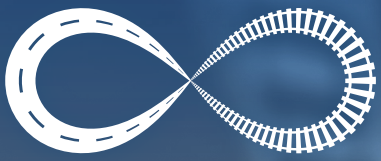

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

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RESTRICTIONS OF USING SPEEDOMETER READINGS FOR DETERMINING VEHICLE COLLISION SPEED

Michal Křižák, Albert Bradáč, Marek Semela, Roman Mikulec
Brno University of Technology, Institute of Forensic Engineering, Czech Republic

Abstract

Investigation or estimation of vehicle collision speed is one of the most important tasks during traffic accident analysis. The speedometer needle is sometimes stuck showing possible speed data especially at severe road accident. That is generally an additional possible indicator for speed estimation for forensic expert. The paper is aimed at accuracy and differences between real speed data and display of speedometer needle data. The possible data inaccuracy can be observed during vehicle braking or in cases of driving stability loss (vehicle skid). Results of correlations between speed registered by speedometer and actual speed have been found during lock-up of wheels through stability loss skid, during acceleration with spinning wheels, and during braking manoeuvre measurements at various friction conditions. Through aforementioned manoeuvres, significant data differences have been shown and explained in this paper.

Keywords: speedometer, velocity, vehicle, comparison, difference

1 Introduction

There are not many publications dealing with the possibility of using a stuck speedometer needle or imprint of the needle left on the gauge face to determine vehicle impact velocity. The authors of these publications concluded that under certain circumstances it is possible to state that the speed displayed by the stuck speedometer needle after a traffic accident is a collision speed. In [1] authors concluded that for the accident vehicles with electronic speedometers, there was a strong correlation between the residual reading of the speedometer and the actual vehicle speed at the impact moment. Their conclusions were based on investigation of 30 traffic accidents with stuck speedometer needles. The frozen needle indication can be used as a reliable indication of motorcycle impact speed in situations where there is no pre-impact lock-up of the speed-sensing wheel for motorcycle speedometers with stepper-motors of high torque resistance. For cases where there is an evidence of pre-impact wheel lock-up an adjustment to the frozen speedometer reading can be made based on the speed-time lag curve for particular vehicle's speedometer, [2]. Passenger cars speedometers indicate slightly higher than the true speed. During braking there is a time delay between vehicle slowing down and speedometer needle visible movement as a reaction on speed change, [3]. The useful approach for vehicle collision speed determination is the needle slap effect, in which an imprint made by the needle of the speedometer is left on the gauge face at the time of impact. Both car and motorcycle instrument panels were examined in order to analyse this effect. It is recommended to analyse speedometers in the laboratory, however it is possible to carry it out right at the accident scene with use of proper equipment. There are limitations in using this methodology, for example data from speedometers cannot be used when wheels lock occurs or when the vehicle is equipped with digital speedometer. Also only

frontal collisions were investigated in this paper, since they are more likely to cause appearance of needle marks compared to other impact situations, [4].. There was also a suggestion for automotive industries in order to regulate the use of materials that promote the exchange between the needle and the gauge plate, to highlight the needle slap effect, [5]. From the above, it can be concluded that in some cases it is possible to identify the speed indicated by the speedometer needle after the accident with the speed indicated at the moment of impact. Now, however, it is necessary to look at what actually shows the speedometer immediately before the impact. The velocity information is provided to the speedometer either analogically from the gearbox output or digitally by a control unit that evaluates the speed at the gearbox output or the speed of the individual wheels (mostly from the ABS sensors). So the question is: What does the speedometer show when the vehicle is intensively braked? There is a slippage in the case of breaking, therefore the vehicle speed and wheel circumference speed are not the same. However, the sensor signal is in most cases processed, so the displayed value on the speedometer does not have to match exactly the values of the sensors. There may be a delay, the control unit may avert over a certain period of time (moving average), etc.

2 Goals

The aim of this research is to verify the relationship between the real value of the vehicle velocity and the value displayed by the speedometer when the speed is changing dynamically, especially during intensive braking maneuver.

