

APPROXIMATION OF TIME HEADWAY ON TWO-LANE HIGHWAYS USING TEST CAR APPROACH

Muttaka Na'iyah Ibrahim¹ and Othman Che Puan²

¹Postgraduate Students, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

²Associate Professor, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

ABSTRACT

Time headway is an essential variable in various traffic engineering applications such as capacity and level of service (LOS) analyses of road segments and intersections, traffic safety analysis, generation of vehicles in microscopic simulations, and so on. From the context of LOS analysis of road segments, the proportion of traffic traveling with headways less than 3 seconds at a point is used as a criterion for assessing the operational performance of two-lane highways. Generally, headways are measured based on spot observation as the time interval between two consecutive vehicles passing a common point of a road. Spot measurement has been identified as the major problem associated with headway data collection as the approach does not consider the variation of the headways along the road segment. It is therefore, essential to develop other techniques for estimating headway along road section as opposed the current practice of spot measurement and deemed applicable for longer segment. This paper presents a new approach for measuring time headway based on space observation using test vehicle method. Field data on time headways were collected on two-lane highways using both spot and space observations and the results compared. Statistical analysis using t-test indicates that the two data sets do not differ significantly.

1. INTRODUCTION

Time headway is defined as the time interval between two consecutive vehicles passing a point on a road measured from the same common feature; usually front bumper to front bumper or rear to rear. Fundamental applications of time headway in traffic engineering include capacity and level of service (LOS) analyses of road segments and intersections, traffic safety analysis, and generation of vehicles in microscopic simulations.

From the context of LOS analysis of road segments, a key index for assessing the operational performance of two-lane highways is the spot percentage of vehicles traveling with headways less than 3s; referred to as platooning or following vehicles (TRB, 2010); determined from field observation. Generally, time headway is measured in the field based on spot observation either manually (using stopwatch) or using automatic

traffic recorders (ATR). Spot measurement has been identified as the major problem associated with headway data collection (Luttinen, 1996) as the approach does not take into account the variation of the headways along the road segment.

Regarding the LOS evaluation for two-lane highways, the spot observed percentage of vehicles with headways shorter than 3s is considered as average proportion of *time spent in platoon* due to inability to pass. In other words, estimates from spot measurements are assumed as representative of segment. This approach was applied in several studies (Al-Kaisy and Durbin, 2011, Bessa and Setti, 2011, Luttinen, 2001, Polus and Cohen, 2009, Polus and Cohen, 2011, Van As and Van Niekerk, 2007) for assessing the operational performance of two-lane highways. Logically, the percent of vehicles with short headways at a particular point may not really represent the proportion over along section. As variation in operational performance, traffic characteristics, and geometric features along the segment could result in different estimates. For the simple reason that *time spent in platoon* is space related measure, it is therefore, essential to devise other techniques capable of estimating time headway based on space measurement.

This paper presents a new approach for measurement of time headway based on space observation using test vehicle method. Field data on time headways were collected on two-lane highways using the proposed technique and the results compared with those based on spot observation to find out whether there exist any significant difference between the two approaches.

2. EXPERIMENTAL PROCEDURE

Data for the study were collected on four lanes segments of two-lane highways located in Skudai and Kota Tinggi Districts, Johor, Malaysia. In the course of the data collection, test vehicle method was applied in which a passenger car was used as the test vehicle. The test car was equipped with a Video Velocity Box (VBox); an on-board data acquisition system used for real time event recording. VBox system is composed of video VBox recorder, GPS data-logger, camera, and SD memory card. To collect the required information, the system is usually connected to the test car and powered using cigar plug. On connecting the VBox

to the test vehicle, the system detects and records the speed of the car at every moment; either at stationary or moving state. The camera attached to the system and fixed on the test car's front windscreen records the traffic event of the road under study. The system automatically stores the recorded events onto the SD memory card inserted into the VBox and later uploaded for processing.

2.1 DATA COLLECTION

Traditionally, data on time headway are obtained from point measurement. In this study, a different approach was applied for estimating time headway based on two variables; (i) distance headway between the test car and its immediate lead vehicle, and (ii) speed of test car. Thus, time headway between the test car and its immediate lead vehicle while moving in the traffic stream was estimated as the ratio of the spacing between the two vehicles and speed of the test car. While speed of test car can be easily obtained from video display during playback of the recorded traffic events, the spacing could not be obtained directly from the video display during playback. As such, the camera was calibrated to establish a relationship between the actual distance headway (spacing) between test car and lead vehicle, and width of the lead vehicle at various separations. This was carried out for various classes of vehicles in accordance with the classification in the Malaysian Highway Capacity Manual, MHCM (MOWM, 2011).

