

## A STUDY OF VEHICLE MOVEMENT PARAMETERS DURING OVERPASS AND OVERTAKING

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**Summary:** The paper presents a comparative analysis results of the experimental and the model data of the vehicle movement parameters during overpass and overtaking in traffic flow. The results shows that the parameter of overpass and overtaking depend of the level of vehicle speed. The results are useful for practice of accident analysis.

### INTRODUCTION

In practice there are various methods for determining the vehicle movement parameters during overpass and overtaking. The models give significant differences and thus different conclusions, which is unacceptable for a case related to road traffic safety. This requires the implementation of experimental studies with modern equipment for checking the validity of such models. The aim of this work is to study of the vehicle movement parameters during overpass and overtaking in field tests.

### MODELS FOR OVERPASS STATIONARY OBSTACLE AND OVERTAKING A VEHICLE

#### A) A model for overpass stationary obstacle with constant speed.

Overpass the obstacle is considered in the example “Overpass a vehicle stopped on the road” shown on fig. 1 [1, 2].

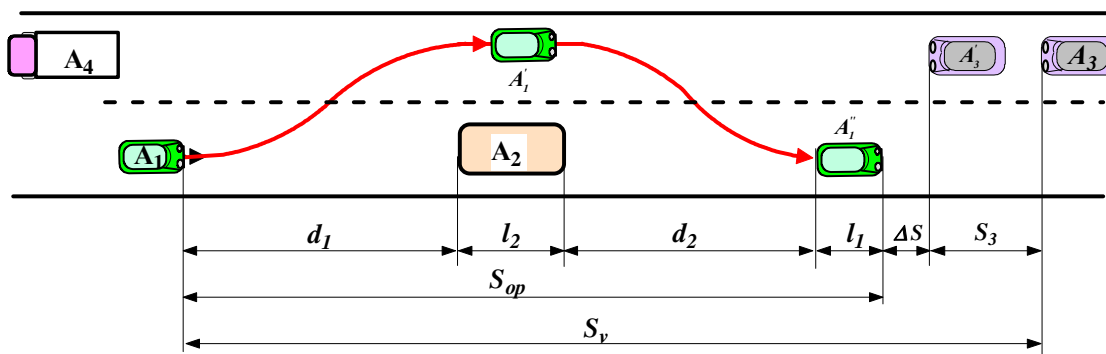


Fig. 1. Overpass stationary obstacle with constant speed.

The distance needed to overpass stationary obstacle (vehicle  $A_2$ ) is given by expression:

$$S_{op} = d_1 + d_2 + l_1 + l_2, \quad (1)$$

where:  $l_1$  is the length of the vehicle  $A_1$ ,  $m$ ;  $l_2$  – the length of the vehicle  $A_2$ ,  $m$ ;  $d_1$  – the safe distance at the start of overpass,  $m$ ;  $d_2$  – the safe distance at the end of overpass,  $m$ .

The distance  $d_1$  is determined from the equation for safe stopping, if the overpass is not possible, taking into account that the front vehicle is stationary.

$$d_1 = (t_r + t_{act} + 0,5t_{inc})V_1 + V_1^2 / 2a_{br} + \Delta S, \quad (2)$$



where:  $t_r$  is the reaction time, s;  $t_{at}$  – the actuating drive time, s;  $t_{inc}$  – the time from start to fully developed deceleration (from 0 to  $a_{br}$ ), s;  $V_I$  – the speed overpassing vehicle, m/s;  $\Delta S$  – the security distance,  $a_{br}$  – the fully braking deceleration,  $m/s^2$ .

Distance  $d_2$  is determined by the condition for the safe return to the right lane without skidding by the equations for the performance “Overpass by changing the lane”

$$d_2 = (8V_I^2 Y_{sh} / g)^{1/2}, \quad (3)$$

where:  $Y_{sh}$  is the lateral shift when changing from one line to the other. It can be reception equal to the width of the line ( $b_l$ );  $g$  - the gravity,  $m/s^2$ ;  $\varphi$  – the coefficient of friction.