3 Methods and Measuring Equipment

The first set of data, that started this research, was acquired during vehicle's dynamics testing in moose test when sudden loss of traction resulted in 180-degree spin with locked wheels. Second test, aimed mainly to confirm aforementioned hypothesis and to determine best testing method, were brake tests from approximately 60 km/h with several vehicles on dry road conditions. Drivers were instructed to drive at constant velocity before braking to estimate average percentage speedometer error. For data evaluation actual vehicles' speed had to be measured and synchronized with video camera capturing position of the speedometer needle and, where possible, also numerical value displayed on vehicle's infotainment screen.

Figure 1 Racelogic VBox Video HD2

Two vehicles were fitted with Racelogic VBox Video HD2, which utilizes GPS-acquired speed. Setup was slightly complex, and manipulation with data proved to be somewhat difficult as VBox does not synchronize GPS data with video frame numbers in tabular form. For this reason, velocity data for each analyzed video frame had to be extracted using OCR techniques. Racelogic VBox utilizes 10 Hz GPS writing frequency and lag, which was considered as adequ-

ate enough. The spin was performed in Skoda Superb III 1.4 TSI, 110 kW, 6-speed manual, year of make 2016. For brake tests, two cars of different makes were used. First, it was Jeep Renegade 2.0 TDi, 103 kW, 6-speed manual, year of make 2015. Second was Ford Focus Combi 1.6 Ti-VCT, 77 kW, 5-speed manual, year of make 2014.

4 Results

4.1 Test 1 – Spin

As was mentioned above, this set of data acquired during vehicle dynamic tests started our research about difference between speedometer readings and an actual vehicle speed. The following figures Fig. 2 and Fig. 3 show the difference between actual speed and speedometer needle (and display) was very high, peaking at 25 km/h difference during the vehicle spin.

