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THE STUDY OF THE OVERTAKING PROCESS IN THE SITUATION WHERE FROM THE OPPOSITE DIRECTION ANOTHER VEHICLE IS APPROACHING

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Abstract: *Taking into account the kinematic measures of the process of vehicle overtaking, in different situations of driving and the area situated between the critical interruption position of the overtaking maneuver and that of its continuing, from the process of overtaking - the dilemma area - where neither the decision of aborting the overtaking maneuver nor that of continuing it is safe, the paper assesses the distances covered by the vehicle running from the opposite direction (vehicle 3), in the consecutive stages of the overtaking process between the vehicle doing the overtaking (vehicle 1) and the one being overtaken (vehicle 2). In this sense, for each of the variants of overtaking had in view and road conditions considered, taking into account the variation of the distance between vehicle 1 and vehicle 3 after the returning in line of vehicle 1, which depends on the speed of the vehicle which is overtaking, we are analysing: the variation of the distance covered by vehicle 3, for the entire duration of the overtaking process between vehicle 1 and vehicle 2, according to this duration and the nature and state of the road, and respectively according to the running speed of vehicle 3 and the nature and state of the road;the variation of the distance covered by vehicle 3 while vehicle 1 covers the separation distance from the line, according to this duration and the nature and state of the road, and respectively according to the running speed of vehicle 3 and the nature and state of the road; the variation of the distance covered by vehicle 3 while vehicle 1 is running in parallel with vehicle 2, according to the duration of their parallel running and the nature and state of the road, and respectively according to the running speed of vehicle 3 and the nature and state of the road; the variation of the distance covered by vehicle 3 while vehicle 1 covers the distance of returning to the initial lane, according to this duration and the nature and state of the road, and respectively according to the running speed of vehicle 3 and the nature and state of the road; the variation of the distance between vehicle 1 and vehicle 3, at the separation moment from the line of vehicle 1, according to the running speed of vehicle 3 and the nature and state of the road; the variation of the distance between vehicle 1 and vehicle 3, at the initiation moment of the return of vehicle 1 to the initial lane, according to the running speed of vehicle 1 and the nature and state of the road, and respectively according to the running speed of vehicle 3 and the nature and state of the road.*
The model of calculation developed can be at the basis of the design of driving assistance systems with the purpose of providing support to the driver in the consecutive stages of the process of overtaking vehicles.
Key words: *vehicle, overtaking, speed, duration, distance, safety*

1. INTRODUCTION

In the process of overtaking vehicles we must perceive and analyze the causality reports of a relatively great number of elements which are not always predictable (the speed of the vehicle which is overtaking and that of the one which must be overtaken; the distance between the vehicle which intends to overtake and the one which is going to be overtaken; each vehicle's position in relation to the width of the road; the speed of the vehicle running from the opposite direction; the distance between the vehicle which intends to overtake and the vehicle running in the opposite direction etc.).

Most of the studies [1, 2, 3, 6, 11, 13, 16, 18, 19, 20] concerning the process of overtaking vehicle follow the evaluation of the safety distances in all the consecutive stages of the overtaking process taking into account the vehicles' positions during these stages, and in the case where another vehicle is approaching from the opposite direction, it is also followed the evaluation of the dilemma area in which it is neither safe to abort the overtaking maneuver nor to continue it.

2. THE NUMERICAL EVALUATION METHOD

2.1 The stages of the overtaking process in the situation where from the opposite direction another vehicle is approaching

In this study, the stages of the overtaking process are take into account in the situation where another vehicle approaches from the opposite direction (Fig. 1).

The symbols used in Figure 1 refer to: 1- the vehicle that is doing the overtaking; 2 - the vehicle that is being overtaken (v_2 = constant); $L_{1,2,3}$ - the length of vehicle 1, vehicle 2 and vehicle 3; I - vehicle 1 is initiating the separation from the line in order to overtake; II - vehicle 1 reaches the speed $v_{1i} > v_1$ and starts running in parallel with vehicle 2; III - vehicle 1 reaches the speed $v_{1p} > v_{1i}$ and initiates the returning to the line; IV - the end of the return to the line of vehicle 1; S_{i3} - the distance covered by vehicle 3 while vehicle 1 covers the distance S_i of separation from the line; S_{p3} - the distance covered by vehicle 3 while vehicle 1 is running in parallel with vehicle 2 on the distance S_p; S_{r3} - the distance covered by vehicle 3 while vehicle 1 covers the distance S_r of returning to the initial lane; $S_{r1\text{-}3}$ - the distance between vehicle 1 and vehicle 3 at the initiation moment of the return of vehicle 1 to the initial lane ($S_{r1\text{-}3} = S_r + S_{r3} + S_{f1\text{-}3}$); S_{d3} - the distance covered by vehicle 3 during the overtaking process initiated by vehicle 1 which runs on the distance S_d, ($S_{d3} = S_{i3} + S_{p3} + S_{r3}$; $S_d = S_i + S_p + S_r$); $S_{f1\text{-}3}$ - the distance between vehicle 1 and vehicle 3 after the return to the line of the vehicle that has done the overtaking; $S_{t1\text{-}3}$ - the distance between vehicle 1 and vehicle 3 at the separation moment from the line of vehicle 1 ($S_{t1\text{-}3} = S_d + S_{d3} + S_{f1\text{-}3}$); t - the duration of covering the separation route from the line (t_i), and respectively that of returning to line (t_r).