If  $Y_{sh} = b_l$  the time of visibility, needed for overpass can be computed as

$$t_{op} = S_{op} / V_I = (l_1 + l_2 + d_1 + d_2) / V_I. \quad (4)$$

The condition for safe overpass stationary obstacle in the presence of a vehicle is complete overpass as between oncoming vehicles  $A_2$  and  $A_3$  is also ensured a safe distance of  $S_s$ .

$$S_s = S_{op} + \Delta S + S_3, \quad (5)$$

where  $S_{op}$  is the distance between vehicle  $A_2$  and oncoming vehicle  $A_3$  at the start of overpass, m;  $S_3$  - path, which oncoming vehicles pass for the time needed to overpass the obstacle, m.

$$S_3 = V_3 t_{ot} = V_3 S_{ot} / V_2. \quad (6)$$

After substitution the condition for safe overpass follows the final type of equation

$$S_s = S_{op} [(V_I + V_3) / V_I] + \Delta S. \quad (7)$$

### B) A model for overtaking into a traffic flow.

Overtaking in traffic flow oncoming vehicle is shown in fig. 2 [1]. The path of overtaking consists of two parts:

- A joint path  $S_2$  is the distance which the both vehicle traveled. This is the path traveled by the overtaking vehicle during the overtaking time  $t_{ot}$

$$S_2 = V_2 t_{ot}. \quad (8)$$

- A relative path to overtaking  $S_{rel}$ . This is the additional distance elapsed between vehicle  $A_1$  to be able to go before vehicle  $A_2$ .

$$S_{rel} = d_1 + l_2 + d_2 + l_1. \quad (9)$$

The successful overtaking depends on the relative path which should be traveled during the overtaking time  $t_{ot}$ . As the  $t_{ot}$  is less so the overtaking is more safely.  $T_{ot}$  depends essentially on the relative difference between the speeds  $V_I - V_2$ .

$$t_{ot} = S_{rel} / (V_I - V_2) = (d_1 + l_2 + d_2 + l_1) / (V_I - V_2), s. \quad (10)$$

The accuracy of expert conclusions depends on correct assessment of the relative path and especially the determination of two distances  $d_1$  and  $d_2$ . They should pay attention on determining distances very precisely and to account all factors and evidence, including testimony of witnesses.

There are two main types of performance overtaking: Overtaking at a constant speed and Overtaking at an acceleration. This paper considers only the case overtaking at a constant speed, when more rapid vehicle overtake another moving at a slow speed at the appropriate time when there is no oncoming traffic. In this case the overtaking takes place immediately without changing the speeds of both vehicles. An example of overtaking at a constant speed is shown in fig. 2.

