Rough Roads, Increasing Speed and Change in Test Vehicle Motion - Data Separation Into 3 Road Segments

Posting Date: 9-April 2015

In earlier articles (2 posted to the Gorski Consulting website on March 6, 2014 and 1 posted on March 20, 2015) we reported on the data obtained from driving our test vehicle over a poor road surface (Sunningdale Road in London, Ontario) on March 3, 2014, April 5, 2014 and on February 27, 2015. The general findings were that, as the vehicle's speed was increased its longitudinal motion remained relatively constant whereas its lateral motion increased. The results were presented over the full length of the road from Clarke Road to Highbury Avenue. In fact, that road contained varying conditions that likely diluted the strength of the findings. Prior to 2011 this road had poor winter-time surface conditions throughout its length. However, in the fall of 2011 the worst section, roughly in the middle of the length, was paved with new asphalt. Thus the full road segment became divided into 3 segments: a rough road segment, a smooth road segment, and another rough road segment. When the results of our testing were reported over the full road length without taking these differences into consideration it likely diluted their significance. It has been our ambition to separate the test data into these 3 partitions and report on the updated results.

Thus the discussion in the present article will be with respect to the separation of the data into the three road segments. This separation has been performed for the February 27, 2015 testing data only. As time permits we will hopefully be able to report on the separated data from the March 3, 2014 and April 5, 2014 testing dates.

Prior to reporting on the updated data it is necessary to refresh the reader about the procedures that were performed in the testing. Thus the following text is a copy of the beginning of the previous articles so that the reader can become acquainted with the testing without having to refer back to the previous articles.

Review of Testing Procedure (Reported in Previous Articles)

A 2007 Buick Allure passenger car was equipped with multiple video cameras.

The test vehicle was driven westbound and eastbound along Sunningdale Road in London, Ontario, between the intersections of Clarke Road and Highbury Avenue, as shown in Figure 1.

The distance over which the testing was conducted was approximately 2 kilometres. The speed of the vehicle was increased at 10 km/h intervals from 40 to 90 km/h.

Sunningdale Road was generally straight and level except for a small sag located near its east end. There was a small bridge at the bottom of this sag as shown in the westward views of Figures 3 and 4.

An Apple iPhone 4S was used as the instrument that sensed the changes in the test vehicle's lateral and longitudinal motion.

The testing was begun at the intersection at Clarke Road where the test vehicle was at a stopped position. The "record" button on the iPhone was activated and then the vehicle was accelerated to the desired speed. While travelling westbound the vehicle passed over the old pavement, some of which is shown in Figure 2. At the approximate location of the small bridge (shown in the background of Figure 2) the section of new pavement was encountered. As the vehicle progressed further westward the new pavement terminated and the vehicle began travelling on the old pavement. Shortly afterward, on approach to the intersection of Highbury Avenue, the vehicle was stopped on the north shoulder, the "pause" button was activated on the iPhone and the data file was sent by e-mail to a remote computer. The vehicle was then turned around and another run was performed in an eastbound direction. This process was repeated at travel speeds of 40 through to 90 km/h, at 10 km/h increments.

Figures 2 through 11 provide westbound views along the full length of Sunningdale where the testing was performed.