In the cases where a vehicle 3 approaches from the opposite direction (Fig. 1), the distance S_{d3} covered by this vehicle while vehicle 1 is overtaking vehicle 2 on the distance S_d, represents approximatively 2/3 of the distance S_d [6, 16, 18, 19, 20]. In such cases, if the decision of aborting the maneuver must be taken, this shall be taken before 1/3 of the distance S_d covered by vehicle 1 in the overtaking process [6, 16, 18, 19, 20], this being considered the critical position. Between the critical position of aborting the overtaking maneuver and that of continuing it, there is a *dilemma area* where neither the decision of aborting the overtaking maneuver nor that of continuing it is safe.

If vehicle 3 which is running from the opposite direction appears before vehicle 1 (which is doing the overtaking) reaches the critical position, the right decision of the driver of vehicle 1 is to abort this. But if vehicle 3 appears after this critical position, then the correct decision is to go on with the overtaking [6, 16, 18, 19, 20].

2.2 The variants of doing the overtaking considered in this study

Among the overtaking variants frequently met in the driving practice, we shall mention (Fig. 1) [1, 2, 3, 11, 13]:

- *variant A*: vehicle 1 is running with speed $v_1 = v_2$ behind vehicle 2 at the safety distance S_1. When the overtaking becomes possible, vehicle 1 accelerates with a_{med} and starts the separation, so that by the end of the first stage (after covering the distance S_i) it has reached the speed $v_{1i} > v_2$ ($v_{1i} = v_1 + a_{med} \cdot t$). After running in parallel on the distance S_p (with the same acceleration a_{med}), at the end of which vehicle 1 reaches the speed $v_{1p} > v_{1i}$, ($v_{1p} = \sqrt{v_{1i}^2 + 2 \cdot a_{med} \cdot S_p}$) and when its front overtakes with S_3 the front of vehicle 2 ($S_3 > L_1$, $S_3 = L_1 + S_{3s}$), this starts the return to the initial lane without accelerating. The distance S_{3s} is considered so that between the back of vehicle 1 and the front of vehicle 2 there is breach t_{3s} of about 2...3 seconds [3]. Thus, it is considered that on the distance S_r of the overtaking final stage, vehicle 1 is running with a constant speed v_{1p} and after it returns to the initial lane, between the two vehicles there is a safety distance S_4.