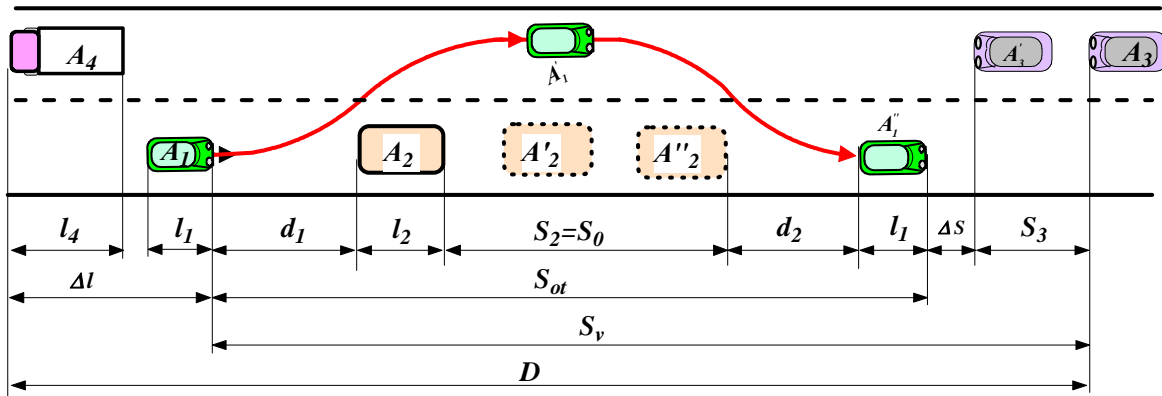


Fig. 2. Overtaking at a constant speeds

The distance  $d_1$  is calculated for safety reasons, if a vehicle  $A_2$  stops suddenly. The driver of a moving vehicle following him will understand that the front vehicle stops at the time when the stoplights appeared on vehicle  $A_2$ . In this case the distance is calculated as

$$d_1 = (t_r + t_{act} + 0,5t_{inc}) V_1 + V_1^2 / 2a_{br1} - V_2^2 / 2a_{br2} + \Delta S. \quad (11)$$

The distance  $d_2$  is calculated on the same formulas. It can be accepted less value  $d_2 \leq d_1$ , but sufficiently for a driver reaction of a vehicle  $A_2$ .

$$d_2 > (t_p + t_{cp} + 0,5t_u) V_2. \quad (12)$$

The overtaking time  $t_u$  and distance needed to overtaking  $S_{ot}$  is:

$$t_{ot} = (d_1 + l_1 + d_2 + l_2) / (V_1 - V_2). \quad (13)$$

$$S_{ot} = (d_1 + l_2 + d_2 + l_1) V_1 / (V_1 - V_2). \quad (14)$$

## RESULTS OF FIELD TEST AND DISCUSSION.

The field test were provided on a straight horizontal section of the road using a test car, which is equipped with precise recording equipment – the data loggers VBOX 20 SL and VBOX 3i, combined with an IMU products of Racelogic Ltd – UK (fig.3.) [3,4]. During the conducted experiment the drivers were selected at random with repeatability of experiments in each series and speeds.

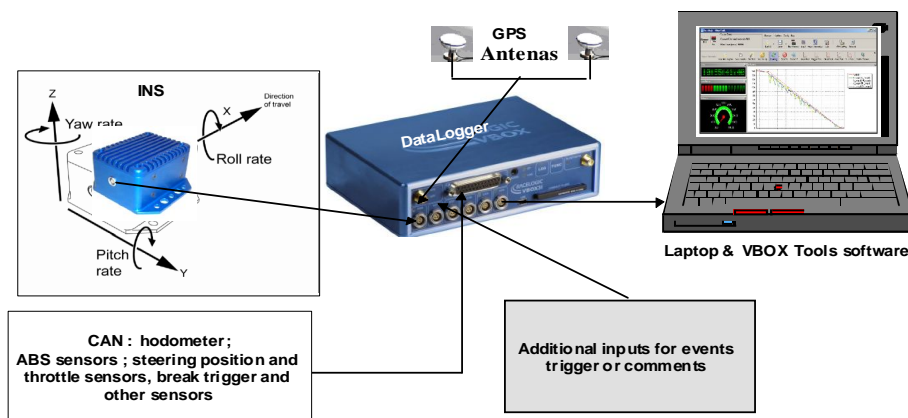


Fig. 3. The test car equipment.

The obtained data were processed using software VBOX Tools [4].

#### A) The field test of stationary obstacle overpass with constant speed.

The results for the safe distance at the start of overpass  $d_1$  is shown in fig. 4, and the safe distance at the end of overpass  $d_2$  is shown in fig. 5.