2.2 CALIBRATION OF CAMERA

The camera used for traffic events recording was calibrated prior to the field data collection. The calibration was carried out using two vehicles; one as test car and the other as lead vehicle (a passenger car was used as the lead vehicle). The test car equipped with VBox for continuous events recording was stationed at one point while the lead vehicle positioned ahead of it at an initial spacing of 7.5 m rear to rear; and then varied in increment of 5 m. All events were recorded into the VBox after which video record was uploaded and played back in computer to extract required information. During the playback, the width of the lead vehicle, W (mm), was measured for each position and recorded against the actual ground distance headway, L (m) between the vehicles. From pairs of recorded variables, a relationship was developed for estimating spacing from the video display based on the width of lead vehicle. Equation 1 is the relationship developed between space headway (L) and width of lead vehicle (W) for passenger car.

$$L = 237.71W^{-0.92} \quad (R^2 = 0.9994) \quad (1)$$

From the relationship, for any measured value of W , a corresponding value of L is estimated. Similar calibration and relationships for other vehicles classes were also developed in relation to the characteristics of passenger car.

2.3 MEASUREMENT OF TIME HEAD USING SPOT AND PROPOSED APPROCHES

To explicitly portray the potential of the proposed method for estimating time headway, the parameter was measured using both spot and suggested approach simultaneously, described as follows. To achieve that, specific observation points were selected on each of the roads along a demarcated 3.5 km segment at which two observers were stationed. One of the observers record the time interval between the passages of a randomly selected *lead vehicle* and the *test car* based on arrival time using a stop watch; and the value taken as the spot time headway. At the same time, as soon as the rear of the *lead vehicle* crossed the reference point, an indication was made by the second observer by raising a flag which is noted by another observer inside the test car during which he voiced out the occurrence for audio recording onto the VBox. Moreover, the flag indication is also seen in the video display during playback. At that moment, the width of the lead vehicle is measured and based on the class of the lead vehicle; the space headway is estimated from the established relationship. The estimated space headway at that instance is then used in relation to the test car speed at that moment to compute the time headway. The procedure was repeated until a reasonable number of observations were made to ascertain the consistency of the estimates or otherwise. Figure 1 depicts a typical video display during playback; showing a lead vehicle and part of test car.



Figure 1: Typical Video Display during Playback

3. RESULTS AND DISCUSSIONS

As stated in the preceding section, time headways were measured using both spot observations and proposed approach (measurement from video display based on width of lead vehicle and speed of test car) concurrently. Results from the field observations are presented graphically.