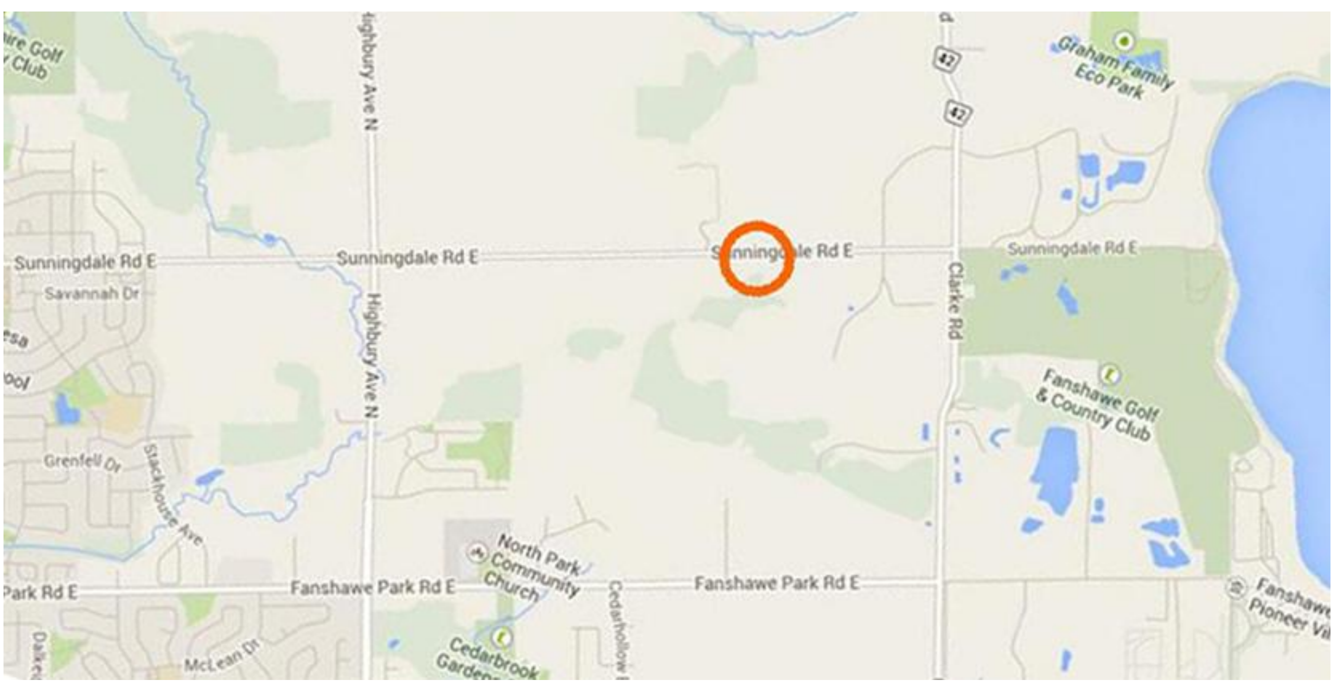

Figure 1: View of testing location on Sunningdale Road in London, Ontario, Canada, between Clarke Road to the east and Highbury Avenue to the west.

Figure 2: View looking westward along Sunningdale Road from just west of the intersection at Clarke Road. The utility pole on the right side of this view containing the"80 km/h" maximum speed sign, is the precise starting point where the captured data was analyzed.

Figure 3: View, looking west along Sunningdale Road. Shortly after commencing the data collection a sag is encountered as shown in this view. Commencing at the location of a small bridge the rough road surface was repaved thus a smoother section of pavement was encountered.

Figure 4: View, looking west along Sunningdale Road. The newer (smoother) section of pavement commenced at the west (far) side of this small bridge.

Figure 5: Upon mounting the upslope of the sag (at small bridge) the roadway entered a long section that was straight and level, as shown in this westward view. The pavement in this area was new and smooth.

Figure 6: Near the end of the smooth section of pavement there was a warning sign posted on the right roadside indicating the return of the older and rougher section of road.

Figure 7: Continuing further westward the end of the newer pavement can be seen in the distant background of this westward view along Sunningdale Road.

Figure 8: View, looking west along Sunningdale Road. The end of the newer section of pavement can be seen in the background.

Figure 9: View, looking west along Sunningdale Road at the point where the newer section of pavement ends and the rougher section of surface returns.

Figure 10: View, looking west along Sunningdale Road, along the rough portion of pavement on approach to the intersection with Highbury Avenue.

Figure 11: View, looking west along Sunningdale Road just east of the intersection with Highbury Avenue. This view shows that the rough segment of pavement ends on the approach to the Highbury intersection.

The point where the rough surface transitioned back into the newer section of pavement (Figure 10) is where the analysis of the gathered data was terminated. Thus each run contained a road segment of rough surface, followed by the smooth surface and then finished off with a segment of rough surface.

Review of Test Results

When the e-mailed data file was retrieved at the office, it was converted into an Excel spreadsheet. Part of the data file reported the rate-of-change of the lateral and longitudinal motion of the vehicle and these two parameters were selected for further review. This rate-of-change in the angle of the vehicle was reported in radians per second. There are 57.3 degrees in one radian. As a measure of the dispersion and differentiation of the data it was decided to take the standard deviation of the data points. This would provide a simple way of showing how quickly the vehicle moved away from its "mean", level position.

Figures12 through 17 contain the tables of data from the separation of the test runs into three separate road segments from the February 27, 2015 testing date. The "Lateral" and "Longitudinal" values being reported in the tables are the motion of the test vehicle, in radians per second, displayed as a standard deviation value. For the time being we have only separated the data for the February 27, 2015 testing date. Separations for the other two testing dates (March 3 and April 5, 2014) are expected to be completed and reported at a later date.

This data from February 27th is charted in Figures 18 through 23 below. In the charts the blue line indicates the lateral motion while the red line indicates the longitudinal motion of the test vehicle. The axis along the bottom of the chart indicates the increasing speed of the test vehicle, from 40 to 90 km/h. The vertical axis is expressed in radians per second, from the minimum of 0.0100 to the maximum of 0.0700.