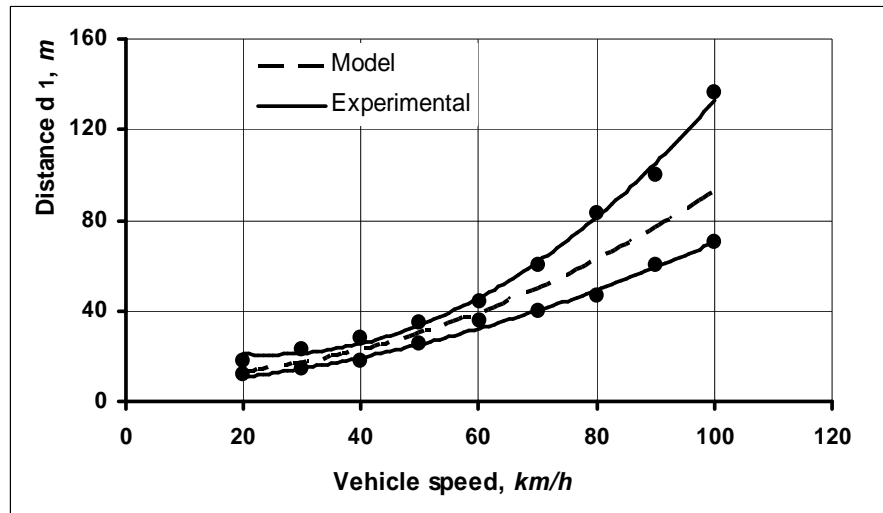


Fig. 4. Relation between the safety distance at the start of overpass  $d_1$  and the speed.

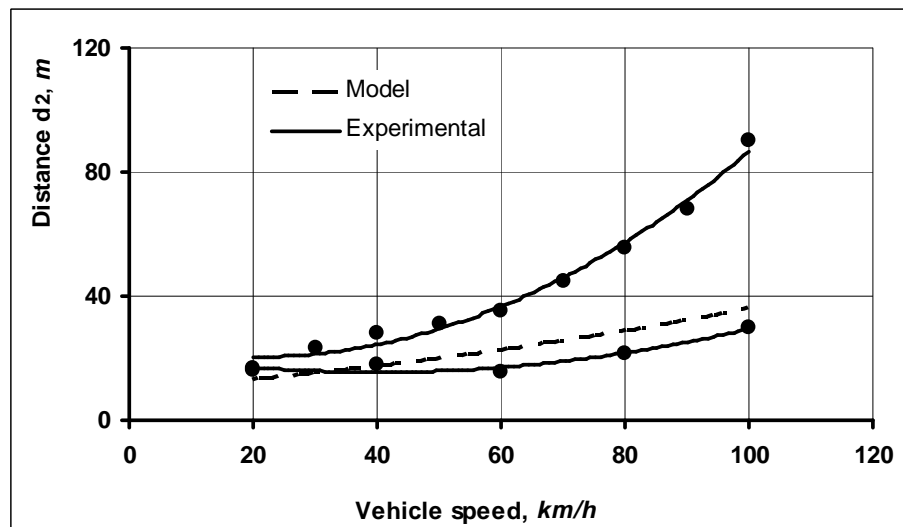


Fig. 5. Relation between the safety distance at the end of overpass  $d_2$  and the speed.

The experimental results for the safe distance at the beginning of overpass  $d_1$  show a good agreement with the model results. For speeds to 60 km/h, the variance of the different drivers is small but over the 60 km/h with increasing the speed increased the deviation.

The experimental results for the safe distance at the end of overpass  $d_2$  show good agreement with the model for the speed under 60 km/h. Increasing the speed over the 60 km/h led to greater deviation from the model results due to the drivers' freedom of choice.

#### B) The field test of overtaking with constant speed.

The results for the safe distance at the start of overtaking  $d_1$  is shown in fig. 6, and the safe distance at the end of overtaking  $d_2$  is shown in fig. 7.

