23rd EURO Working Group on Transportation Meeting, EWGT 2020, 16-18September 2020, Paphos, Cyprus

The Impact of Trucks on the Bluetooth Equipment Rate on Freeways

Martin Margreiter [a]*

[a] *Technical University of Munich, Arcisstr. 21, Munich 80333, Germany*

Abstract

The extraction of travel time data from Bluetooth is nowadays widely used in various countries. However, data from several studies shows a large variation in the equipment rate with Bluetooth devices in different areas of the world. In particular, most research points to significantly higher rates in European countries in comparison to the USA. Based on the evaluation of a dataset of almost two billion single Bluetooth detections, this work suggests one main reason for this difference being the significantly higher Bluetooth equipment rate amongst trucks on German freeways in relation to passenger cars. The findings show that trucks have an approximately five times higher chance to be equipped with a detectable Bluetooth device.

Peer-review under responsibility of the scientific committee of the 23rd EURO Working Group on Transportation Meeting.
Keywords: Bluetooth Detection; Freeways; Equipment Rate; Penetration Rate; Trucks; Heavy Duty Vehicles

1. Motivation

Travel time measurements are nowadays widely utilized as a valuable data source for traffic state detection aiming at traveler information or as an input for traffic management. Especially on freeways it has proven to be an inexpensive, simple and reliable input for the traffic management algorithms of road operators (see Click 2012 and Margreiter 2016). Most of those algorithms rely on a continuous (over space and time) and sufficient supply and quality of information from the related traffic detectors. For travel time measurements this quality is defined by the detection rate: the rate of vehicles which are providing data (active or passive) as a share of the overall traffic volume. For this present work the travel time measurement is based on Bluetooth technology. Research has shown that Bluetooth detection rates vary significantly in different countries and regions of the world ranging from 0.2 % up to 70 % (Margreiter 2019). The distribution of those values shows lower determined rates in the USA (approximately 6 % in average) in comparison to various European countries (around 30 % in average). A higher detection rate guarantees a higher validity of the extracted traffic-related information as well as time-benefits when detecting incidents simply due to the higher quantity of data points. Therefore, the objective of this work is to evaluate the cause of this effect based on the results of a large-scale data study. The study is using a database of around two billion individual Bluetooth detections from around 200 Bluetooth detectors which are installed next to freeways in the South of Germany. The data was provided by the Motorway Directorate of Northern Bavaria (ABDN).

2. Methodology

The general principle of travel time data generation based on Bluetooth detectors is the presence of electronic devices with activated Bluetooth interfaces in the vehicles which are passing by the Bluetooth antennas. As can be seen in Fig. 1, the Bluetooth device is then detected and re-identified by two adjacent antennas next to the freeway. Using the detection timestamps, the vehicle's travel time between the two detector locations can be calculated. Further information about this detection principle can be found in Sharifi (2011), Bhaskar (2013) and Kessler (2019).

* Corresponding author. Tel.: +49-89-289-28586; fax: +49-89-289-22333.
E-mail address: martin.margreiter@tum.de

Peer-review under responsibility of the scientific committee of the 23rd EURO Working Group on Transportation Meeting.

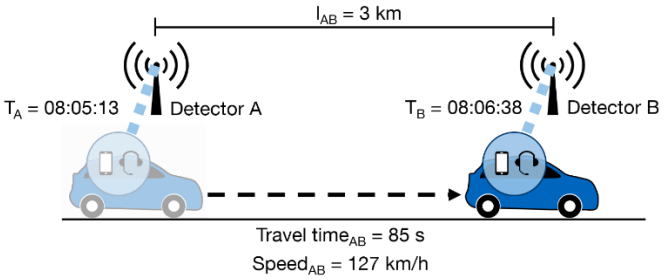

Fig. 1. Bluetooth detection principle for travel time measurement between two stationary Bluetooth antennas.