Figure 18 displays the westbound data along the 1st Rough Road Segment. Eastbound travel along this segment is displayed in Figure 19 because, for eastbound travel this is the 2nd Rough Road Segment.

Figures 20 and 21 display the westbound and eastbound data along the Smooth Road Segment.

Similarly, Figure 22 displays the westbound data for the 2nd Rough Road Segment. Figure 23 displays the eastbound data for that road segment which is the 1st Rough Road Segment for eastbound travel.

Westbound Testing on Sunningdale Rd - February 27, 2015

1st Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0346	0.0529
50	0.0422	0.0462
60	0.0447	0.0456
70	0.0471	0.0404
80	0.0534	0.0400
90	0.0622	0.0426

Figure 12: Data from westbound testing on 1st Rough Road Segment.

Smooth Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0181	0.0264
50	0.0213	0.0264
60	0.0254	0.0255
70	0.0283	0.0253
80	0.0311	0.0254
90	0.0324	0.0254

Figure 13: Data from westbound testing on Smooth Road Segment.

2nd Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0403	0.0642
50	0.0442	0.0582
60	0.0538	0.0569
70	0.0529	0.0512
80	0.0626	0.0509
90	0.0624	0.0454

Figure 14: Data from westbound testing on 2nd Rough Road Segment.

Eastbound Testing on Sunningdale Rd - February 27, 2015

1st Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0337	0.0505
50	0.0424	0.0518
60	0.0531	0.0511
70	0.0543	0.0523
80	0.0602	0.0476
90	0.0661	0.0545

Figure 15: Data from eastbound testing on 1st Rough Road Segment.

Smooth Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0204	0.0249
50	0.0249	0.0270
60	0.0294	0.0234
70	0.0335	0.0234
80	0.0411	0.0240
90	0.0421	0.0234

Figure 16: Data from eastbound testing on Smooth Road Segment.

2nd Rough Road Segment

Speed	Lateral Motion	Longitudinal Motion
40	0.0342	0.0455
50	0.0392	0.0441
60	0.0480	0.0446
70	0.0520	0.0443
80	0.0610	0.0358
90	0.0659	0.0482

Figure 17: Data from eastbound testing on 2nd Rough Road Segment.

