h up to end of segment at timecode of 00;09;55;00	30 km/h	90	33	0.0264	0.0392
27000 to 30000	SB, begin U-turn at Ferguson Line @ 15 seconds into segment or at timecode 00;10;10,00, begin accel-eration from speed of @ 15 km/h to travel NB on Wonderland at @ 23 seconds into segment or at timecode 00,10;18;00; reached speed of 70 km/h by end of seg-ment at timecode 00;10;28;00	turning at 15-20 km/h, then accel-erate to 70 km/h	90	33	0.0326	0.0529

Figure 15: 2nd Portion of Summary of Results

In Figure 15 we see the results of the reduction in the test vehicle's speed as it followed the slow-moving farm vehicle. Then, as the U-turn occurred and the test vehicle was accelerated northward the lateral rotation increased again.

Throughout the testing the longitudinal rotation remained relatively low and this has been observed in previous testing. This can be explained when considering that any passenger vehicle is much longer than it is wide. Thus it is more difficult to cause "pitch-pole" types of motions than it is to roll the vehicle laterally. This has interesting implications for causes of loss-of-control. If a vehicle's lateral motion is increased with increasing speed then the tire force is more likely to be different on one side of the vehicle versus the other. Unbalanced forces about the centre-of-gravity are the cause of yaw (rotation about the vertical axis). Almost all single-vehicle, loss-of-control collisions are preceded by yaw and these data may explain why so many higher speed loss-of-control collisions occur on poor road surfaces.

Figure 16 shows the data as the test vehicle travelled northbound. Once again the lateral rotation drops as the vehicle comes to a stop at Glanworth Drive on approaching sample 42000.

Samples	Location	Speed (km/h)	Sampling Rate (Hertz)	Length of Recording (Sec)	Stan Dev in Longitudinal Rotation (Rad/Sec)	Stan Dev in Lateral Rotation (Rad/Sec)
30000 to 33000	NB on Wonderland commencing from speed of 70 km/h accelerating with cruise set to 80 km/h reached at @ 4 seconds into segment; passed Orr Drive at 30 seconds into segment or at timecode 00;10;58;00; travelling at cruise speed of 80 km/h to end of segment at timecode 00;11;01;00	Accelerating from 70 km/h to 80 km/h in 1st 4 seconds, then constant speed of 80 km/h	90	33	0.0250	0.0641
33000 to 36000	NB, at cruise speed of 80 km/h, passing small bridge at creek at @ 6 seonds into segment or at timecode 00;11;07;00; passed Harry White Drive at 28 seconds into segment or at timecode 00;11;29;00; end of segment of recording at @ timecode of 00;11;34;00	80	90	33	0.0295	0.0699
36000 to 39000	NB, at constant cruise speed of 80 km/h, end of segment of recording at @ timecode of 00;12;07;00	80	90	33	0.0306	0.0660
39000 to 42000	NB at cruise speed of 80 km/h, start braking @21 seconds into segment or at timecode 00;12;28;00; large upheaval at @ 00;12;25;00 which appears to be about 2 seonds after largest upheaval visible in recorded data suggesting video could be out of sync by @ 2 seconds. Come to a rolling stop at Glanworth with a second of reaching end of segment, end of recording of segment at @ 00;12;40;00	80 km/h, commence braking @ 21 seconds into recording to a rolling stop at end of recording	90	33	0.0273	0.0598

Figure 16: 3rd Portion of Summary of Results

Once again as the vehicle increases its speed past the Glanworth intersection Figure 17 shows how the lateral rotation of the vehicle increases. And as the vehicle is braked to reach the driveway to end the testing the lateral rotation diminishes. All these results are consistent with what one would expect as the iPhone was reporting valid data about the motion of the test vehicle.

The average longitudinal and lateral rotations shown in these figures provide an indication of the average effect that the road had on the vehicle over a distance of several hundred metres. While that information is useful it does not provide the details about what effects were created by localized depressions or undulations that might exist over a few meters or less. In order to reveal these influences a more in-depth look at the data is needed. Thus charts showing these details have also been prepared.

Samples	Location	Speed (km/h)	Sampling Rate (Hertz)	Length of Recording (Sec)	Stan Dev in Longitudinal Rotation (Rad/Sec)	Stan Dev in Lateral Rotation (Rad/Sec)
42000 to 45000	NB on Wonderland accelerating from rolling stop at Glanworth, reached 80km/h cruise speed at 16 seconds into segment or at @ timecode 00;12;56;00; end of segment recording at 00;13;13;00	from rolling stop to cruise speed of 80 km/h within 16 seconds	90	33	0.0407	0.0767
45000 to 48000	NB on Wonderland at constant cruise speed of 80 km/h passing onto newer section of pavemsent at @ 17 seconds of segment or at @ timecode of 00;13;30;00; recording of segment ends at timecode 00;13;46;00	80	90	33	0.0273	0.0577
48000 to 51000	NB Wonderland at constant cruise speed of 80 km/h travelling over new smooth pavement near new Hwy 401 underpass; begin braking at 11 seconds into segment or @ timecode of 00;13;57;00; start L turn at 18 seconds into segment or at timecode 00;14;04;00 at speed of 40 km/h; Come to a stop in driveway at timecode 00;14;14;09	80 km/h slowing to a stop	90	33	0.0233	0.0453

Figure 17: 4th Portion of Summary of Results

The following charts provide details of the motion of the test vehicle as it passed south and north along Wonderland Road. There are 3000 samples of data in each chart. Since there are approximately 90 samples per second, each chart shows approximately 33 seconds of travel time.

Figure 18 shows the first 3000 samples or the first 33 seconds of data as the test vehicle is stopped through the first part of the chart and then pulls out of the driveway and begins to travel southbound on Wonderland Road. The rough surface of the unfinished driveway causes high rotations of the vehicle. Once the vehicle enters onto the newly paved surface of Wonderland the rotations diminish near the end of the chart.

Referring back to Figure 14 we note that the lateral rotation of the test vehicle was 0.0408 radians per second over these first 33 seconds of motion. We can see in the charted details that this value was higher because of the motions caused while exiting the driveway. Conversely the chart shows that once the vehicle entered onto the newly paved surface the rotations dropped dramatically. Also one can see the very small rotations in the first portion of the chart where the vehicle is stopped. Thus these results illustrate that the sensed rotations on consistent with what one would expect.

In Figure 19 we see the charted rotations, between 3001 and 6000 samples, as the test vehicle continues southbound on the newly paved portion of Wonderland Road and then rotations become more prominent near the end of the chart where the test vehicle crosses onto the older portion of pavement south of Highway 401. Referring back to Figure 14 we see that the average lateral rotations over this road segment is 0.0424 radians per second, or not much different that the average in the first 3000 samples. Yet these detailed charts provide the additional details of how those averages were obtained by displaying the specific areas where large or small rotations were obtained.