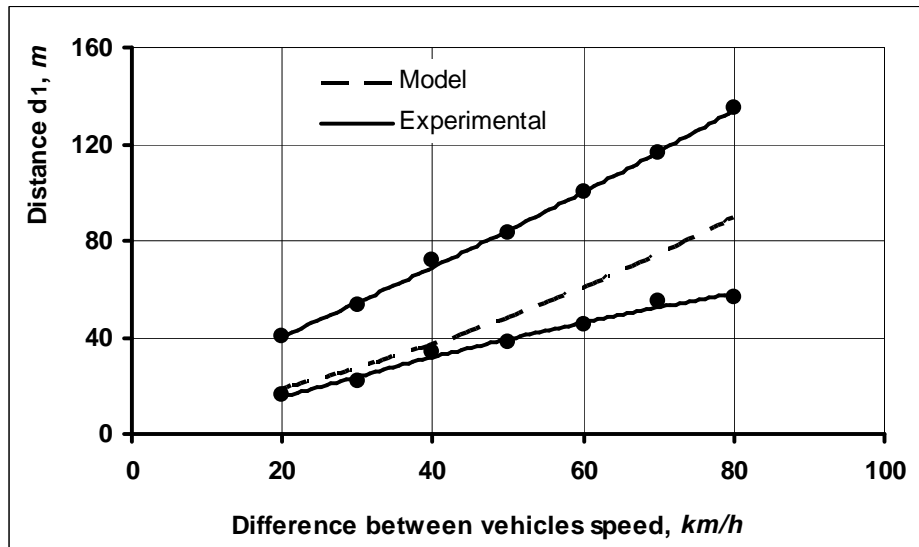


Fig. 6. Relation between the safety distance at the start of overtaking  $d_1$  and the relative speed.

The results of experimental studies on the safe distance at the start of overtaking  $d_1$  (fig. 6) are further to towards larger values in the whole range model. Which means that the same drivers when overtaking choose a safer strategy - greater distances.

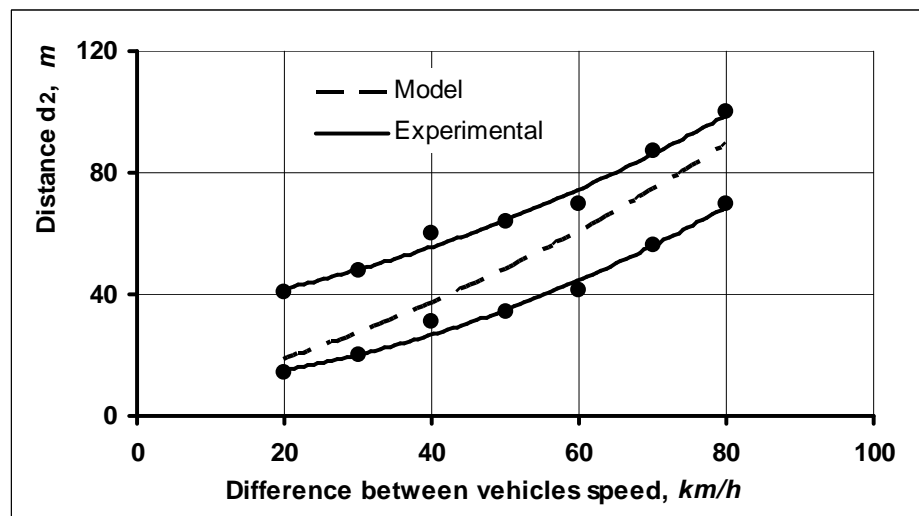


Fig. 7. Relation between the safety distance at the end of overtaking  $d_2$  and the relative speed.

The results of experimental studies on the safe distance at the end of overtaking  $d_2$  (Fig.7) showed higher values than the model for relative speed to 50 km/h and smaller values than the model for the relative speed over 50 km/h.

## CONCLUSION

1. At low levels (absolute and relative) speeds experimental and model results are close and can be used confidently in the expert practice.
2. In this work were used limited studies on overpass and overtaking, but the results show that the use of models in expert practice should be careful.



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