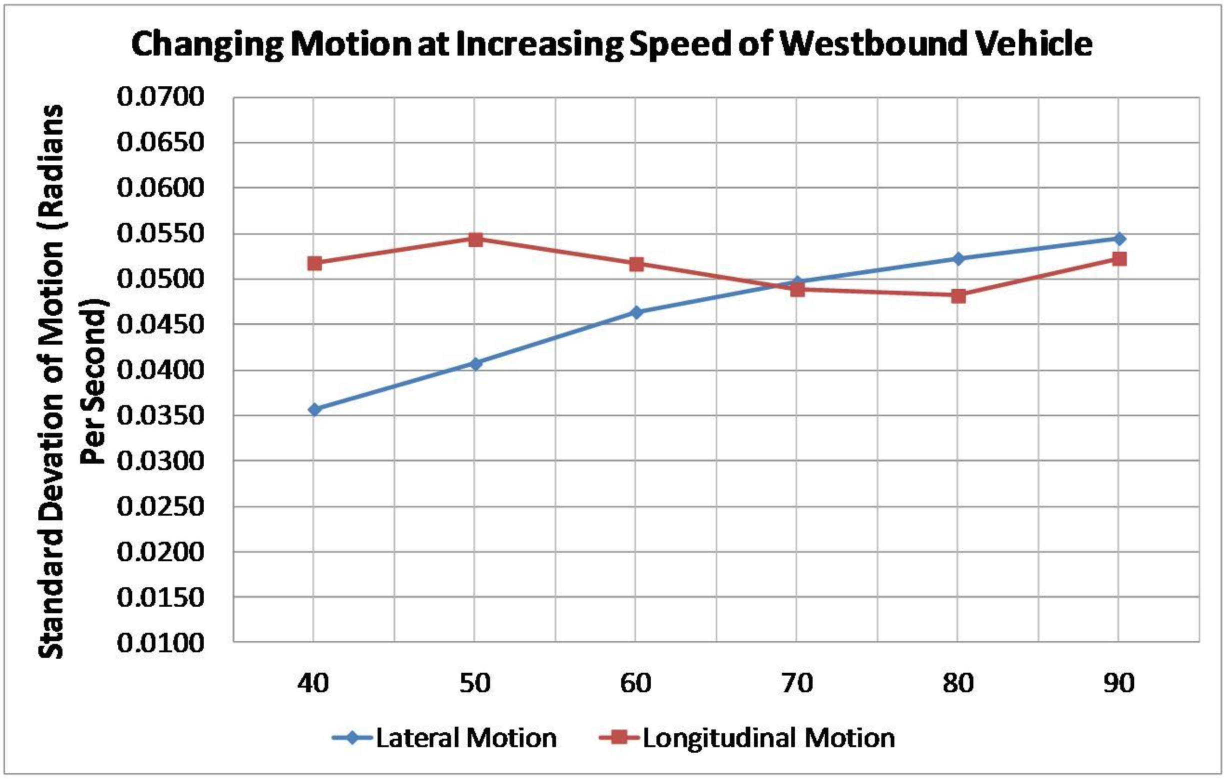

Figure 18: March 3, 2014 - Westbound runs along 1st Rough Road Segment.

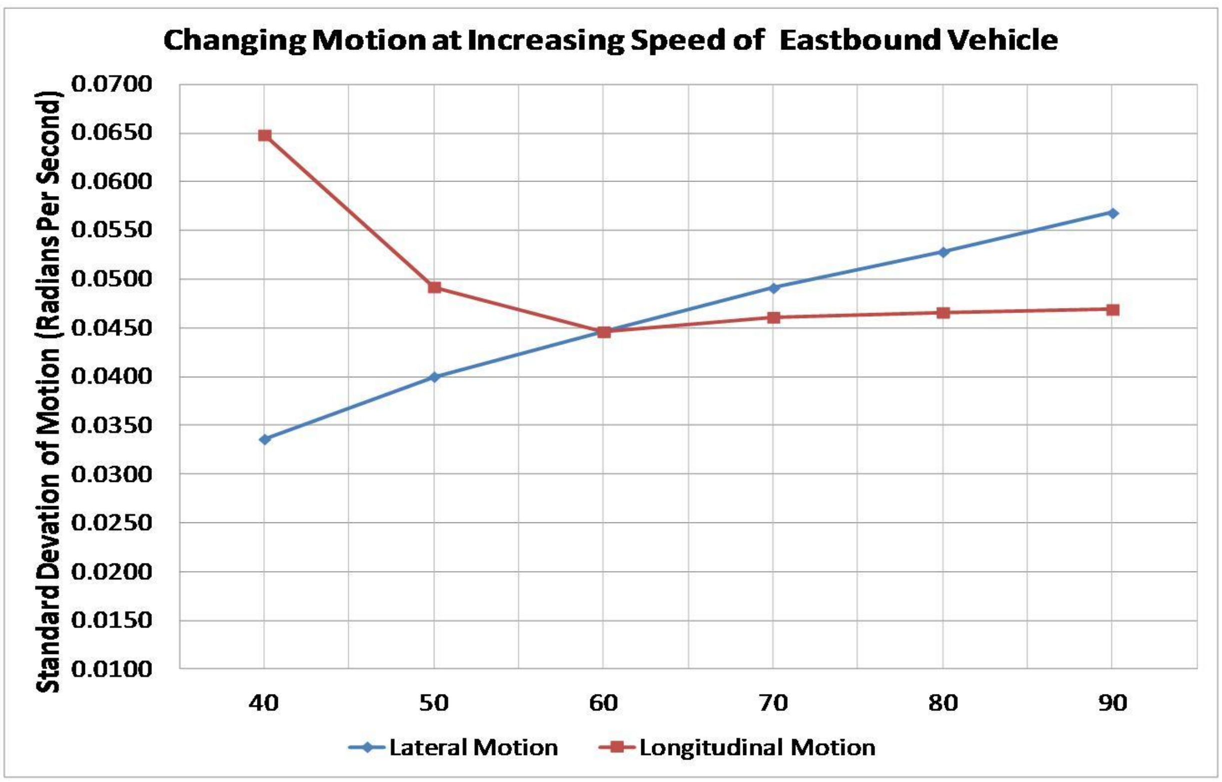

Figure 19: March 3, 2014 - Eastbound runs along 2nd Rough Road Segment (opposite side of road to data in Figure18).