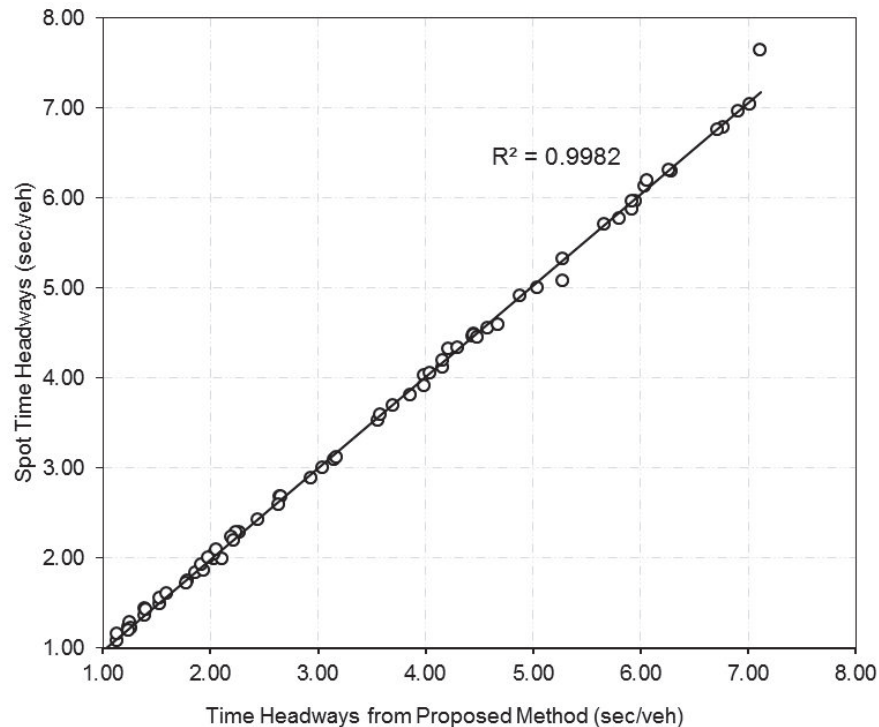


Figure 2: Relationship between Spot and Proposed Method Time Headways (sec/veh)

In order to examine how well the measured time headways from proposed method fit the observed values from spot measurement, a relationship between the two estimates was plotted as illustrated in Figure 2.

The results shown in Figure 2 demonstrate that the relationship between the two estimates is well fitted as the data points were roughly distributed around the 45° diagonal. This suggests that the approach presented in this study has the potential of being an alternative method for field measurement of time headway along a road section as headway values from the proposed method closely approximate those from spot observations.

Likewise, a statistical analysis was carried out using t-test at 95% confidence level ($\alpha = 0.05$) to find out whether there exists any significant difference between the two data sets. Findings from the statistical analysis revealed that there exists no significant difference between the two data sets as *t-statistics* value (-0.0262) is far less than the *critical value of t distribution* (± 1.9773).

Findings from this study demonstrate that the proposed method can be used to measure time headway based on space observation. By extension, the approach can be applied to estimate percent of travel time spent in platoon on two-lane highways. This could be achieved by making series of test runs with test car over the segment to be evaluated and observing the required variables based on moving car observer in according with the procedure described in the Manual of Transportation

Engineering Studies (Robbertson and Findley, 2010).

To estimate the percent of travel time spent in platoon, for any measured value of *lead vehicle width*, a corresponding spacing can be estimated from the relationship developed. The time headway is then estimated as the ratio between the spacing and the speed of the test car corresponding to the measured lead vehicle width. The estimated headway is then checked against 3 s, if it is less than the 3 s cut-off, time spent behind the lead vehicle at that headway would be recorded and then taken as the time spent in platoon until the displayed speed value changes. As the speed of the test car changes, the width of the lead vehicle is measured again to estimate the corresponding spacing and headway. Individual times consumed in platoon for each run are then summed up and their percentages compared to the total travel time taken as the time spent following for that run.

4. CONCLUSIONS

This study presented a new technique for estimation of time headway based on space observation using test vehicle method. Time headways were measured using both the method proposed in this work and the conventional spot observation concurrently. Estimated time headways from the two different approaches approximately represent each other as a strong correlation exists between them. Also, statistical analysis demonstrated that there exists no significant difference between the two data sets as *t-statistics*

value (-0.0262) is far less than the *critical value of t distribution* (± 1.9773). However, in terms of applicability; especially for performance assessment of two-lane highways over space, percent of spot headways less 3 s may not accurately represent the proportion over a long segment. It is therefore, suggested that the method presented here be used to measure headway as well as time spent in platoon on two-lane highways as the approach could produce actual time spent following contrary to that of point measurement and assumed as representative of segment.

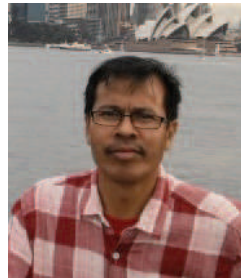
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Othman Che Puan

B. Eng. Civil (Hons.) in 1987 from Middlesex Polytechnic (University), UK; Master of Philosophy in Civil Engr'g. (Highway & Traffic Engr'g.) in 1991 & PhD (Civil Engr'g.) in 1999 from University of Wales, Cardiff, UK. He is currently an Associate Professor of Transportation Engr'g. & Planning at Faculty of Civil Engr'g., Universiti Teknologi Malaysia.



Muttaka Na'iyah Ibrahim

B. Eng. Civil (Hons.) in 1999 from Bayero University, Kano, Nigeria; M. Eng. (Highway & Transportation) in 2008 from University of Benin, Benin city, Nigeria; Lecturer, Bayero University, Kano, Nigeria & PhD Student at Faculty of Civil Engr'g., Universiti Teknologi Malaysia.