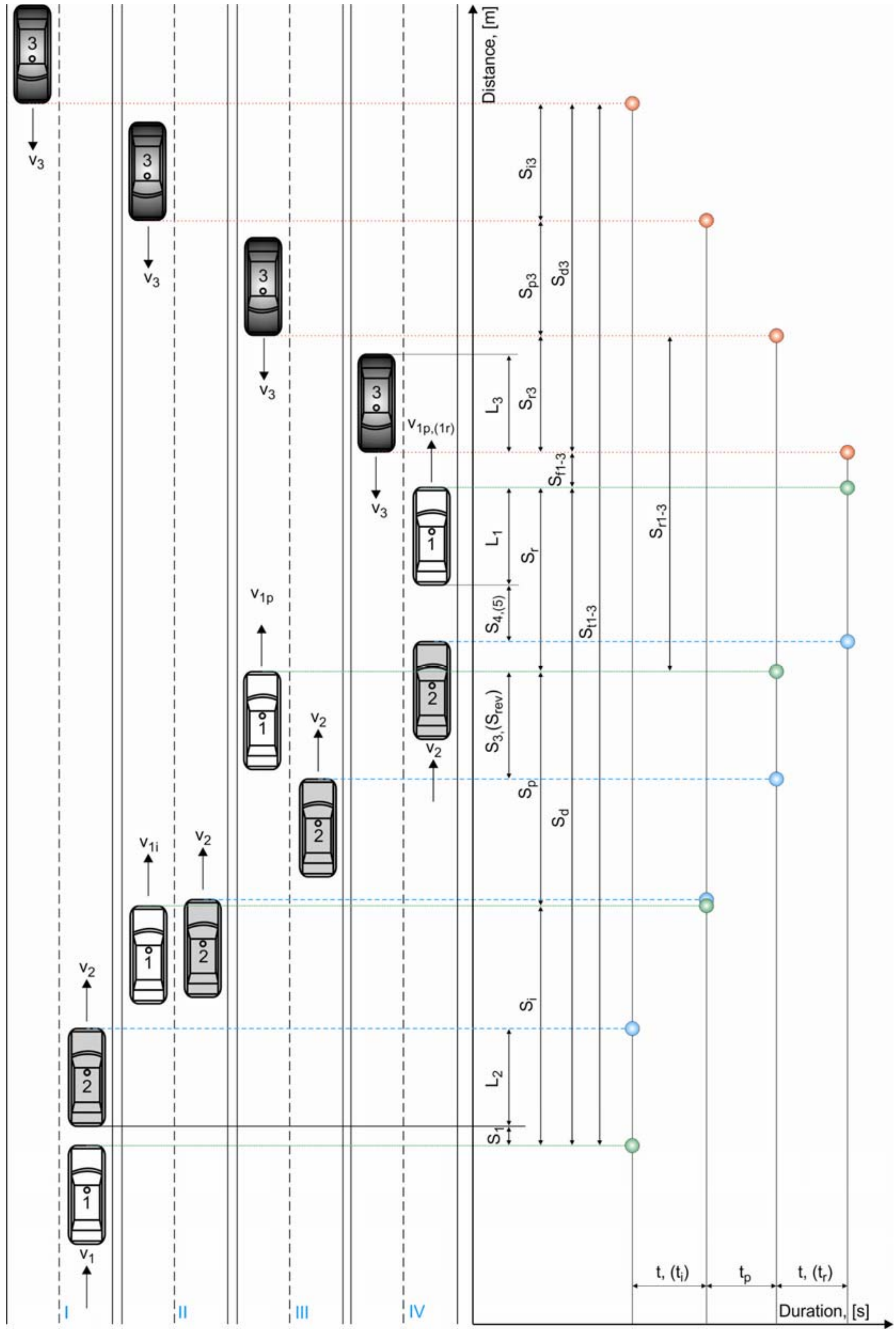

Fig. 1. The distances of the overtaking stages in relation to their corresponding duration for the situation where a vehicle (3) is approaching from the opposite direction.

- *variant B*: vehicle 1 running with the speed $v_1 > v_2$ ($v_1 = constant; v_2 = constant$) is overtaking vehicle 2 starting from a safety distance S_1. When the back of vehicle 1 is overtaking with S_{3s} the front of vehicle 2, it starts the return to the initial lane so that after the return between 1 and 2 there is a safety distance S_4. During the overtaking process both v_1 and v_2 are maintained constant and $v_{1p} = v_{1i} = v_1$.
- *variant C*: vehicle 1 is running with constant speed $v_1 > v_2$, and when it gets to the safety distance S_1 behind 2 and it realises it is possible to overtake, it starts the separation from the line and at the same time it accelerates. After that, vehicle 1 is running in a similar way to *variant A*.
- *variant D*: similar to variant *C* up to the moment when vehicle 1 starts the return to the initial lane. At this time its running speed is v_{1p}, after that it is considered that it continues running with the same uniform accelerated movement. After the distance S_r is covered by vehicle 1, it reaches the speed $v_{1r} > v_{1p}$, ($v_{1r} = v_{1p} + a_{med} \cdot t$) and by the end of the overtaking there must be a safety distance S_5 between the vehicles.

2.3 Notations used in the model of calculation according to the conditions of overtaking

For each of the overtaking variants *A, B, C* and *D,* various conditions of the driver are taken into account. They are symbolized by *a, b, c, d* and *e* (table 1) [13]. If we refer both to the driver's condition and to the overtaking variant, we shall use the notations according to table 1.

The values of the perception-reaction time at breaking of the driver-vehicle assembly both for the one that is doing the overtaking and the one that is being overtaken, according to driver's condition are considered like this [13]: $t_{pr(a)}$ = 0.48...0.6 s; $t_{pr(b)}$ = 0.8...1 s; $t_{pr(c)}$ = 0.92...1.2 s; $t_{pr(d)}$ = 1...1.5 s; $t_{pr(e)}$ = 0.96...1.3 s.

Table 1

Notations used according to the driver's condition and the overtaking variant

Driver condition / **Overtaking variant**	**A**	**B**	**C**	**D**
❑ is expecting danger (a)	a-A	a-B	a-C	a-D
❑ normal behavior in situations which present an imminent danger (b)	b-A	b-B	b-C	b-D
❑ driving conditions on wet roads (c)	c-A	c-B	c-C	c-D
❑ the number of elements perceived in order to make a decision is bigger than four (d)	d-A	d-B	d-C	d-D
❑ for the sunshine and sunset (e)	e-A	e-B	e-C	e-D
If a certain condition of the driver refers to more overtaking variants, for example, condition (a) refers both to overtaking variant C and D, then the notation used shall be „a-C,D” etc.				

If in the numerical model it is necessary to be used a certain measure (M) which varies between the minimal value (M_{min}) and the maximum one (M_{max}), considering a variable *j* which shall detect values of the seize considered between the range (M_{min}...M_{max}), it is defined a generally valid relation for the model of calculation developed, with the form [13]: $M_j = M_{min} + (j-1) \cdot \frac{M_{max} - M_{min}}{10}$, j=1...11.