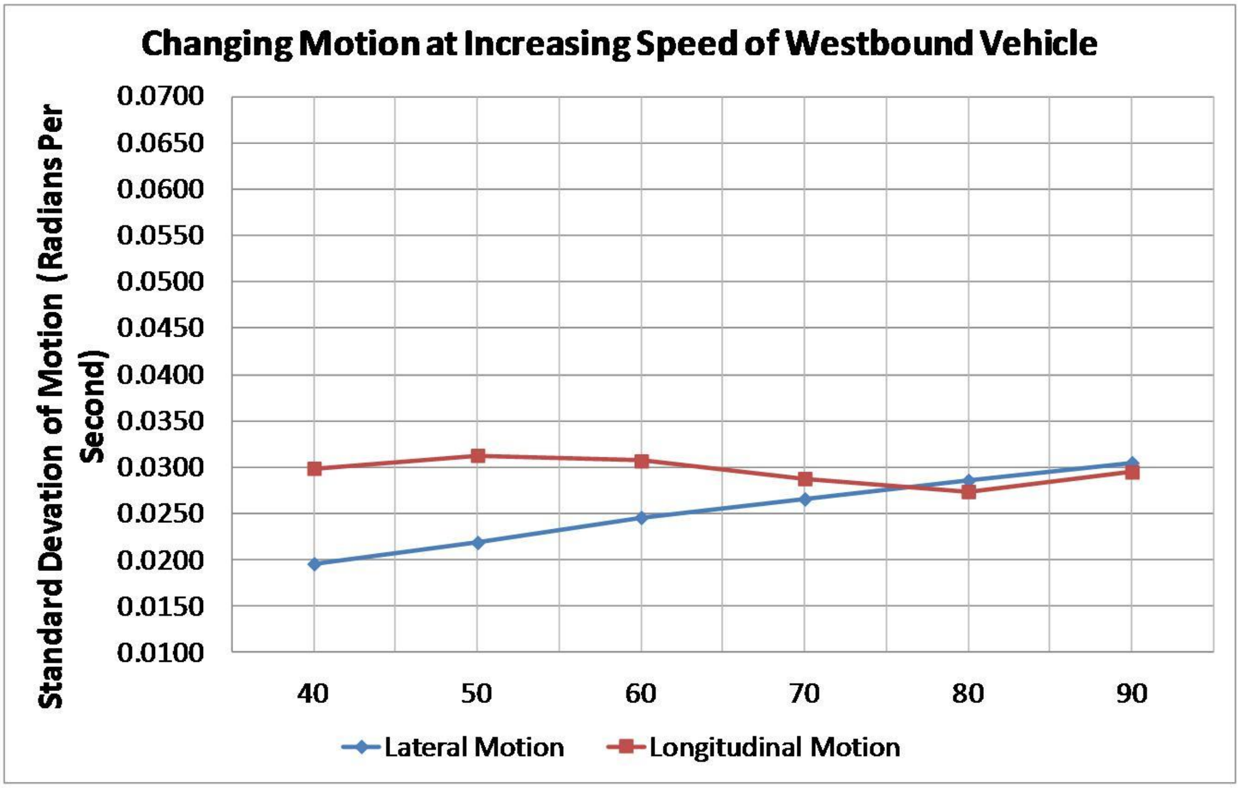

Figure 20: April 5, 2014 - Westbound runs on Smooth Road Segment.

