Investigation of the overtaking and overtaken vehicles speeds on two-lane roads in the traffic conditions of the Russian Federation

P I Pospelov¹,³, A V Kostsov¹, D S Martyahin¹, D M Nemchinov²

¹MADI, 64, Leningradsky avenue, Moscow, 125319, Russian Federation
²TransInzhProekt, 21, Avtozavodskaya street, Moscow, 115280, Russian Federation
³Email: pospelov@madi.ru

Abstract. The speeds investigation results of the overtaking, overtaken and moving on the opposite lane vehicles on two-lane roads in the conditions of the Russian Federation are presented in this paper. The investigations were carried out using unmanned aerial vehicles in compliance with generally accepted scientific methods. Based on the statistical processing of the measurement results, generalized vehicles speed data within the overtaking sections was obtained. It was noted that the presented investigations may be a rationale for improving the requirements for the design of roads on the territory of the Russian Federation. In addition, the obtained data may be used to develop measures to improve traffic safety on existing roads, which will have a generally beneficial effect on traffic safety.

1. Introduction

It has generally recognized that accidents in overtaking vehicles on two-lane roads cause some of the most severe consequences. The approaches to the designation of overtaking sight distances existing in the regulations of the Russian Federation are not adequately considering the modern traffic conditions on the country's road network. Therefore, the most important direction to improve the traffic safety on two-lane roads is investigating of modern traffic conditions in the overtaking areas in general and the traffic speed in such areas in particular.

The continuing vigorous motorization growth of the Russian Federation population sharply puts the task of ensuring road safety. Despite the overall decrease in the number of road accidents (Figure 1), the risk of accidents on the roads of the Russian Federation as of 2015 is 3-4 times higher than in countries with a high motorization level [10].

It has generally recognized that accidents in overtaking vehicles cause the most severe consequences - significant harm to the health and death of the victims. Studies conducted by German researcher fellows in the year 2016 have confirmed that accidents in overtaking lead to the most severe consequences on two-lane roads. At the same time, the main places of road accident concentration detected on-road sections with insufficient overtaking sight distance [5]. Thus, the implementation of measures to ensure overtaking in conditions of secured sight distance on two-lane roads is one of the primary tasks in preventing fatal crashes and severe injuries. The regulatory system of the Russian Federation establishes requirements for minimum values of sight distances sufficient for overtaking. Such values of sight distances are presented in Table 1.
Figure 1. Trends in road accidents.

Table 1. Regulation of the sight distance in Russia.

| Estimated speed, km/h | Sight distance at overtaking, m, in regulations of the Russian Federation |
|-----------------------|-----------------------------------------------------------------------|
| SNiP II-D.5-72 (1972) | CP 34.13330.2012 (2013),                                              |
| SNiP 2.05.02-85 (1985)  | CP 34.13330.2012 rev.1 (2017)                                         |
| SNiP 2.05.02-85* (2004) |                                                                     |
| 120                   | 800                                                                   |
| 100                   | 700                                                                   |
| 80                    | 600                                                                   |
| 60                    | 500                                                                   |

Figure 2. Sight distance determination scheme in overtaking

Considering the traffic conditions on the roads of the Russian Federation that have changed over the last decade, the authors performed research on traffic conditions on overtaking sections. The following overtaking model has adopted for the research work (Fig. 2) [11]:

a) The overtaking begins at the moment when the vehicle 1 approaches the overtaken vehicle 2 by a distance equal to the difference in their braking distances \((S_1 - S_2)\) and the way the vehicle passes from the moment when the driver decides to overtake \((L_1)\). Therefore, considering that the vehicle 1 is at a distance \((L_2)\) from the vehicle 2 and knowing the speeds difference of the vehicles \((V_1 - V_2)\), determine the path that the vehicle 1 will pass until it equals the vehicle 2 \((L_1)\) on the horizontal road segment \((i = 0)\):

\[
L_1 = \frac{(l_1 + l_2) \cdot v_1}{v_1 - v_2} = \frac{v_1^2}{v_1 - v_2} + \frac{k_3 \cdot V_1 \cdot (V_1 + V_2)}{2 \cdot g \cdot \varphi_1}, \quad (1)
\]
where $V_1$ and $V_2$ - is the speed of the rear and front vehicle, respectively, m/s; $\varphi_1$ - is the longitudinal friction (adhesion) coefficient; $k_3$ - is the operational brakes state coefficient, assumed equal for both vehicles; $l_4$ - is the vehicle length, m.

