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WHERE AND WHEN DO DRIVERS SPEED? A FEASIBILITY STUDY OF USING PROBE VEHICLE DATA FOR SPEED ENFORCEMENT PLANNING

Jiří Ambros (Corresponding author)

CDV – Transport Research Centre

Líšeňská 33a, 636 00 Brno, Czech Republic, jiri.ambros@cdv.cz

Jan Elgner

CDV – Transport Research Centre

Líšeňská 33a, 636 00 Brno, Czech Republic, jan.elgner@cdv.cz

Richard Turek

CDV – Transport Research Centre

Líšeňská 33a, 636 00 Brno, Czech Republic, richard.turek@cdv.cz

Veronika Valentová

CDV – Transport Research Centre

Líšeňská 33a, 636 00 Brno, Czech Republic, veronika.valentova@cdv.cz

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1. INTRODUCTION

Speed has been recognized as the most influential risk factor – e.g., in the US, speeding was a contributing factor in 27 percent of all fatal crashes in 2016 (*1*). The proportion may be even higher, for example, on Czech roads speeding has been attributed to approx. 40 percent of fatal crashes in recent years, making it the most frequent cause of road deaths (*2*).

Among various speed management measures, speed enforcement has a high potential. In order to make speed enforcement operations the most effective, they should target the critical locations and conditions. Their definition is usually based on previous speeding-related crashes (*3–6*), which makes planning a reactive approach, limited by statistically low occurrence of crashes. An alternative approach is to use GPS data, collected during driving by so called probe vehicles (also known as floating car data). This data enables obtaining information on vehicle speeds, without being limited in time and space (*7*). Probe data has been used mainly for purposes of navigation and traffic monitoring, but also in various safety-related studies. Less often probe vehicle data was used in studies related to speed enforcement. Previous studies (*8, 9*) were positive about feasibility of applying probe vehicle data, but they also indicated some potential challenges, such as sample size and representativeness, or varying approaches to data aggregation. In addition, neither of the two studies attempted validating the obtained speeds, i.e. comparing them to some of traditional measurement techniques (ground truth).

Some studies, built on GPS data, also attempted statistical modelling. The explanatory variables, which they used, usually comprised behavioral characteristics (*10*, *11*). For the present study focusing on speed enforcement, it would be more practical to model speeding, based on observable road characteristics. In fact, many such models were developed (see reviews *12* and *13*), but their response variable was usually operating speed, not speeding. Therefore, there is a lack of studies, which would model speeding in a measurable way, based on tangible characteristics.

The current paper aims to contribute to the previous research by studying the feasibility of using probe vehicle data from the perspective of speed enforcement planning. Firstly, validity of a sample of probe vehicle speed data was checked through comparison with average speed control data. Next, descriptive analysis was performed, focusing on speeding on road segments in individual hour intervals. Statistical models were also developed to explain which road parameters contribute to speeding. In a sum, the feasibility study aimed to find out whether the probe vehicle data help answering *where* and *when* drivers speed, which is potentially useful for planning the allocation of Police enforcement resources.

2. METHODOLOGY

2.1. Data

The feasibility study focused on five road corridors in Prague, which were identified by Traffic Police Directorate as prone to speeding. Their length varied between approx. 1 and 7 km. The roads mostly had two lanes in each driving directions, divided by median; some parts were 1+1 lane, without median. Speed limits were 50, 70 or 80 km/h. Traffic volumes (AADT) were between approx. 10,000 and 50,000 veh/day. All corridors were in relatively flat terrain.

Probe vehicle data, covering the selected corridors through January to December 2017, was obtained from a private company Princip a.s. The data was sourced from a fleet of approx. 10,000 company vehicles. The recording consisted of GPS positions, at interval between 20 and 60 seconds, together with speed. According to the data provider, accuracy was 2.5 m and 2 km/h for GPS and speed, respectively.

2.2. Sample validation

The idea of validation of a sample of probe vehicle speed data was to check its representativeness by comparison to some of traditional speed measurement technique – average speed control was chosen for this purpose. Average speed control (ASC) measures the average speed over a road section, based on camera identification of vehicles when entering and leaving the enforcement section.

The study utilized a partial overlap between analyzed road corridors and ASC sections. Following consultations with company TSK Praha, which manages ASC in Prague, four sections were selected for validation, using 2 months of ASC data (April and November 2017). Given the spatiotemporal focus of the study, comparison was conducted in 1-hour intervals, aggregated from two datasets:

1. ASC data – average hourly speeds, provided by TSK Praha.
2. Probe vehicle speeds – since the sample size was significantly smaller compared to ASC data (approx. 6%), and thus often influenced by outliers, median was used to characterize speeds in hourly intervals.

Differences were tested by non-parametric statistical tests. Based on their results, comparison was concluded as follows:

- In two shorter sections (up to 1 km), differences were on average up to 4 km/h.
- In two longer sections (over 1 km), differences were on average 15 km/h.

Given the focus on accurate speeding estimations, the differences in longer sections were not seen as satisfactory, and it was decided to keep the length of analyzed segments below 1 km.

2.3. Descriptive analysis of speeding

For descriptive analysis, segments of road corridors were created. The idea was to define homogeneous segments with constant values of parameters, which may potentially be related to speed choice and driving speed and speeding. Based on cross-section and geometry parameters the studied corridors were divided into homogeneous sections with constant values of explanatory variables. After splitting between driving directions and exclusion of some non-typical cases, 71 segments was obtained, with lengths between 100 and 500 m.