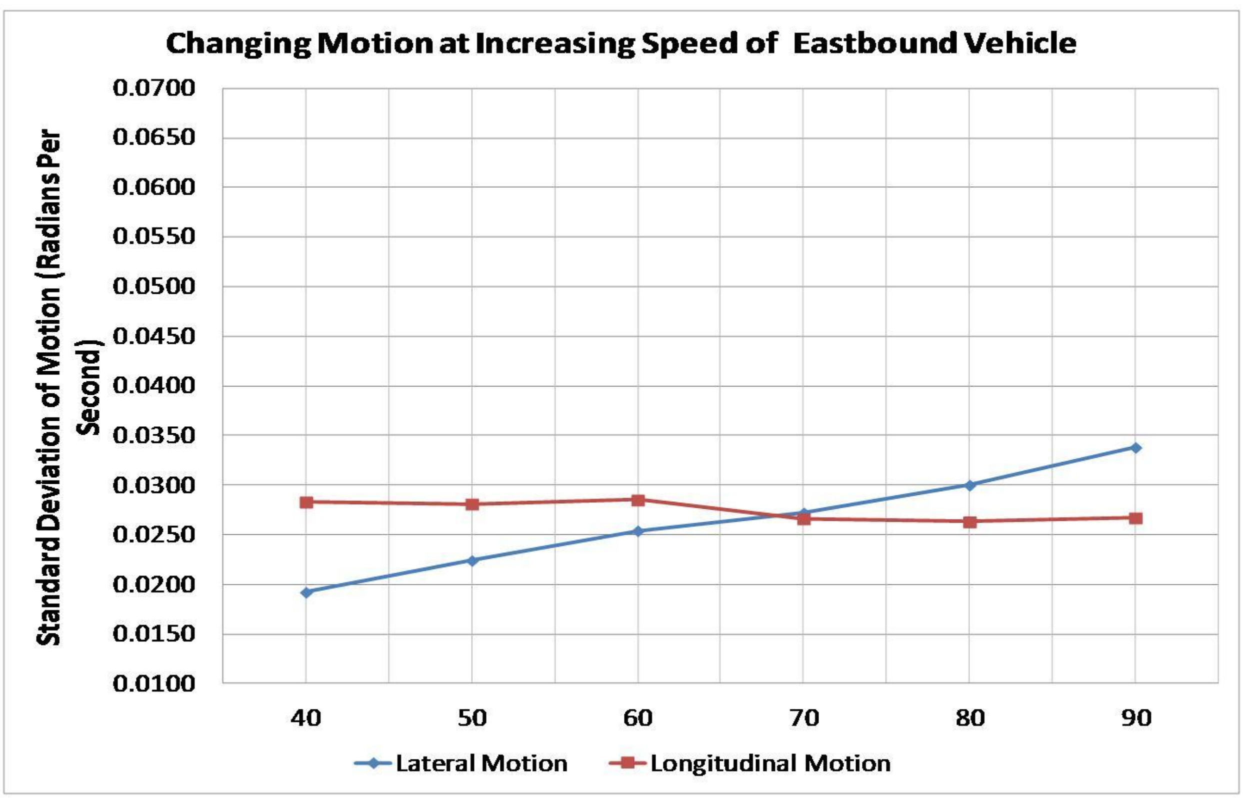

Figure 21: April 5, 2014 - Eastbound runs on Smooth Road Segment.

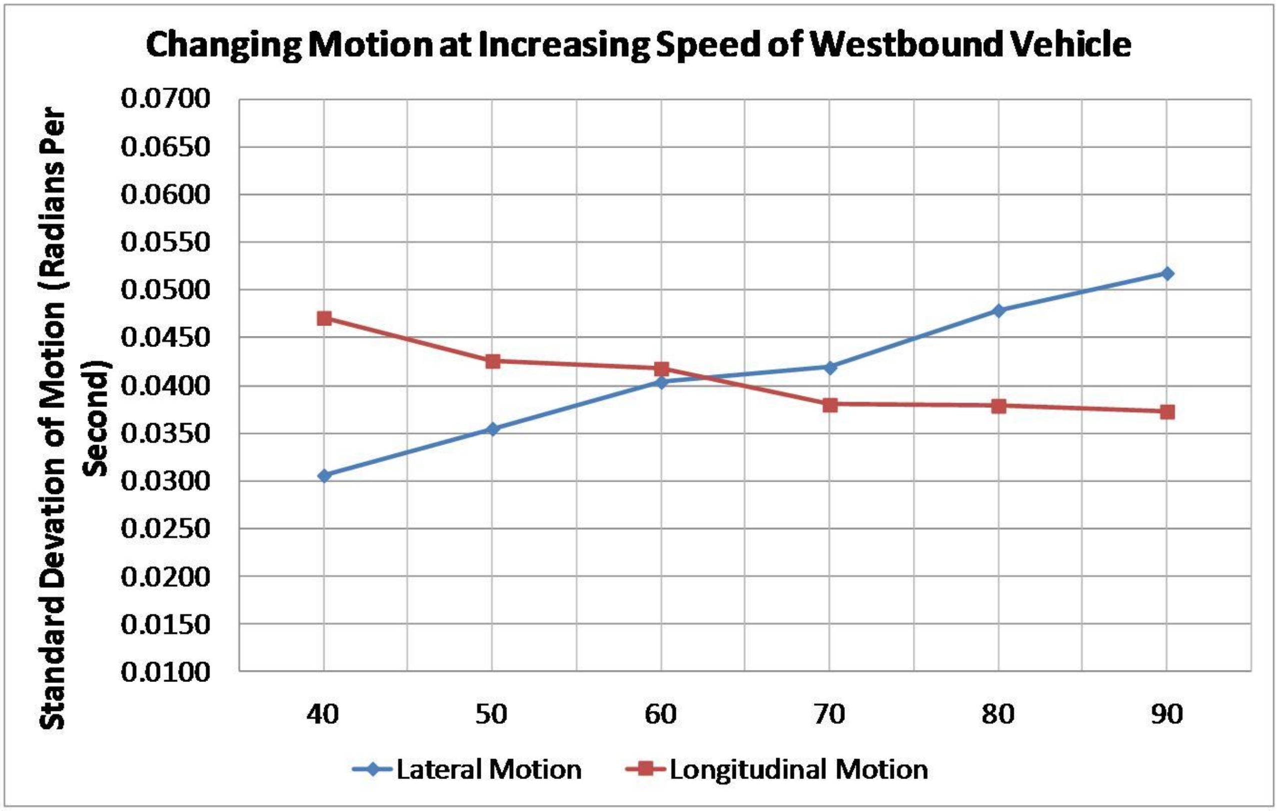

Figure 22: February 27, 2015 - Westbound runs on 2nd Rough Road Segment.