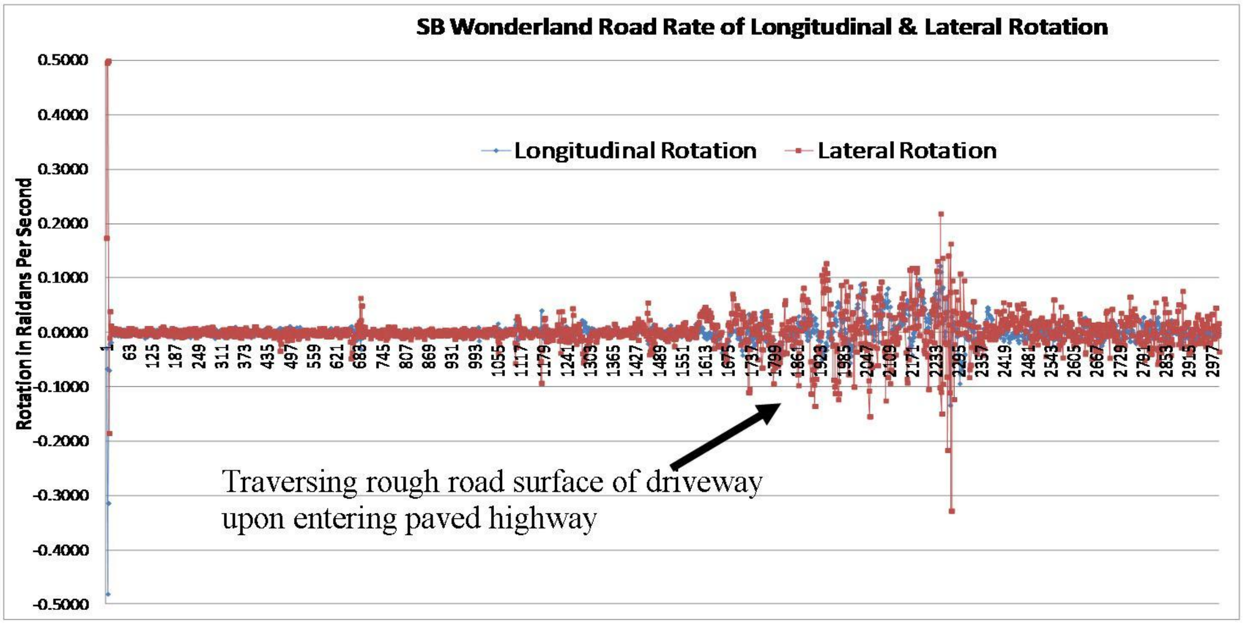

Figure 18: Chart between 0 and 3000 samples.

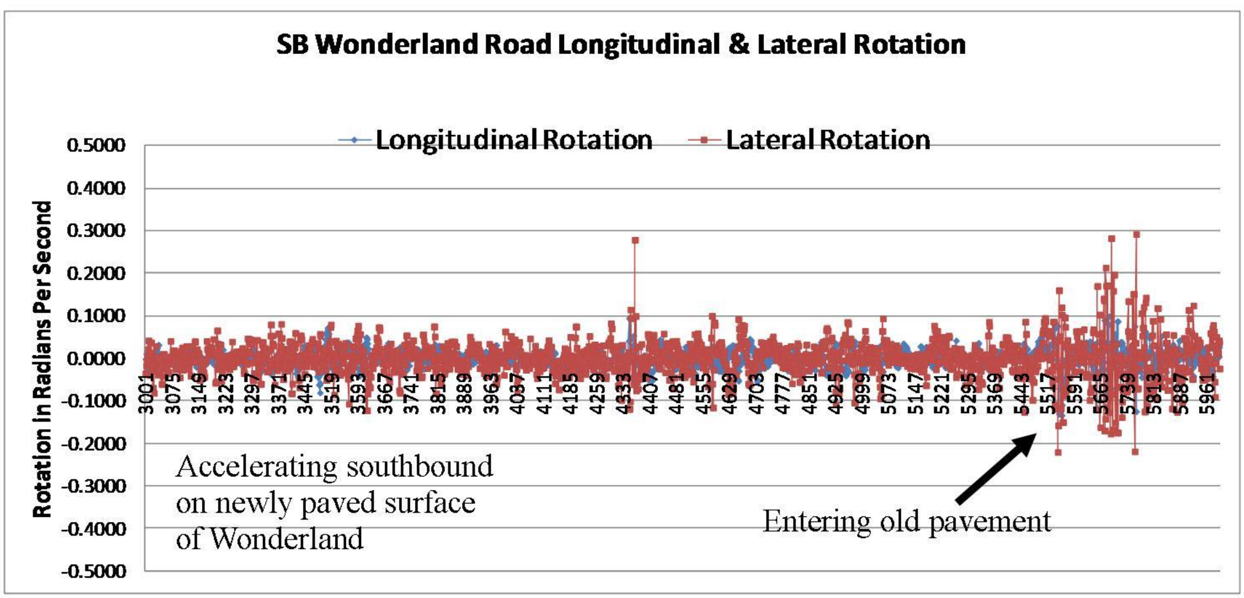

Figure 19: Chart between 3001 and 6000 samples.

In Figure 20 we see the road segment between 6001 and 9000 samples. Figure 14 indicates that this is where the test vehicle reached the cruising speed of 80 and was moving at this constant speed southbound over the old pavement while travelling toward the intersection with Glanworth Drive. Figure 14 indicates that the average lateral rotation is0.0680 radians per second, or substantially higher than the previous averages. The chart of Figure 20 shows that there is not a single portion of the road that stands out as the prominent factor in causing this high rotation, although there is one value near sample 7680 that caused a rotation rate between 4000 and 5000 radians per second.

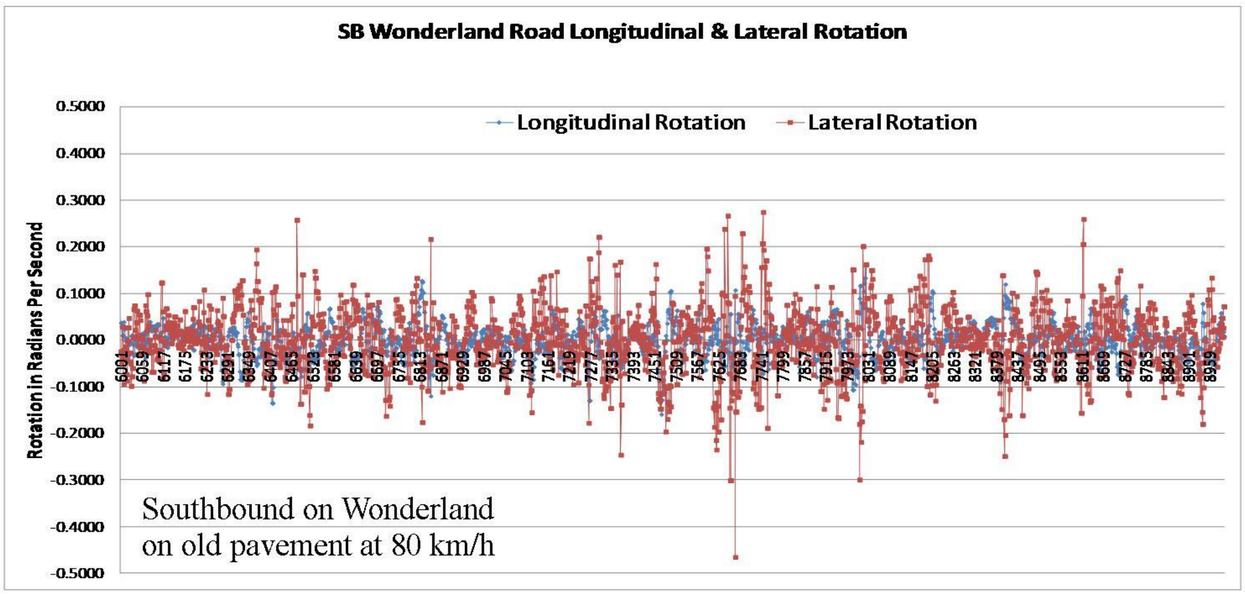

Figure 20: Chart between 6001 and 9000 samples.