For each of the overtaking variants *A, B, C* and *D* various natures and states of the road on which the vehicles are running, symbolised by *nsr1* and *nsr2* (table 2) are taken into account. In the model of numerical calculation, in order to define the coefficients of adhesion which characterize the nature and state of each road considered (φ_{nsr1} = 0.7...0.8; φ_{nsr2} = 0.45...0.55, [1, 2, 3, 14, 15] - on longitudinal direction), we shall use the variable jd = 1...2 (jd = 1↔ *nsr1*; jd = 2 ↔ *nsr2*), so that: $\varphi_{jd} = \varphi_{med_{jd}}$.

If we refer both to the nature and state of the road and to the overtaking variant, we shall use the notations according to table 2 [13]. For roads with a longitudinal pitch under an angle α, instead of coefficient φ_{jd} we shall use the global coefficient of adhesion $\varphi_{0_{jd}}$, given by the following relation: $\varphi_{0_{jd}} = \varphi_{jd} \cdot \cos\alpha \pm \sin\alpha$, ("+" ascent; "–" descent). In this study the road is considered to be horizontal (α = 0).

Table 2

Notations used according to the nature and state of the road and the overtaking variant

Overtaking variant / Nature and state of the road	A	B	C	D
❑ concrete-asphalt, dry (nsr1)	A-nsr1	B-nsr1	C-nsr1	D-nsr1
❑ concrete-asphalt, wet (nsr2)	A-nsr2	B-nsr2	C-nsr2	D-nsr2

If a certain state and nature of the road refers to various overtaking variants, for example the nature and state of the road (nsr1) refers both to the overtaking variant C and variant D, then the notation used is „C, D-nsr1" etc.
In the case of referring both to the driver's condition (ex.-a) and to the overtaking variant (ex.-A) as well as to the nature and state of the road (ex.-nsr1), the notations used shall be as follow „a-A,nsr1".

In order to detect the variation of the safety distance S_1 at the separation moment from the line according to the perception-reception time t_{pr} of the driver-vehicle assembly which is doing the overtaking for various *A, B, C* and *D* overtaking variants and various natures and states of the road, the speed of the vehicles v_1, v_2, the time t_{pr}, the deceleration of a dynamic breaking *d*, are considered as follows [13]: $v_{1(A)_{ct.}} = 50\ km/h$; $v_{1(B,C,D)_{ct.}} = 60\ km/h$; $v_{2(A,B,C,D)_{ct.}} = 50\ km/h$; $t_{pr} = 0.48 \ldots 1.5\ s$; $d_{(A,B,C,D)_{jd}} = \varphi_{med_{jd}} \cdot g,\ m/s^2$, g is the gravitational acceleration. At this stage of calculation, in the numerical model developed, the speeds $v_{1(A)_{ct.}}$, $v_{1(B,C,D)_{ct.}}$ and $v_{2(A,B,C,D)_{ct.}}$ are considered to be constant, at the mentioned values, and the medium accelerations [1, 2, 3, 13] of the vehicle which is doing the overtaking, pertaining to overtaking variants *A, C* and *D* according to the stages of the overtaking process (Fig. 1 - stages I, II, III and IV) are considered as follow: $a_{(A)} = 1.42\ m/s^2$; $a_{(C,D)} = 0.88\ m/s^2$. For the overtaking variant B, the speed of the vehicle which is doing the overtaking is constant over the whole overtaking process, the medium acceleration $a_{(B)}$ pertaining to this overtaking is null.

In order to detect variations of the searched measures, the running speed of the vehicle that is being overtaken is considered the same ($v_{2(A,B,C,D)}$ = 30...50 km/h) for each of the overtaking variants *A, B, C* and *D* [13]. The running speed of the vehicle that is doing the overtaking is considered like this [13]: for overtaking variant A - the same as that of the vehicle that is being overtaken ($v_{1(A)} = v_{2(A,B,C,D)}$ = 30...50 km/h), and for the overtaking variants *B, C* and *D* taken into account - bigger than that of the vehicle that is being overtaken ($v_1 > v_2; v_{1(B,C,D)} = 40...60\ km/h$).

2.4 The distances covered by the vehicle running in the opposite direction during the overtaking process

Considering that the distance S_{d3} (Fig. 1) is covered by vehicle 3 during the overtaking process initiated by vehicle 1 which is running on the distance S_d (evaluated according to [13]), it is determined according to the relation [6, 16, 18, 19, 20]:

$$S_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = \frac{2}{3} \cdot S_{d\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}, \quad (1)$$

and assuming that vehicle 3 (see Fig. 1) is running with a constant speed on the distance S_{d3}, its speed can be determined like this:

$$v_{3d\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = \frac{S_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}}{t_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}}, \quad (2)$$

where t_{d3} represents the duration in which vehicle 3 covers the distance S_{d3}:

$$t_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = 2 \cdot t_{j,jd} + t_{p\begin{pmatrix}A\\B\\C,D\\C,D\end{pmatrix}_{\begin{pmatrix}j,jd\\j\\j,jd\\j,jd\end{pmatrix}}}, \quad (3)$$

where t_p represents the duration of covering the distance S_p of parallel running of vehicle 1 with vehicle 2 [13]:

$$\begin{pmatrix} t_{p\begin{pmatrix}A\\C,D\end{pmatrix}_{j,jd}} \\ t_{p(B)_j} \end{pmatrix} = \begin{pmatrix} \dfrac{v_{1p\begin{pmatrix}A\\C,D\end{pmatrix}_{j,jd}} - v_{1i\begin{pmatrix}A\\C,D\end{pmatrix}_{j,jd}}}{a_{\begin{pmatrix}A\\C,D\end{pmatrix}}} \\ \dfrac{S_{p(B)_j}}{v_{1i(B)_j}} \end{pmatrix}, \quad (4)$$

and $t_{j,jd}$ is the time in which vehicle 1 covers the distance S_i of separation from the line, and respectively the distance S_r of returning to the initial lane (Fig. 1) [1, 2, 3, 11, 13]:

$$t_{j,jd} = \sqrt{\frac{D_{t_j}}{1.56 \cdot \varphi_{t_{jd}}}}, \qquad (5)$$

in which we shall consider the lateral safety distance D_t (cca. 3...3.25 m) [13] between the longitudinal axes of vehicle 1 and 2 involved in the overtaking process during the parallel running stage on the distance S_p and the coefficient of adherence on the transverse direction φ_t, characterized by the nature and state of the road ($\varphi_{t_{jd}} \cong 0.8 \cdot \varphi_{a_{jd}}$, and the coefficient of sliding $\varphi_{a_{jd}}$ represents approximatively 80% of the coefficient of adherence on longitudinal direction φ_{jd} [1, 2, 3, 13]).

The distance S_{i3} (see Fig. 1) covered by vehicle 3 during time $t_{j,jd}$ in which vehicle 1 covers the distance S_i of separation from the line, and respectively the distance S_{r3} (Fig. 1) covered by vehicle 3 during time $t_{j,jd}$ in which vehicle 1 covers the distance S_r of returning to the initial lane, is determined as follows:

$$S_{i3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = v_{3d\begin{pmatrix}A\\B\\C\\D\end{pmatrix}\begin{pmatrix}j,jd\\j\\j,jd\\j,jd\end{pmatrix}} \cdot t_{j,jd} = S_{r3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}. \qquad (6)$$

The distance S_{p3} (see Fig. 1) covered by vehicle 3 during time t_p in which vehicle 1 is running in parallel with vehicle 2 on the distance S_p (see Fig. 1) is determined according to the relation:

$$S_{p3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = S_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} - S_{i3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} - S_{r3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}, \qquad (7)$$

The distance $S_{t1\text{-}3}$ (see Fig. 1) between vehicle 1 and vehicle 3 at the time of separation from the line of vehicle 1 is determined as follows:

$$S_{t1-3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = S_{d\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} + S_{d3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} + S_{f1-3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}, \qquad (8)$$

in which the distance $S_{f1\text{-}3}$ is situated between 30...90 m according to the speed of the vehicle that is overtaking, like this [19, 20]:

$$S_{f1-3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = \begin{pmatrix}30\\55\\75\\90\end{pmatrix} m, \text{if } v_{\begin{pmatrix}1pA\\1pB\\1pC,D\\1rD\end{pmatrix}\begin{pmatrix}j,jd\\j\\j,jd\\j,jd\end{pmatrix}} = \begin{pmatrix}50\ldots65\\66\ldots80\\81\ldots95\\96\ldots110\end{pmatrix} km/h$$

The distance $S_{r1\text{-}3}$ (Fig. 1) between vehicle 1 and vehicle 3 at the initiation moment of the return of vehicle 1 to the initial lane is determined like this:

$$S_{r1-3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} = S_{r\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} + S_{r3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}} + S_{f1-3\begin{pmatrix}A\\B\\C\\D\end{pmatrix}_{j,jd}}. \qquad (9)$$

3. OBTAINED RESULTS

The model of numerical calculation developed in the program MathCAD based on the physical phenomena during the consecutive stages of the overtaking process of vehicle 1 and 2, where the overtaking conditions (overtaking variants, speed of the vehicles, possibility to break dynamically, driver's condition, nature and state of the road, etc) have been taken into account and which allowed the evaluation of the kinematic measures of the overtaking process of vehicles 1 and 2 [13], has been extended in this paper in order to study the overtaking process in the situation where another vehicle 3 approaches from the opposite direction. Results with a graphical interpretation of the kinematic measures of the vehicle overtaking process are obtained by applying the calculation method.

The variation of the distance S_{d3} covered by vehicle 3 (see Fig. 1) during t_{d3} corresponding to the parallel running of vehicle 1 with vehicle 2 during t_p and the running of vehicle 1 on the distance S_i during $t_{j,jd}$ and respectively S_r during the same time $t_{j,jd}$, period ($t_p + 2 \cdot t_{j,jd} = t_{d3}$) during which vehicle 1 is running on the distance S_d (see Fig. 1) for each of the running variants studied and for each road taken into consideration, we shall follow Figure 2 and according to its running speed v_{3d} Figure 3.

The variation of the distance S_{i3}, and respectively the distance S_{r3} (see Fig. 1) covered by vehicle 3 according to the running duration of vehicle 1 on the distance S_i, and respectively S_r according to the nature and state of the road can be seen in Figure 4 while the variation according to its running speed v_{3d} and the nature and state of the road can be seen in Figure 5.