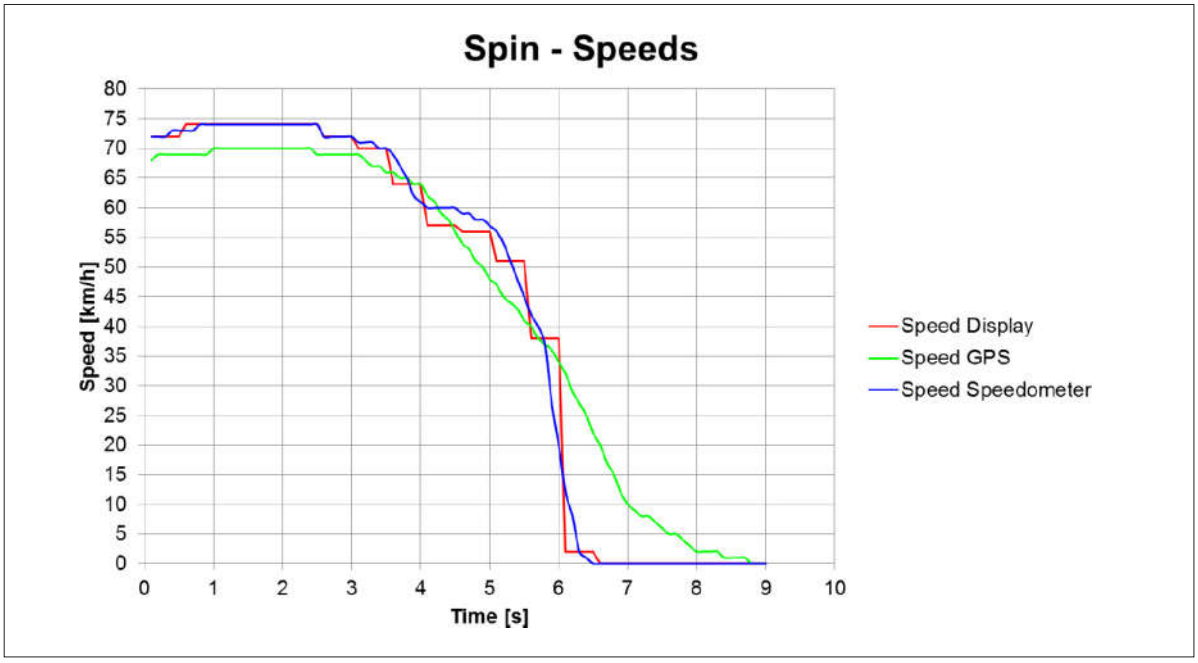

Figure 2 Vehicle speed measured during spin

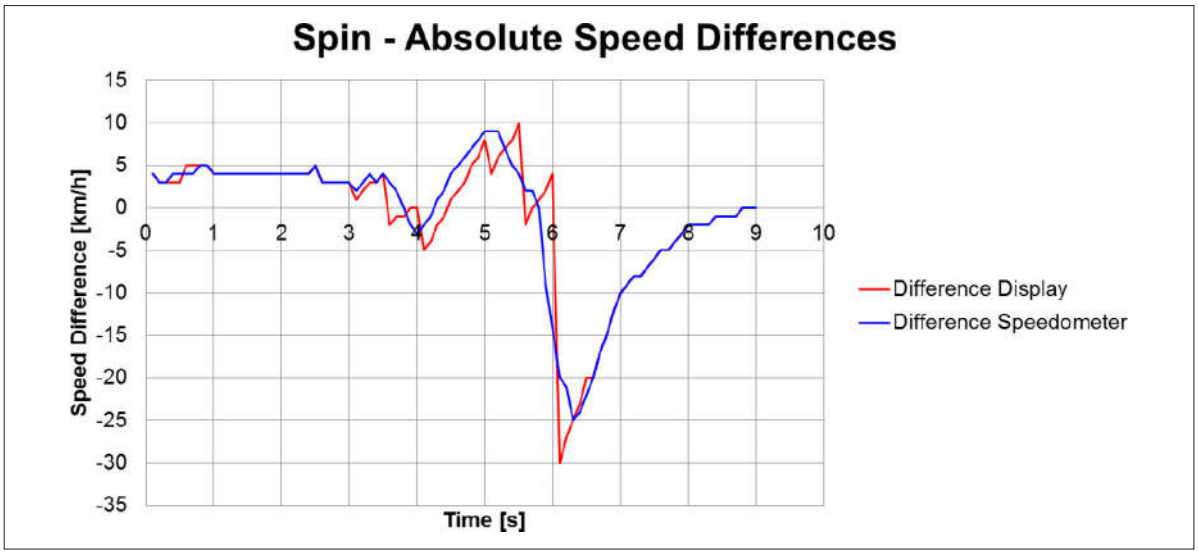

Figure 3 The absolute speed differences of the measuring equipment during the vehicle spin

4.2 Test 2 – Vehicles with Racelogic VBox

10 Hz GPS frequency of Racelogic's VBox provided more accurate data with lower speed measurement lag. From the following figures can be seen the desired outcome this research was aiming for, i.e. to showcase the difference between actual vehicle speed gained by an independent measurement equipment and speedometer reading. At constant speeds this is expected and is related to speedometer construction and legislation, but during the brake test those differences were much higher (see Fig. 4 and Fig. 5).