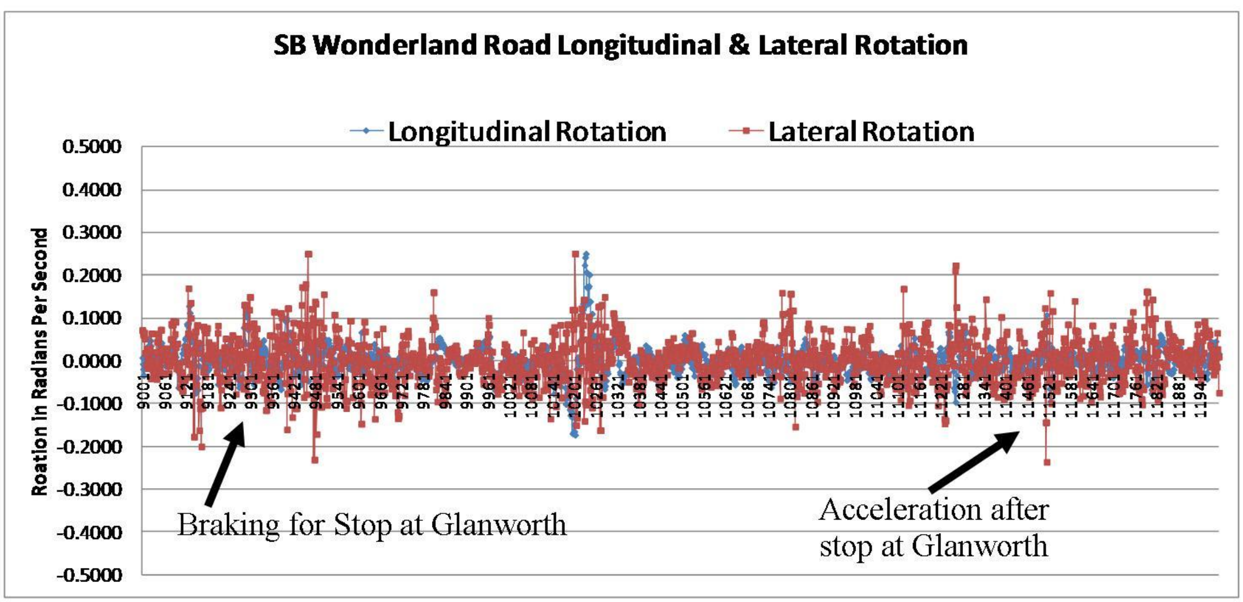

Figure 21: Chart between 9001 and 12000 samples.

Thus one might want to look at this area of the road in more detail to see what feature might have caused this high value. Thus one can see how these data can be useful, not only in illuminating the average condition of a road segment but also it isolating specific problem areas that may need correction.

Figure 21 shows the data as the test vehicle is braked and comes to a brief stop at the Glanworth Drive intersection. One would expect that the rotations would be reduced as the vehicle slows down and that is what occurs.

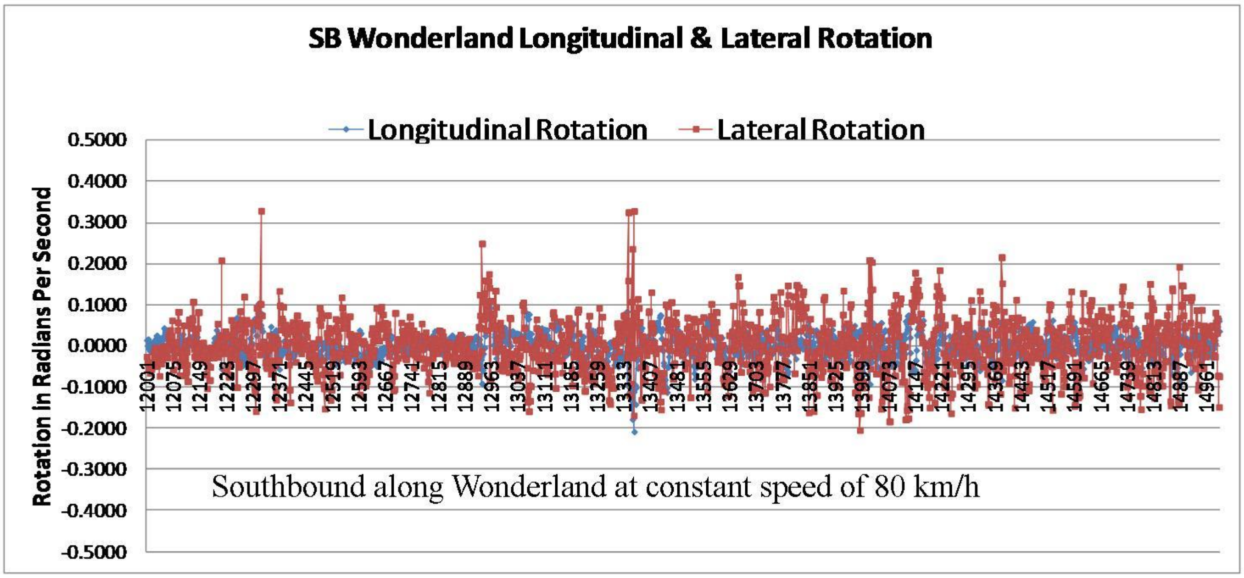

Figure 22: Chart between 12001 and 15000 samples.