The evaluation of data from several years over multiple detector locations indicated a strong correlation between the Bluetooth detection rate and the overall truck share on the freeway (see Fig. 2). To evaluate the truck share within the Bluetooth dataset of all vehicles having detectable devices on board, this work uses a methodology based on comparing the evaluated Bluetooth-based travel times with the travel times of a ground truth dataset originating from automatic number plate recognition (ANPR). The average speed calculated from Bluetooth travel times is generally 18 to 22 km/h below the ANPR ground truth values. This is due to the significantly higher Bluetooth equipment rate amongst trucks on German freeways and can therefore be used to also determine the detection rate amongst them. For this purpose, the average speeds of trucks and passenger cars from inductive loops at the test site were used.

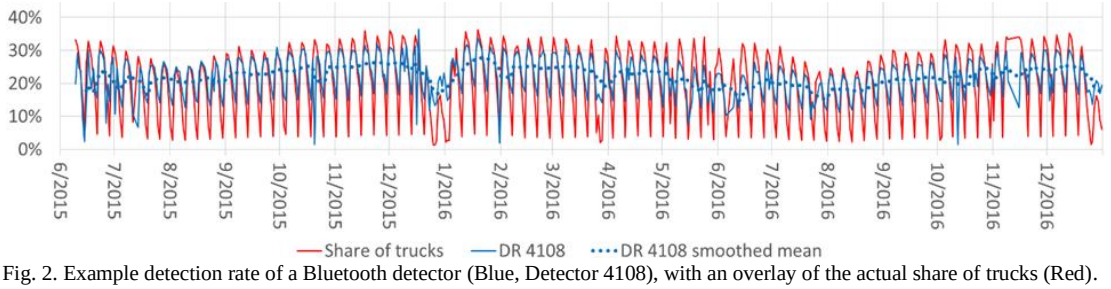

Fig. 2. Example detection rate of a Bluetooth detector (Blue, Detector 4108), with an overlay of the actual share of trucks (Red).

3. Results

The results show that the average Bluetooth detection rate of passenger cars is around 12 to 17 %, whereas trucks have a five times higher probability to be equipped with Bluetooth devices and show detection rates between 65 and 70 %. This leads to a significant reduction of the overall detection rates on German freeways at weekends and during holidays because generally less trucks are operating on weekends and also because there is a ban for trucks on German freeways on Sundays as well as on bank holidays from 0:00 to 22:00. When using Bluetooth-determined travel times for traffic management purposes, this particular data characteristic has to be taken into account to avoid a bias in the resulting travel times.

References

Bhaskar, A., Chung, E., 2013. Fundamental Understanding on the Use of Bluetooth Scanner as a Complementary Transport Data. Transportation Research Part C: Emerging Technologies 37, pp. 42–72, DOI: 10.1016/j.trc.2013.09.013.

Click, S. M., Lloyd, T., 2012. Applicability of Bluetooth Data Collection Methods for Collecting Traffic Operations Data on Rural Freeways. TRB 91st Annual Meeting. Washington D.C., USA.

Kessler, L., Karl, B., Bogenberger, K., 2019. Spatiotemporal Traffic Speed Reconstruction from Travel Time Measurements Using Bluetooth Detection. 22nd IEEE Intelligent Transportation Systems Conference ITSC, Auckland, New Zealand.

Margreiter, M., Busch. F., Carstensen, C., 2019. The Evolution of Bluetooth Detection Rates. TRB 98th Annual Meeting, Washington, D.C., USA.

Margreiter, M., 2016. Fast and Reliable Determination of the Traffic State Using Bluetooth Detection on German Freeways. World Conference on Transport Research, Shanghai, China.

Sharifi, E., Hamedi, N., Haghani, A., Sadrsadat, H, 2011. Analysis of Vehicle Detection Rate for Bluetooth Traffic Sensors: A Case Study in Maryland and Delaware. 18th World Congress on Intelligent Transport Systems, Orlando, USA.