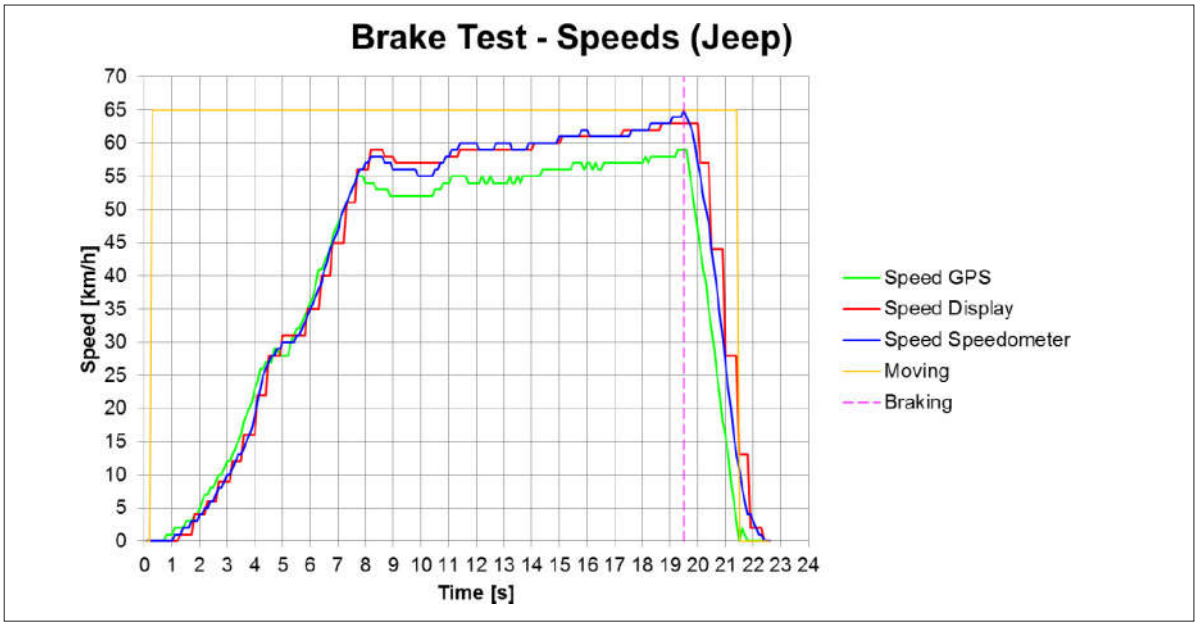

Figure 4 Comparison of GPS measured speed (green line), infotainment display (red line) and speedometer (blue line)

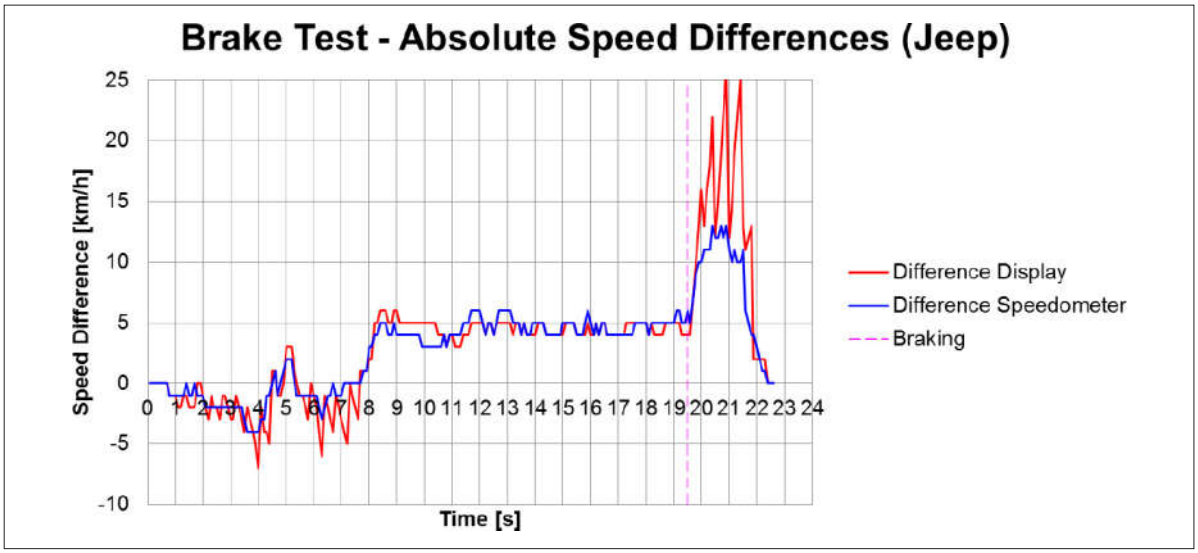

Figure 5 Absolute speed differences between GPS readings and display (red line) or speedometer (blue line)