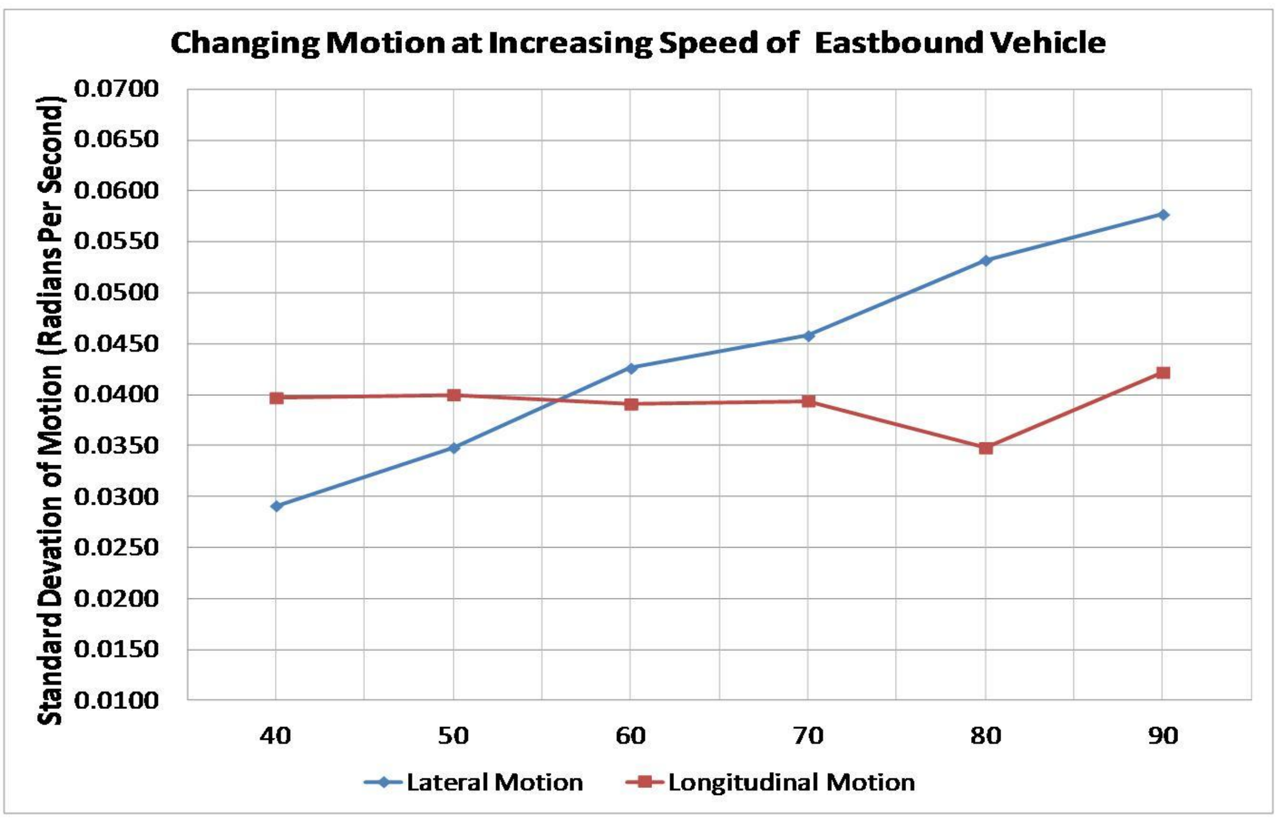

Figure 23: February 27, 2015 - Eastbound runs on 1st Rough Road Segment (Opposite side of road to data in Figure22).

Discussion

In the area of Sunningdale Road where the testing was conducted the road surface is prone to frost upheaval, usually commencing in mid-January and then receding in late March. Thus the February 27, 2015 testing was performed when the frost upheaval was present. The effect of the upheaval of the road surface can be seen in the higher levels of motion displayed in the Rough Road Segments versus the Smooth Road Segment.

In the earlier articles it was noted that, at the lower speeds of 40-50 km/h the rate-of-change in the longitudinal motion was higher than it was for the lateral motion. However, as the speed was increased, the rate-of-change of the longitudinal motion stayed the same, or perhaps even showed a reducing trend with increasing speed. However, the rate of change in the lateral motion rose significantly as the speed of the test vehicle was increased such that, at the highest speeds (80 and 90 km/h) the lateral motion was higher than the longitudinal motion. These observations were made before the data was separated into the three segments. As a result of the separation into the noted three segments we can now see more clearly whether these previous observations hold true.