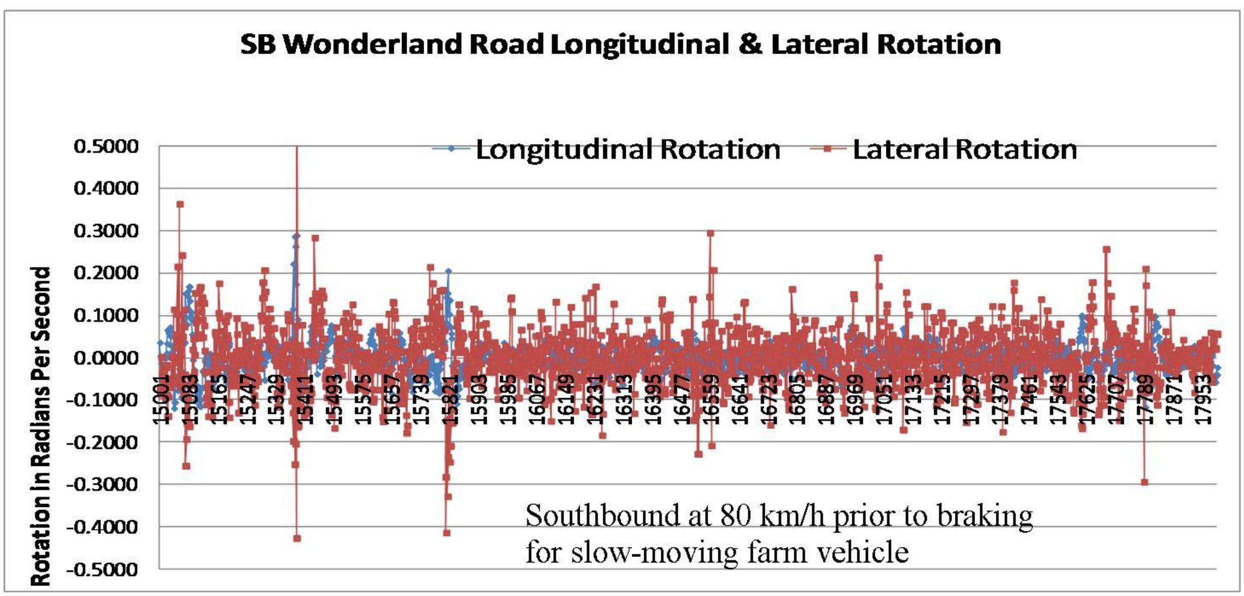

Figure 23: Chart between 15001 and 18000 samples.

Figures 22 and 23 show what happens as the test vehicle continues southward past the Glanworth intersection. At the constant speed of 80 km/h we see that the average lateral rotations rise to 0.0632 and 0.0731 respectively. Those are very high values. That can be appreciated by examining any of the data previous obtained on other roads and highways in the Road Data page of the Gorski Consulting website.

In Figures 24, 25 and 26 we see the reduction in rotations as the test vehicle is slowed to a speed of 30 km/h because of a slow-moving farm vehicle. Again, these results illustrate that the sensed data is consistent with what would be expected.

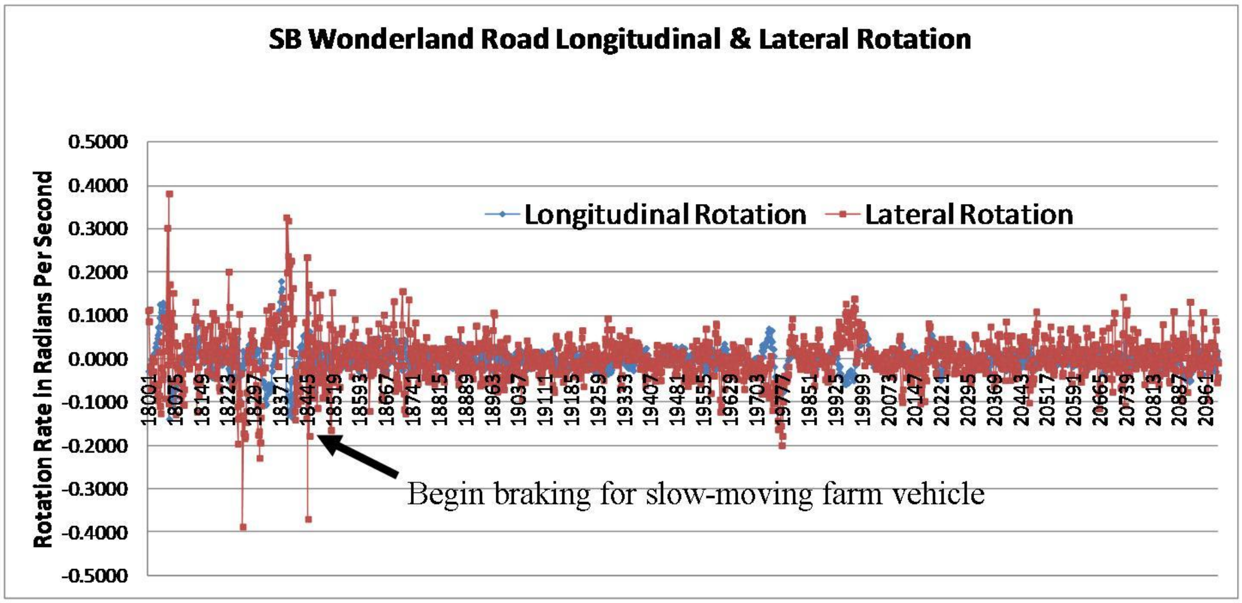

Figure 24: Chart between 18001 and 21000 samples.

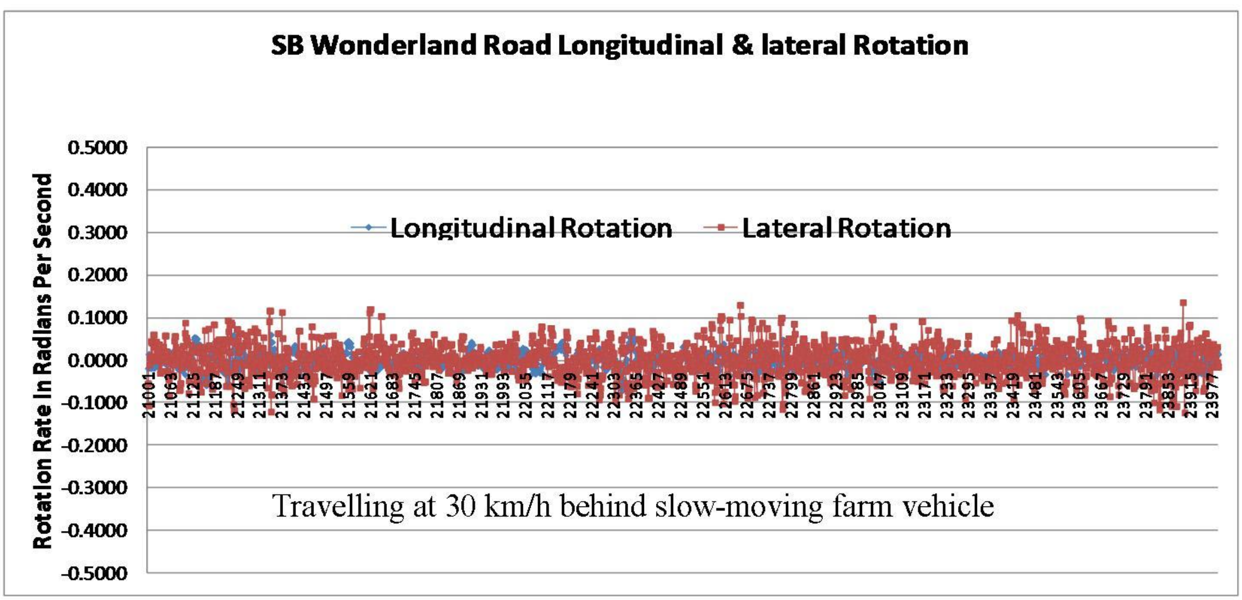

Figure 25: Chart between 21001 and 24000 samples.