In addition to *total* speeding (i.e., number of all records, which exceeded the speed limit, divided by total number of records), following speeding categories, based on Czech legal definitions, were used:

- *small* speeding (up to 5 and 10 km/h over the speed limit on urban and rural roads, respectively)
- *medium* speeding (up to 20 and 30 km/h over the speed limit on urban and rural roads, respectively)
- *high* speeding (up to 40 and 50 km/h over the speed limit on urban and rural roads, respectively)

Speeding rates were calculated and visualized in polar graphs, which enable looking up the values in specific hourly intervals. In Figure 1, an example is presented, which compares total speeding rates in six expressway segments (three in each driving direction). The graph illustrates differences between segments (higher rates in segments F and G), as well as differences between driving directions, or daytime and nighttime values.

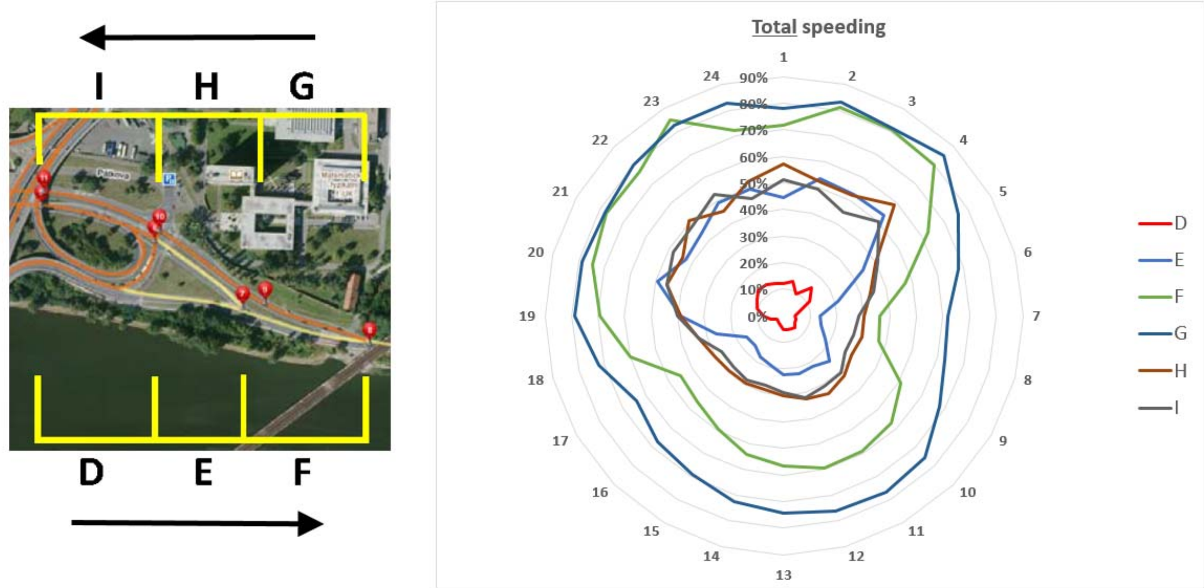

FIGURE 1 Example graph of total speeding from six expressway segments.

2.4. Explanatory models of speeding

To provide more insight into speeding performance, explanatory models were developed. Speeding was used as a response variable; road parameters, collected during previously mentioned segmentation were used as potentially explanatory variables. Approximate AADT was also added, based on 2017 census by TSK Praha (*14*). Linear regression modelling in IBM SPSS (backward-elimination) was used.

The identified influential variables were: AADT, speed limit, number of lanes, median barrier, roadside activities and horizontal alignment. Based on their positive signs, all the variables are supposed to contribute to increase of speeding:

- AADT: only marginal association to speeding.
- Speed limit: higher speeding for 50 km/h segments, compared to 70 or 80 km/h segments.
- Number of lanes: higher speeding on 1+1 segments, compared to 2+2 lanes.
- Median barrier: speeding increases in order no barrier → solid barrier → cable barrier.
- Roadside activities: the less activities, the higher speeding.
- Horizontal alignment: higher speeding in curves, compared to tangent segments.

Most of the mentioned associations are consistent with previous research; nevertheless, no reference was found to support the mentioned higher speeding in curves. In terms of speed, rather opposite may sound logical. However, relationships related to speed and speeding may not be identical; in fact, they may even contradict each other, as evidenced by example of contradictory relationship between speed limit and speeding.

3. CONCLUSIONS

The goal of the presented study was to answer where and when drivers speed. To this end, probe vehicle data was analyzed on a sample of Prague expressway and collector road segments. After checking data validity through comparison to average speed control data, descriptive analysis of speeding was performed, focusing on homogeneous road segments in individual hour intervals. Statistical models were also developed to explain which road parameters contribute to speeding. In general, the applied concept proved as feasible: locations and time intervals, which are most prone to speeding, were identified, as well as contributory factors, such as lower speed limit, lower number of lanes, absence of roadside activities, or presence of horizontal curves.

The feasibility study may be thus considered successful – it proved, that speeds from probe vehicles provide practical source for identifying where and when drivers speed. The obtained information may help planning improving effectiveness of planning Police speed enforcement resources and actions. Future research should focus on the identified challenges, such as free-flow speed estimation, validation, and relationship to crashes. Additional studies may also verify usefulness of probe vehicle data in other activities towards optimization of speed enforcement – for example revision of speed limits.

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