b) The vehicle 1 returns to its lane in front of the vehicle 2 at a safe distance ($l_3$) equal to its braking distance ($S_2$), increased by the safety gap ($l_0$) and the length of the vehicle ($l_4$). Then the path passed by the vehicle 2 before returning to its lane ($L_2$) will be equal to:

$$L_2 = \frac{(l_3 + l_4) \cdot V_1}{v_1 - v_2} = \left[ \frac{k_3 \cdot V_2^2}{2 \cdot g \cdot \varphi_1} + l_0 + l_4 \right] \cdot \frac{V_1}{v_1 - v_2}.$$  

(2)

c) Overtaking is possible when the vehicle 1 returns to its lane at the time of meeting the oncoming vehicle 3 moving at a speed $V_3$. During the overtaking period, this vehicle passes the path ($L_3$) equal to:

$$L_3 = \frac{l_1 + L_2}{V_4} \cdot V_3,$$

(3)

Then the sight distance from the overtaking condition will be

$$S_0 = L_1 + L_2 + L_3 = (l_0 + l_1 + 2 \cdot l_4 + \frac{k_3 \cdot V_2^2}{2 \cdot g \cdot \varphi_1}) \cdot \frac{V_4 + V_3}{V_1 - V_2}.$$  

(4)

From the equation (4), within the adopted model, the sight distance of the oncoming vehicle depended mostly on speeds of the overtaking ($V_1$) and overtaken ($V_2$) vehicles, as well as the vehicle moving in the opposite traffic direction ($V_3$).

2. Investigation of overtaken and overtaking vehicles speeds on two-lane roads

In order to actualize the requirements for sight distances accepted by the regulatory system of the Russian Federation (Table 1), the authors have conducted studies aimed at determining the speeds of vehicles in such areas. Investigations have carried out on a network of two-lane roads in the Moscow region.

The investigation of traffic speeds has carried out using the aerial video method recording using unmanned aerial vehicles (UAV) (Figure 3) in compliance with specially developed [9] and generally accepted scientific methods [8], and subsequent processing of the record received using the software package Movavi Screen Capture Studio.

![Figure 3. Operating moment during the measurement using UAV.](image)

The obtained data of the overtaking ($V_1$) and overtaken ($V_2$) vehicle values have presented as the theoretical distribution curves according to Poisson's law corresponding to those obtained
during the measurements. The smoothing of the experimental data was carried out by the methods described in [6]. Based on the statistical processing results of the obtained data array, cumulative curves have constructed containing data on the speeds of the overtaking \( V_1 \) and overtaken \( V_2 \) vehicles, and the vehicle moving in the opposite traffic direction \( V_3 \), presented in Figure 4.

![Figure 4. Frequency of accidents vs vehicles speed](image)

### 3. Conclusion

The investigations conducted allowed establishing the values and ratios of the overtaking \( V_1 \) and overtaken \( V_2 \) vehicle speed, as well as a car, moving in the opposite traffic direction \( V_3 \) on the overtaking sections of two-lane roads in the conditions of the Russian Federation. The investigations presented in the paper may be used as the substantiation for the improvement the requirements to design roads in the Russian Federation territory. Moreover, the data obtained may be implemented for the development of measures to improve traffic safety on existing roads, which will have a generally beneficial effect on traffic safety.

### References

[1] CP 34.13330.2012 2013 Automobile roads. Updated version of SNiP 2.05.02-85 * (Moscow) (in Russian).

[2] Revision No. 1 to the CP 34.13330.2012 2017 Automobile roads. Updated version of SNiP 2.05.02-85* (Moscow) URL: http://docs.cntd.ru/document/1200095524 (in Russian)

[3] SNiP II-D.5-72 1973 *Automobile roads. Design code* (Moscow: Stroyizdat) (in Russian)

[4] SNiP 2.05-85 1985 *Automobile roads* (Moscow: Gosstroy) (in Russian)

[5] Richter T, Ruhl S, Ortlepp J, Bakaba E 2016 Prevention of overtaking accidents on two-lane rural roads *Transportation Research Procedia* 14 4140-4149.

[6] Zaks L 1976 *Statistical estimation* (Moscow, Statistics) p. 598 (in Russian)

[7] STSI 2018 Statistics URL: http://gibdd.ru/stat/.

[8] Silyanov V V, Domke E R 2008 *Road service quality of roads and city streets* (Moscow: Academy Publishing Center) p. 352

[9] Pospelov P I, Kostsov A V, Martyahin D S, Martyahin K Yu 2018 Application of unmanned aerial vehicles to the investigation of vehicle traffic modes *Vestnik MADI* 2.
[10] Pugachev I et al 2016 Factor analysis of the organization and road safety system In Proceedings of the Twelfth international scientific and practical conference Organization and safety of traffic in large cities, St. Petersburg.

[11] Babkov V F 1979 Design of roads (Moscow: Transport) vol. 1, p. 367.