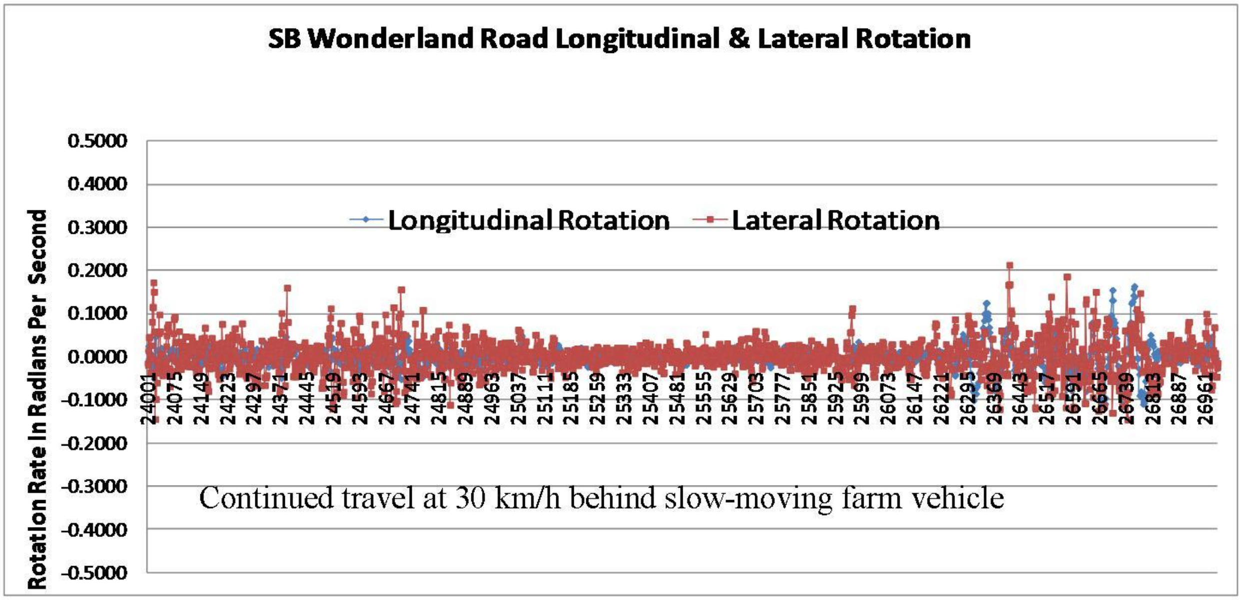

Figure 26: Chart between 24001 and 27000 samples.

In Figure 27 we see the data as the test vehicle reaches Ferguson Line and a U-turn is made to continue the testing northbound on Wonderland. During the U-turn there is an increase in the rotation of the vehicle even through its speed has been reduced to 15-20 km/h, and this would be expected. By the end of this chart the test vehicle has already increased its speed to 70 km/h and is travelling on the return route northbound on Wonderland. As expected, as the vehicle's speed increases the rotation rate also increases.

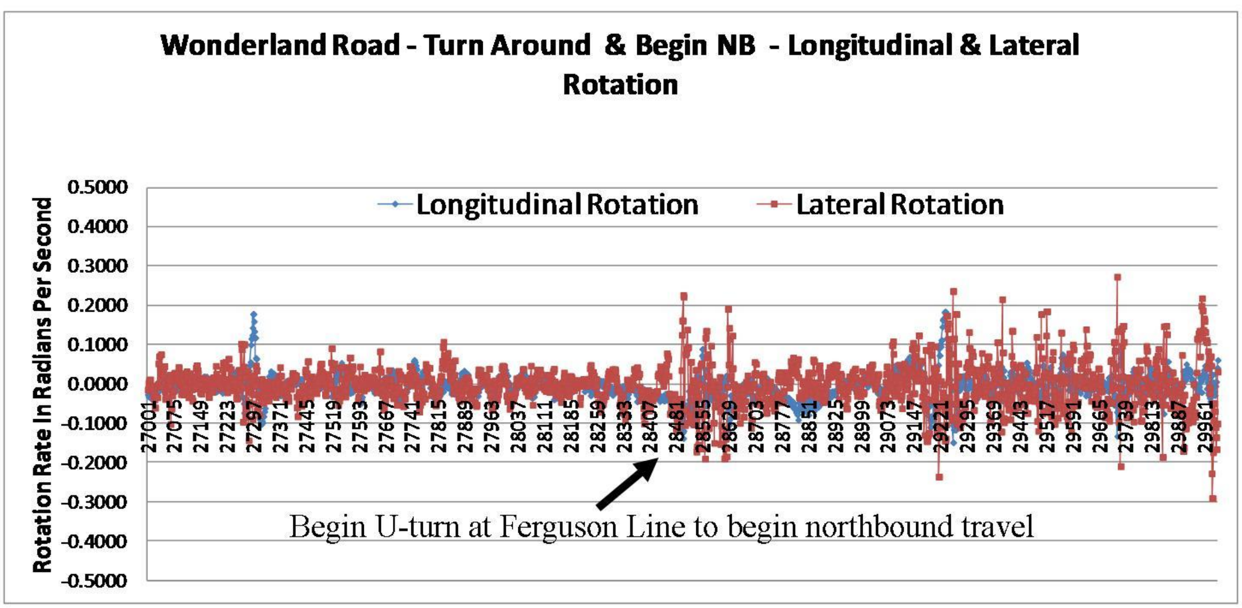

Figure 27: Chart between 27001 and 30000 samples.

In Figure 28 we see the test vehicle accelerating for an additional 4 seconds until it reaches its cruise speed of 80 km/h. Figure 16 indicates that the average lateral rotation within these 33 seconds of data is 0.0641 radians per second. That is not as high as the highest value that occurred between 15000 and 18000 samples when the test vehicle was southbound near Harry White Drive. Yet it is still very high.

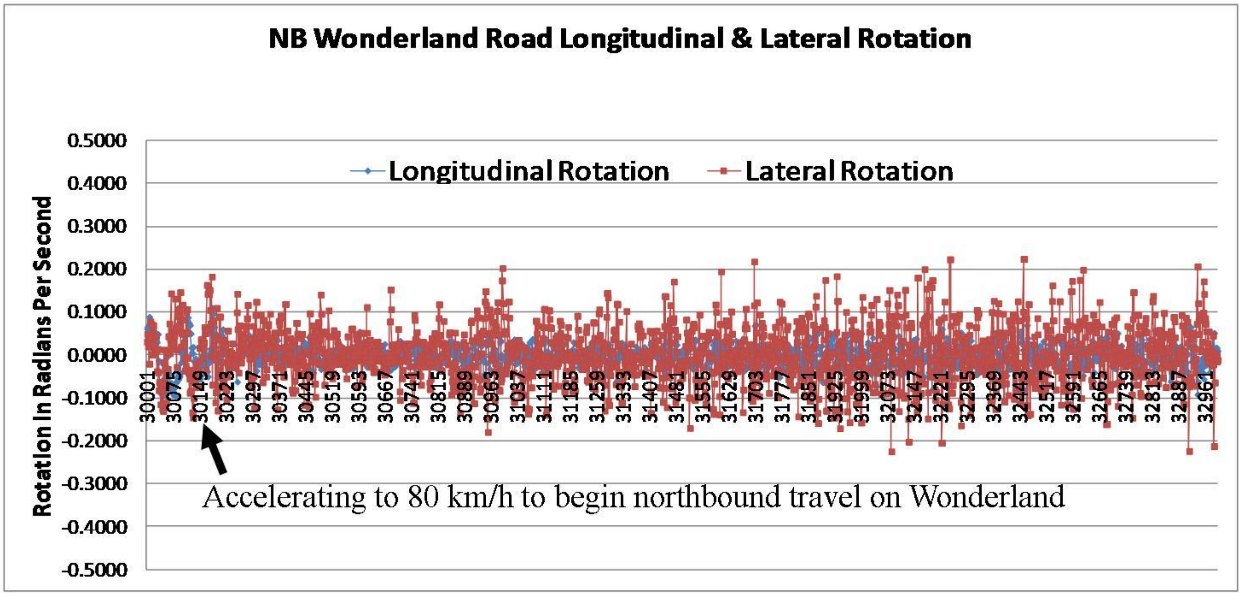

Figure 28: Chart between 30001 and 33000 samples.