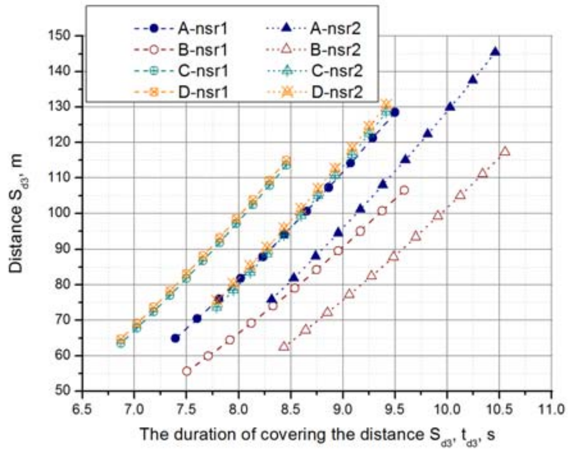

Fig. 2. Variation of the distance S_{d3} covered by vehicle 3 according to duration t_{d3} corresponding to covering this distance and according to the nature and state of the road.

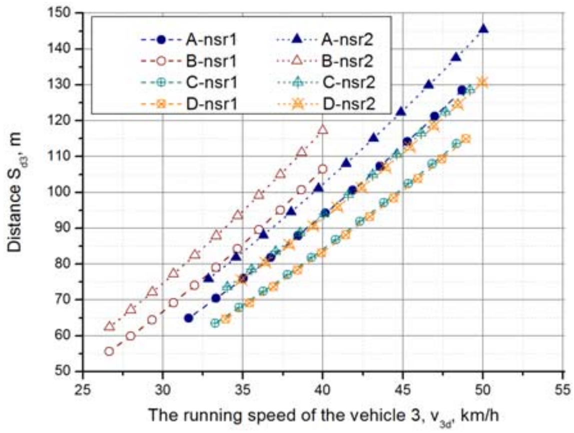

Fig. 3. Variation of the distance S_{d3} covered by vehicle 3 according to its running speed v_{3d} and according to the nature and state of the road.

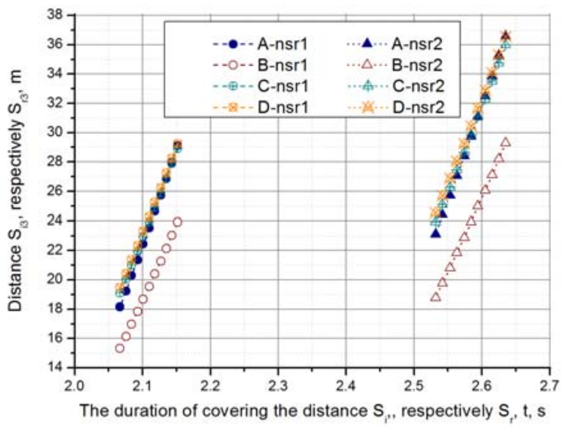

Fig. 4. The variation of the distance S_{i3} and S_{r3} covered by vehicle 3 according to the duration of the running of vehicle 3 and that of vehicle 1 on the distance S_i and respectively S_r and according to the nature and state of the road.

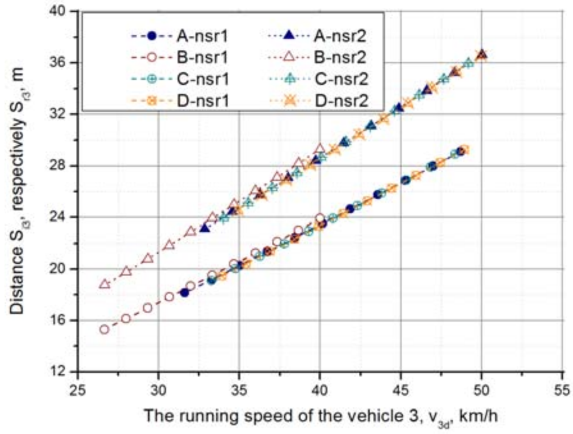

Fig. 5. The variation of the distance S_{i3} and S_{r3} covered by vehicle 3 according to its running speed v_{3d} and the nature and state of the road.

The variation of the distance S_{p3} (see Fig. 1) covered by vehicle 3 according to its running duration t_p (the same as the duration of covering the distance S_{p3} by vehicle 3), respectively its running speed v_{3d} can be seen in Figure 6 and Figure 7 for each of the running variants taken into account and for each road considered.

The variation of the distance S_{t1-3} (see Fig. 1) according to the running speed of vehicle 1 $v_{1p,(1r)}$ (determined according to [13]), and respectively according to the running speed of vehicle 3 v_{3d} can be seen in Figure 8 and 9 for each of the running variants studied and for each road considered.