Calculated differences were afterwards corrected for difference at constant velocity and calculated into percentage difference, as is shown on Fig. 6. With the first vehicle (Jeep Renegade), the average difference in constant speed was between 4 and 5 km/h, during the brake test the speed difference between an actual speed and speed displayed by the speedometer needle was over 10 km/h (the inaccuracy was even higher, peaking over 20 km/h in case of speedo-

meter display thanks to its 2 Hz refresh rate). Average differences from multiple brake tests are shown on Fig. 7. With second tested vehicle (Ford Focus Combi) differences at constant velocity were again between 4 and 5 km/h, but under heavy braking these differences went down, as could be seen from Fig. 8 which shows average differences from multiple brake tests with Ford.

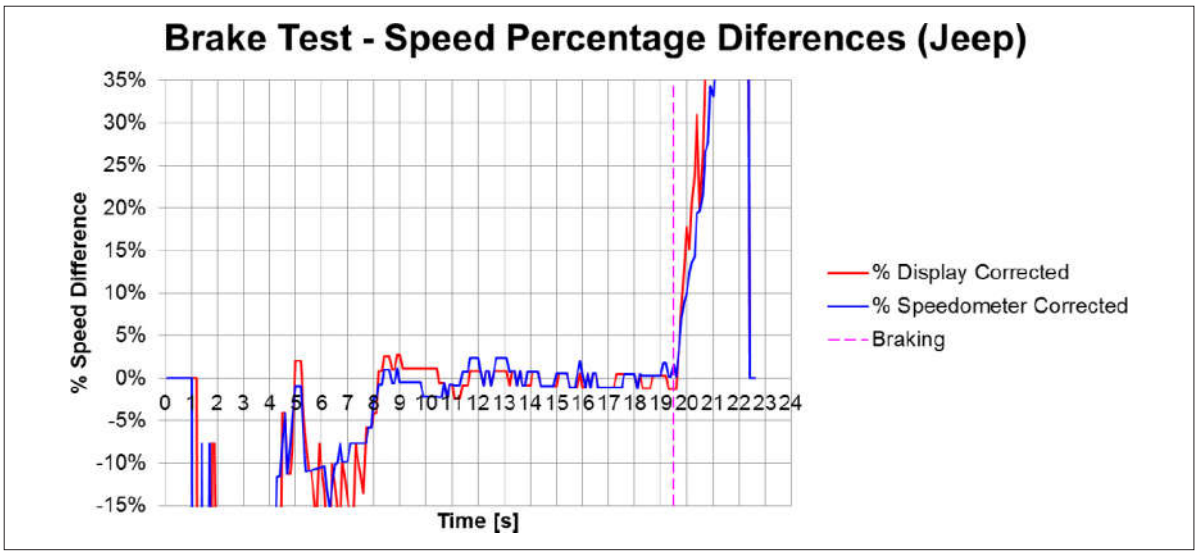

Figure 6 Corrected percentage diff. between GPS readings and display (red line) or speedometer (blue line)

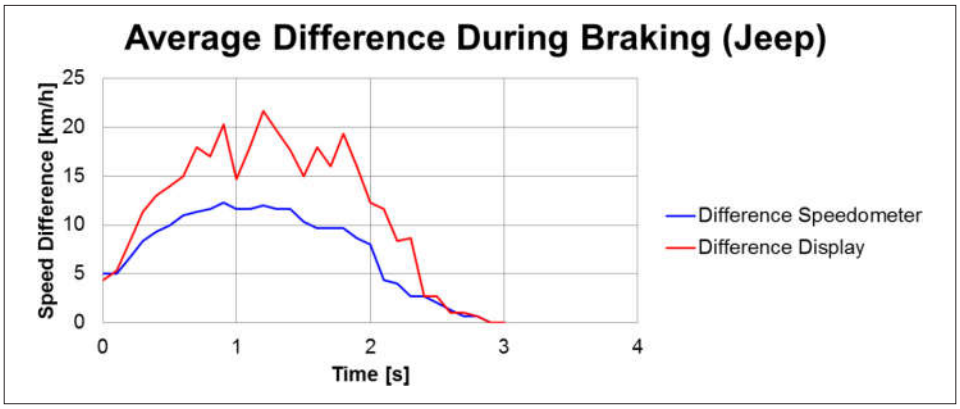

Figure 7 Average difference between actual speed and speed shown by speedometer (blue line) and by display (red line) during heavy braking