Figure 16 indicates that the data in Figure 29 produced an average lateral rotation of 0.0699 thus the rotation has increased. In particular we see a large spike in the rotation just as the test vehicle in near Harry White Drive.

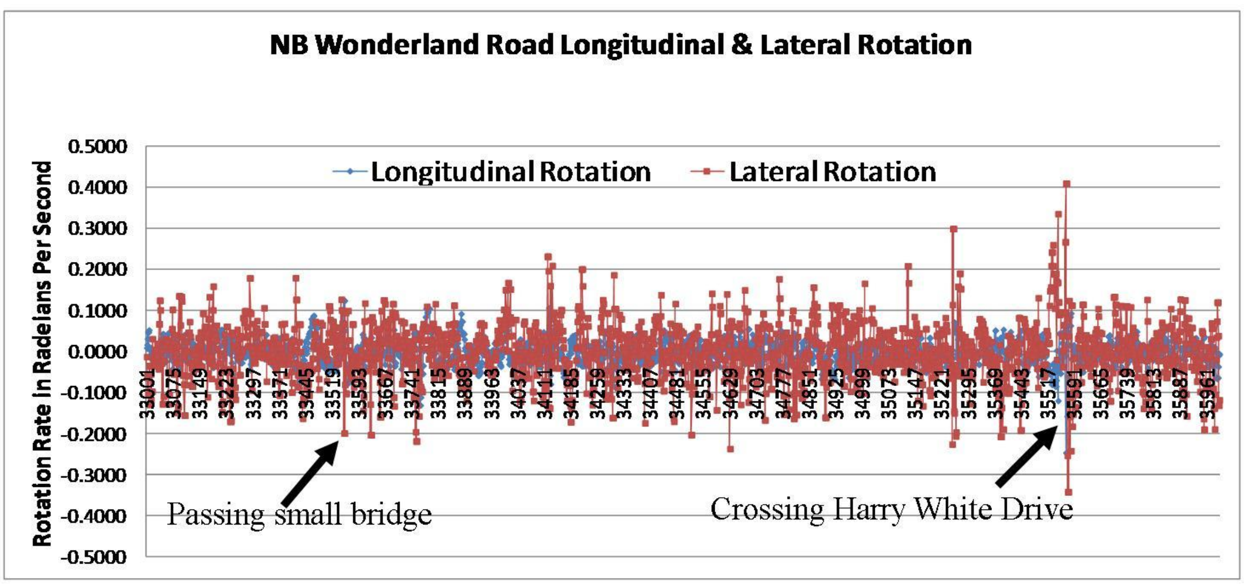

Figure 29: Chart between 33001 and 36000 samples.

Figure 16 indicates that the data in Figure 30 also shows a high lateral rotation rate of 0.0660 radians per second.

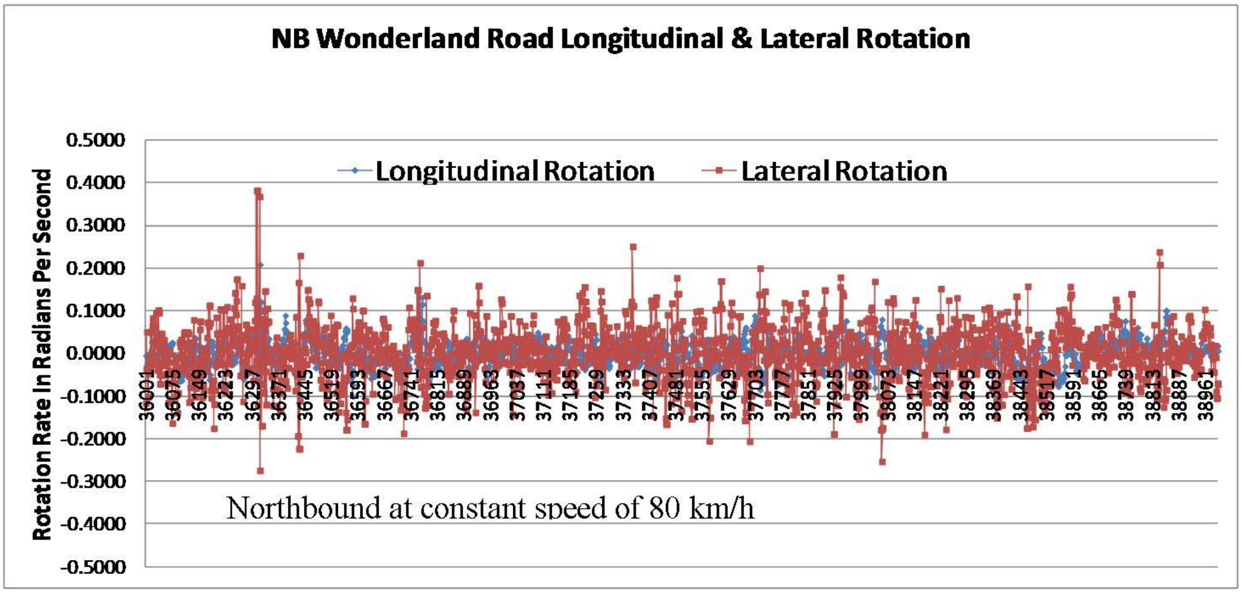

Figure 30: Chart between 36001 and 39000 samples.

Figure 31 shows an interesting set of data in that the average lateral rotation is reduced to 0.0598 because of the braking that has commenced for the stop at Glanworth Drive. Yet we see a very large spike in the lateral rotation just before the braking occurred. The spike is so high that the red line is drawn extending beyond the range of the chart. Thus this would be an area of the road that would be worthwhile exploring.