Upon a review of the separated data the obvious observation is that the vehicle's motion is much less when travelling over the Smooth Road Segment than over either of the two Rough Road Segments. The charts in Figures 20 and 21 show that the lateral and longitudinal motion on the Smooth Road Segment is in the general range of 0.0200 to 0.0300 radians per second. These values are substantially lower than the data for the Rough Road Segments (Figures 18,19, 22 and 23) when the data is in the range of 0.0300 to 0.0600 radians per second.

Another observation is that, even on the Smooth Road Segment, the lateral motion appears to show a rising trend with increase of the vehicle's speed. Meanwhile, the longitudinal motion does not show this rising trend. In fact, one might believe that there could be a slight trend of lower longitudinal motion with increasing speed.

Figures 18 and 19 show the Rough Road Segment that is at the east end of the road length. This is the 1st Rough Road Segment if travelling westbound or the 2nd Rough Road Segment if travelling eastbound. There appears to be a singular outlier in this data for the eastbound longitudinal motion at 40 km/h wherein the motion is unusually high (0.0650 radians per second). Otherwise, the remaining data seems to support the conclusion that the longitudinal motion remains relatively constant with increasing speed, or there might be a slight negative relationship. Regardless, the lateral motion, whether travelling westbound or eastbound, continues to demonstrate that there is an increase of lateral motion with increased speed (See Figures 20 and 21).

Figures 22 and 23 provide the westbound and eastbound data for the Rough Road Segment at the west end of the road length. This is the 2nd Rough Road Segment if travelling westbound or the 1st Rough Road Segment if travelling eastbound. Again, this data in consistent in demonstrating that lateral motion increases with the vehicle speed whereas the longitudinal motion remains relatively constant, or perhaps is reduced slightly with increasing speed.

The new data re-affirms what was indicated in the earlier articles. There appeared to be some choppiness in the longitudinal data as it rose or fell from one speed to another, while generally exhibiting no large increase during increasing speed.

In contrast, the lateral motion data seemed to exhibit a steady, incremental increase that matched very well with the incremental increase in vehicle speed. This pattern was exhibited regardless of the test vehicle's travel direction or whether the vehicle was travelling on a smooth or rough road segment.

The data from the separation of the road length into the three segments of smooth and rough road has been performed only for the testing that was done on February 27, 2015. It can be recalled from previous articles that testing was also done on March 3, 2014 and April 5, 2014. Thus the data from these additional testing dates can also be separated and re-examined. It is also likely that a fourth set of tests will be performed in the middle of summer in 2015 so that we can completely eliminate the possibility of any frost upheaval in the road surface as a factor.

These findings are important. When investigators attempt to determine the causes of a loss-of-control collisions it is imperative that they understand what contributions the road surface might have to the loss-of-control. Gorski Consulting has conducted testing on many roads in Southern Ontario wherein the lateral and longitudinal motions of the test vehicle have been documented. This data is available on the "Road Data" page of the Gorski Consulting website. This data enables the comparison of one road versus another based on objective measures. The additional analysis that we conduct on Sunningdale Road provides further instruction regarding the meaning of the road data. The observation that the lateral motion of a test vehicle increases with vehicle speed and that the longitudinal motion remains relatively constant is not a finding that is known in the collision reconstruction community.

What degrees of motion constitute a potential danger to the loss-of-control of a vehicle is also not discussed. In many instances, the first responders are police investigators who have very little training or experience in such assessments yet they are required to make a determination. That determination is then reported in a variety of official research claiming to support countermeasures for improving roadway safety.

In other instances, road user associations such as the Canadian Automobile Association (CAA) use the news media to bombard the public with opinion polls that ask average drivers to report the worst roads in their area. Without any useful knowledge or experience these road users report these roads to the CAA website and then the roads with the most complaints are announced as the "Worst Roads" in Ontario. That information is then used to pressure local politicians to repair those worst roads regardless of priorities determined by the local road authorities. While not perfect, local road authorities have better understanding and experience than average road users about which road segments need to be serviced before others. If the CAA had wanted to capture the worst roads they could easily do so by referring to the "Road Data" on the Gorski Consulting website or perform similar objective testing, however their campaigns continue, year after year without acknowledging the harm being done.

The present system also makes it impossible for road users to obtain objective data about the roads on which they drive because local road authorities who collect such data keep it secret for fear of civil litigation. It is for this reason that Gorski Consulting will continue to add to the database of road testing on our website as it is important to the safety of all road users that some objective measure be made available to the public.

Gorski Consulting
London, Ontario, Canada