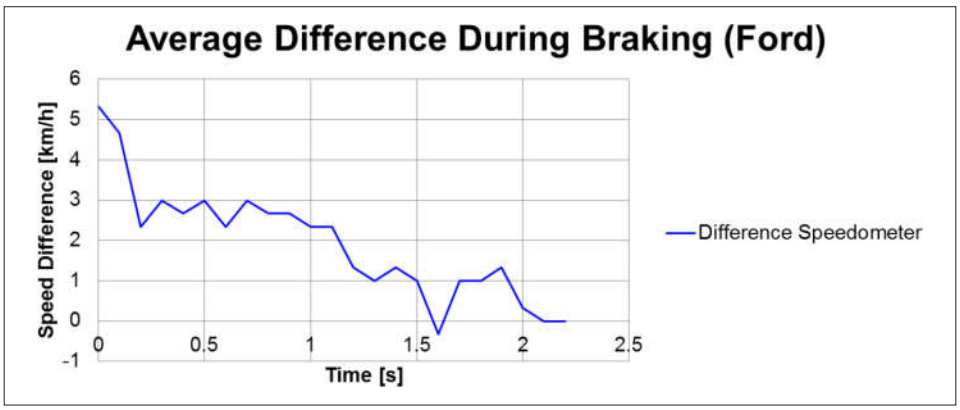

Figure 8 Average diff. between actual speed and speed shown by speedometer (blue line) during heavy braking

5 Discussion

Stuck speedometer needle or the imprint of the needle left on the gauge face is in some cases used as a foundation for collision speed determination. Research in this area seems to be focused especially on frontal collisions as these are most likely to provide the mentioned imprint. However there is an inaccuracy between an actual vehicle speed and speed displayed by speedometer (either the speedometer needle or the display) depending mainly on vehicle's manufacturer. This inaccuracy can be even greater in cases of vehicle acceleration or deceleration, especially during heavy braking, because speedometer needles show certain small lag between the beginning of deceleration and actual needle movement. Most importantly however, the difference is largely magnified when wheels are partially locked-up, as many vehicles have the displayed speed based on speed of the individual wheels. It stands to reason there is a difference between angular velocity of partially locked-up wheel which is translated by ECU to the speed displayed by a speedometer and actual vehicle's speed. This was observed during vehicle spin caused by a traction loss during dynamic tests (see Fig. 3) as the speedometer reading was at 0 km/h while the vehicle itself was still moving. Difference between speedometer needle and actual velocity in this case was more than 25 km/h. During heavy braking, different makes of vehicles showed different behavior. While Jeep's speedometer difference went up over 10 km/h from 4 to 5 km/h at constant velocity (which was most probably caused only by the speedometer lag), speed difference in case of vehicle Ford was decreased which means that wheel lock-up effect was higher than the effect of the speedometer lag. Percent-wise, the difference between indicated and real velocity during heavy braking from 50 and 60 km/h was nearing significant 20 %.

6 Conclusion

This pilot research confirmed the assumption of the speed difference displayed by vehicle speedometer and an actual vehicle speed. This difference was observed with vehicles of different manufacturers during performed braking tests on dry tarmac road surface. There is a presumption that the difference will be even higher on road surface with lower traction (e.g. wet road surface). Even with 10 Hz GPS sampling rate, Racelogic VBox is limited by the quality and strength of the GPS signal which can prove problematic during relatively short time of the brake test. For further research on wet or extremely slippery road surface (wet tarmac or skidpad) an independent decelerometer with high measurement frequency will be used.

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