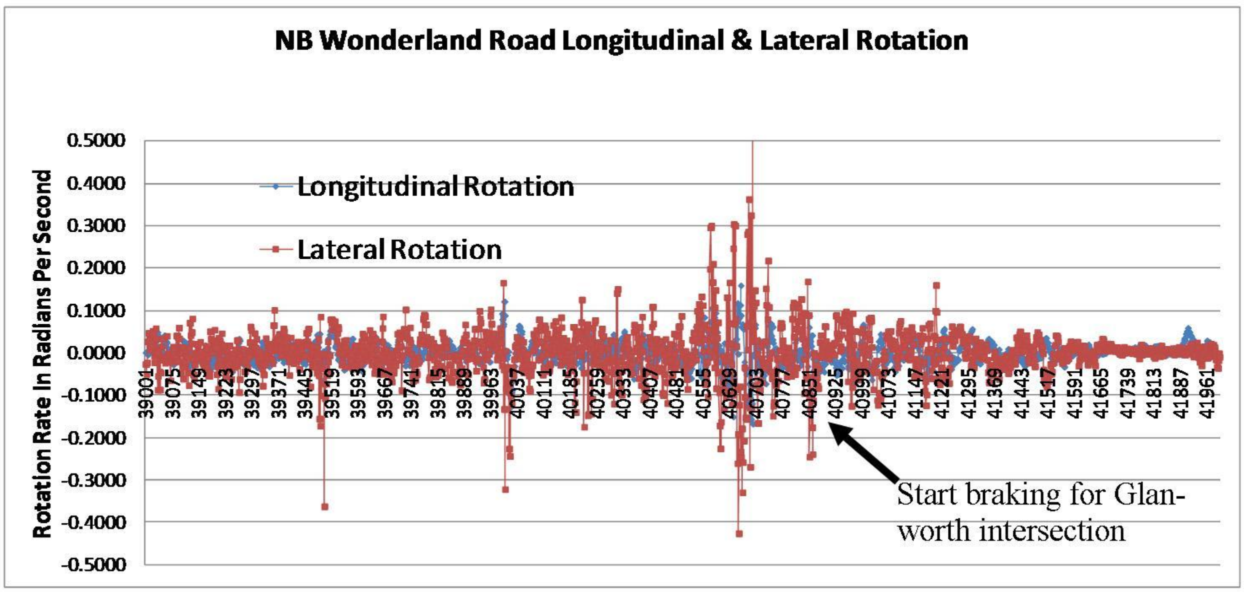

Figure 31: Chart between 39001 and 42000 samples.

Similarly, Figure 32 shows another area of high rotation as the test vehicle was accelerating for about 3 seconds from its rolling stop at the Glanworth intersection. Figure 17 indicates that this road segment produced the highest, average, lateral rotation of 0.0767 radians per second. Beyond the above-mentioned area of high rotation during the acceleration there are also several spikes of rotation after the vehicle has reached it cruise speed of 80 km/h.

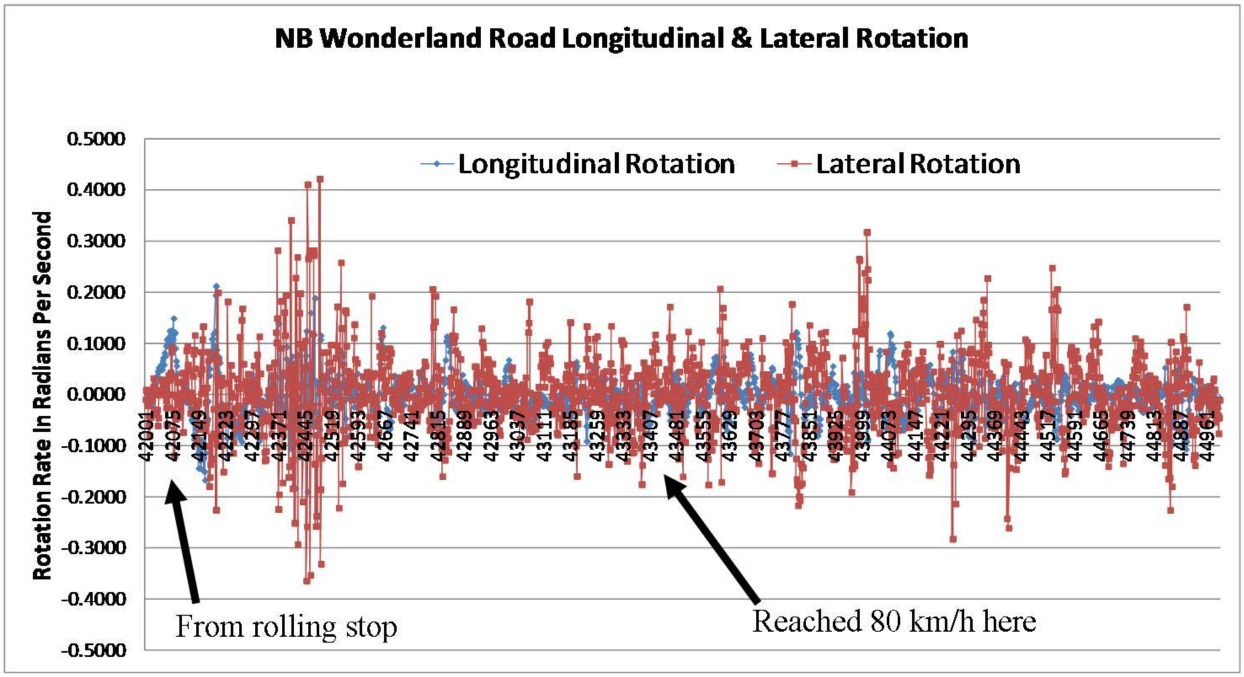

Figure 32: Chart between 42001 and 45000 samples.

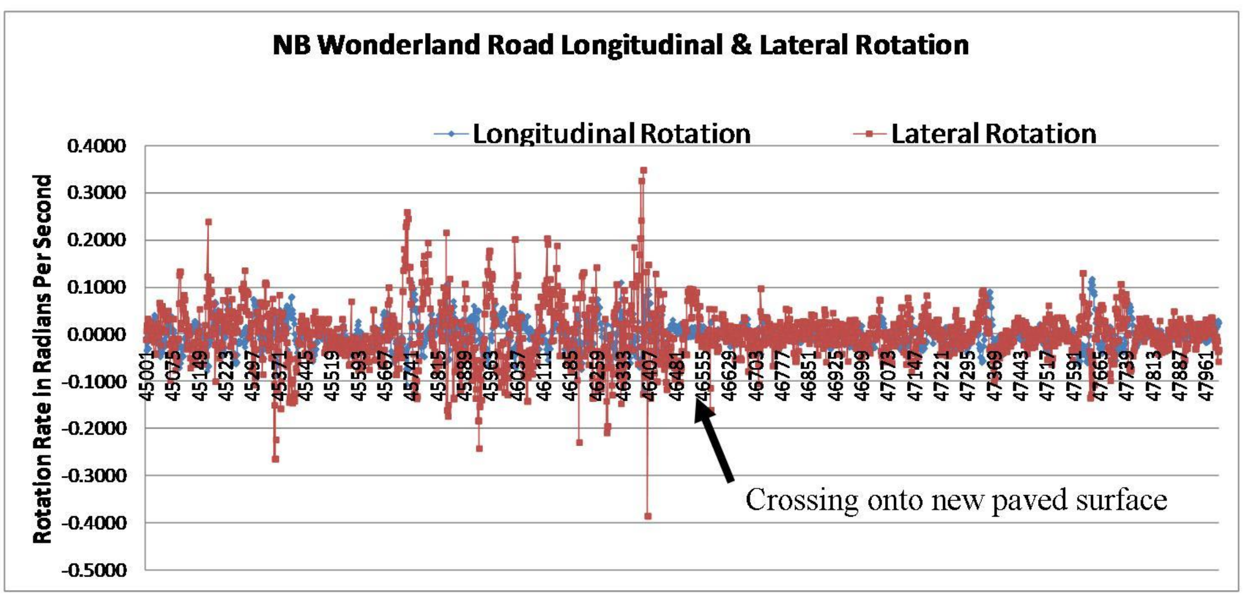

Figure 33: Chart between 45001 and 48000 samples.