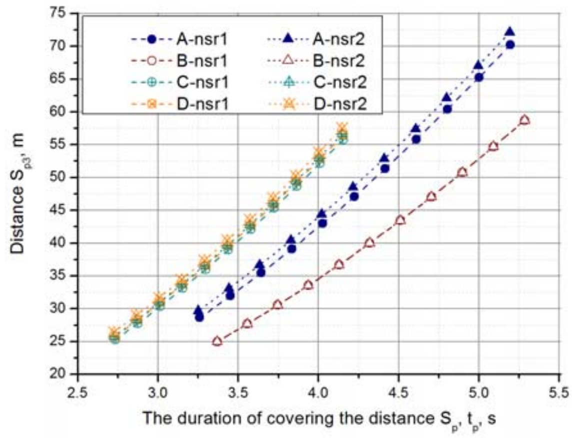

Fig. 6. The variation of the distance S_{p3} covered by vehicle 3 according to the duration of the parallel running t_p of vehicle 1 with vehicle 2 and the nature and state of the road.

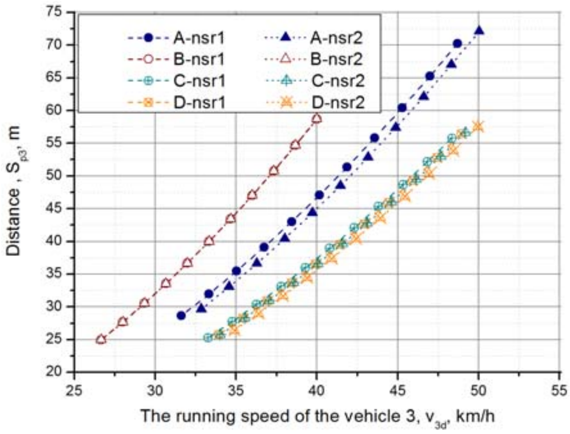

Fig. 7. The variation of the distance S_{p3} covered by vehicle 3 according to its running speed and the nature and state of the road.

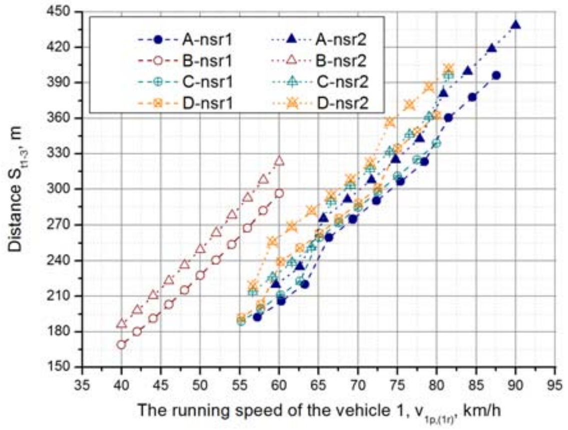

Fig. 8. The variation of the distance S_{t1-3} between vehicle 1 and vehicle 3 at the time of separation from the line of vehicle 1 on the initial lane according to the running speed of vehicle 1 $v_{1p,(1r)}$ and the nature and state of the road.

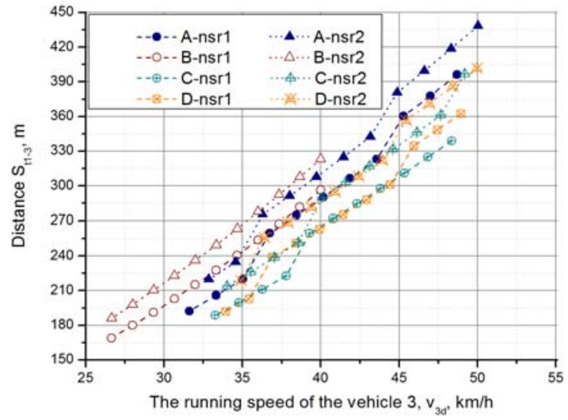

Fig. 9. The variation of the distance S_{t1-3} between vehicle 1 and vehicle 3 at the time of separation from the line of vehicle 1 on the initial lane according to the running speed of vehicle 3 v_{3d} and the nature and state of the road.

The variation of the distance S_{r1-3} (see Fig. 1) between vehicle 1 and vehicle 3 at the initiation moment of the return of vehicle 1 to the initial lane according to the running speed of vehicle 1 $v_{1p,(1r)}$ and that of vehicle 3 v_{3d} can be seen in Figure 10 and Figure 11 for each of the running variants studied and for each road considered.

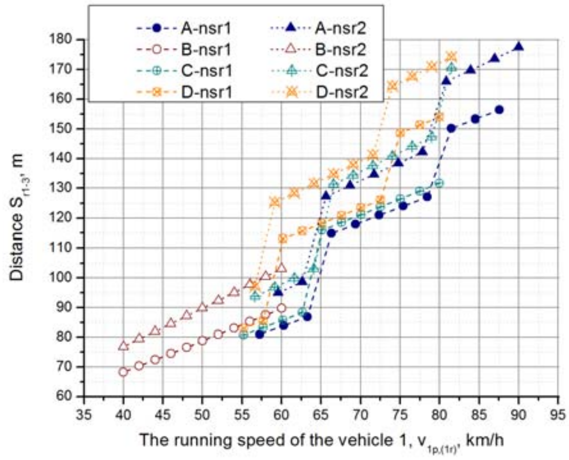

Fig. 10. The variation of the distance S_{r1-3} between vehicle 1 and vehicle 3 at the initiation moment of the return of vehicle 1 to the initial lane according to the running speed of vehicle 1 $v_{1p,(1r)}$ and the nature and state of the road.