These high rotations persist into Figure 33 until the test vehicle reaches the area of the newly paved asphalt and then we see an obvious decrease in lateral motion. Even though in Figure 33 the test vehicle continues travelling at highway speed the lateral motion continues to be low, again as expected, until the vehicle makes its left turn into the driveway north of Highway 401.

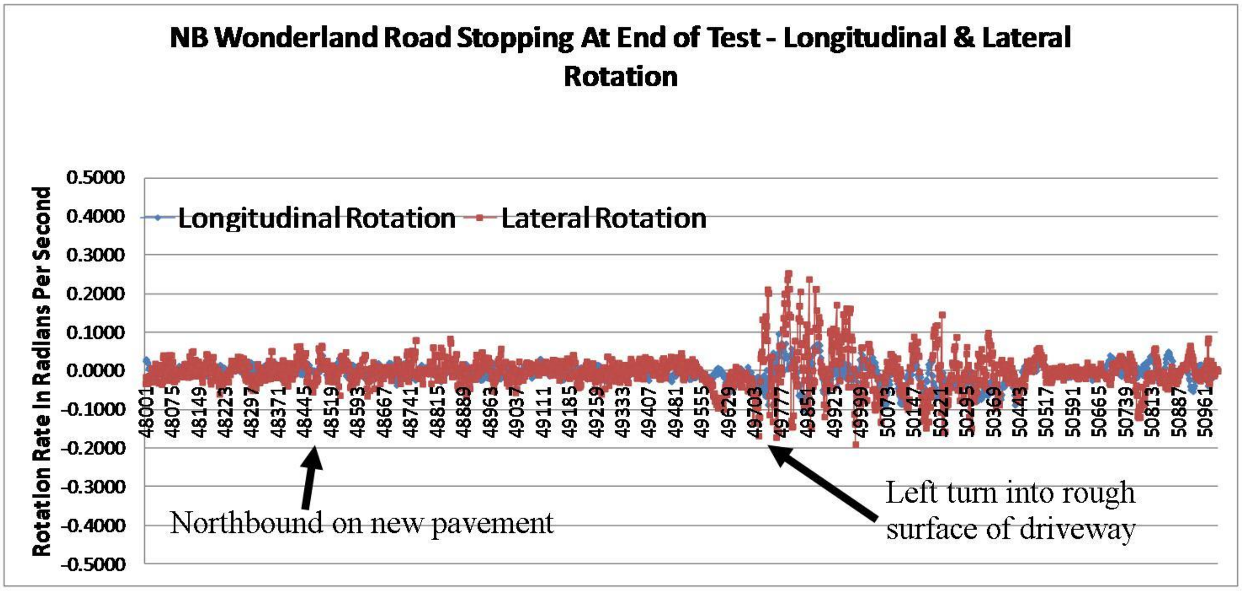

Figure 34: Chart between 48001 and 51000 samples.

Thus throughout this testing process we see that the sensed data is consistent with what would be expected and therefore this methodology provides a valid, reliable and accurate documentation of the road conditions.

Of greater utility is that the road data is matched to the output of the multiple video cameras attached to the test vehicle. Thus we can know precisely what portion of the road caused the data. As an example, we can explore what caused the large motions in the test vehicle at the beginning of Figure 32 as the test vehicle was being accelerated forward after it had stopped for the Glanworth intersection. Figure 35 is a screenshot taken from the Premiere video project showing the views of four video cameras at the point where the test vehicle was beginning to accelerate forward from its stop. One can see the speedometer/tachometer in the upper left corner. The speedometer is at “zero” and the tachometer is at about 1800 rpm. So this is where the acceleration began.

We can also see, in the upper right, a “zoomed in” from the camera looking forward through the vehicle’s windshield. This view helps to show what features of the road the vehicle will be approaching.

At the bottom left is a view from a camera mounted on a lateral pole that is anchored to a bike rack behind the test vehicle. Thus this view shows the portion of the road to the left of the vehicle and we can see the vehicle’s left rear tire. Thus we know precisely where the vehicle is on the road when these views are shown.

Figure 35: Screenshot from Premiere video project showing the northbound test vehicle stopped at the intersection of Glanworth Drive and beginning to accelerate forward.

Finally, in the bottom right, is a view looking forward toward the driver's seat from a camera mounted behind the two front seats. A view like this provides information about the driver's actions.

Next, in Figure 36 we see the scenario after the test vehicle has advanced slightly so that its speed in now 20 km/h, as evidenced by the view of the speedometer. And finally, in Figure 37, we see the scenario after the test vehicle has reached a speed of 30 km/h.

When these views are seen in video it is possible to see the "bounce" of the vehicle and cameras when there is a large disturbance caused by the road. And this is precisely what was observed in the video project as the frames were viewed. Thus we could establish that the test vehicle was being disturbed just as it was passing over the intersection.

The significance of this is that the City of London has plans to change the stop sign arrangement such that vehicles travelling north and south of Wonderland will not have to stop and vehicles on Glanworth will be controlled by the stop sign. This is a good idea because of the increased traffic volume on Wonderland created by the building of the interchange at Highway 401. However, what will happen to vehicles passing through this intersection at highway speed? Look at the results of the displacement of the test vehicle when it is only travelling at 20 to 30 km/h. Is it likely that the lateral rotation of a vehicle passing through the intersection at 80 to 90 km/h will be much higher? How about the longitudinal rotation, will it also be higher in combination with the lateral rotation? Is it not likely that there could be a problem here if the City does not pay attention to this layout of the intersection but only changes the positioning of the stop signs?

This is an example where our methodology can expose roadway problems before they cause a serious, injury-producing event. The cost of the methodology is rather low. A vast number persons possess smartphones and a large number of those use iPhones.

The use of video cameras also does not have to be a large expense. Although GoPro cameras were used in this testing it is actually advantageous to use lower-cost, older GoPros set at low resolutions because the real challenge is that most consumer based computers cannot handle the information content of just 3 or 4 videos running at the same time. In fact, the videos used the current project were shot at just 720p and that content then had to be “shrunk” to enable the project to run with multiple camera views without seizing up. Thus cheap cameras are actually a benefit.

The idea is to gather objective evidence about road conditions that is currently not available to the public. Various testing is performed by jurisdictions that document the smoothness of a road segment and these methods employ specialized vehicles and equipment. However, the methodology here is different. We use a passenger car that is popular in the marketplace such that its suspension is relatively typical of what would be driven by an average driver. It is of little concern that our vehicle’s performance cannot be matched precisely to the specialized instrumentation used to document road surface smoothness. Our test vehicle is one that could be expected to be on the road and the road must be so designed that it allows the driver of such a vehicle to travel safely on any road.

Currently all our data in the Road Data database was created using the 2007 Buick Allure. Although aged it has had improvements such a new struts on all four wheels. The fact that another vehicle may be used for the testing in the future might have to be taken into consideration when comparing the results obtained from the current vehicle. However, there is no reason to argue that the results are invalid or unreliable. The results are based on the instrument that was used and that instrument is well known.

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