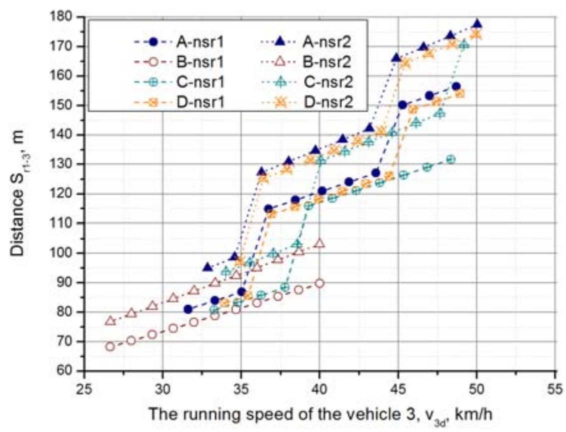

Fig. 11. The variation of the distance S_{r1-3} between vehicle 1 and vehicle 3 at the initiation moment of the return of vehicle 1 to the initial lane according to the running speed of vehicle 3, v_{3d} and the nature and state of the road.

4. CONCLUSIONS

Among the conclusions resulting from this study we shall mention:

- using a computerized analysis with all its advantages (reduction of projecting time, simulation of the various functioning conditions, the large applicability in fields of interest etc.) becomes a useful and necessary tool to the contemporary engineers who develop their activity within the projection, construction, development and safety of vehicles; it must be emphasized that using a computerized analysis does not represent a necessary and sufficient condition in issuing some final considerations, but given the complexity of the mathematical models developed at the present time, it may be a trustful tool used by specialists;

- the road safety can be increased by estimating correctly the speed of vehicles and by making an appropriate appreciation of the safety distances necessary to overtaking;
- the numerical model developed in order to evaluate the kinematic measures of the process of overtaking vehicles allows changing the entry data, taking into account other conditions for overtaking and getting results with a graphical interpretation.

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STUDIUL PROCESULUI DE DEPĂŞIRE ÎN SITUAȚIA ÎN CARE DIN SENS OPUS SE APROPIE UN ALT AUTOVEHICUL

Rezumat: Ținând seama de mărimile cinematice ale procesului depăşirii autovehiculelor, în diferite situații din conducerea auto şi de zona aflată între poziția critică de întrerupere a manevrei de depăşire şi cea de continuare a ei, din cadrul procesului de depăşire - zona de dilemă - în care nu este sigură nici decizia de abandonare a manevrei de depăşire şi nici cea de continuare, în lucrare se evaluează distanțele parcurse de autovehiculul care se deplasează din sens opus (autovehiculul 3), în etapele consecutive ale procesului depăşirii dintre autovehiculul care efectuează depăşirea (autovehiculul 1) Şi cel depăşit (autovehiculul 2). În acest sens, pentru fiecare din variantele de depăşire avute în vedere Şi condiții de drum considerate, ținând seama de variația distanței dintre autovehiculul 1 şi autovehiculul 3 după revenirea în coloană a autovehiculului 1, care depinde de viteza autovehiculului care depăşeşte, se analizează:

- variația distanței parcurse de autovehiculul 3, pe toată durata procesului de depăşire dintre autovehiculul 1 şi autovehiculul 2, în funcție de această durată şi natura Şi starea drumului, respectiv în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului;
- variația distanței parcurse de autovehiculul 3, în timpul în care autovehiculul 1 parcurge distanța de desprindere din coloană, în funcție de această durată şi natura şi starea drumului, respectiv în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului;
- variația distanței parcurse de autovehiculul 3, în timpul în care autovehiculul 1 se deplasează paralel cu autovehiculul 2, în funcție de durata deplasării paralele a acestora şi natura şi starea drumului, respectiv în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului;
- variația distanței parcurse de autovehiculul 3, în timpul în care autovehiculul 1 parcurge distanța de revenire pe banda inițială, în funcție de această durată şi natura şi starea drumului, respectiv în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului;
- variația distanței dintre autovehiculul 1 şi autovehiculul 3, la momentul desprinderii din coloană a autovehiculului 1, în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului;
- variația distanței dintre autovehiculul 1 şi autovehiculul 3, la momentul inițierii revenirii autovehiculului 1 pe banda inițială, în funcție de viteza de deplasare a autovehiculului 1 şi natura Şi starea drumului, respectiv în funcție de viteza de deplasare a autovehiculului 3 şi natura şi starea drumului.

Modelul de calcul dezvoltat poate sta la baza proiectării unor sisteme de asistare la conducere cu scopul asigurării un suport conducătorului auto în etapele consecutive ale procesului depăşirii autovehiculelor.

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