

Analysis of a Traffic Accident During Turn and Overtake - Case Study

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Abstract: Traffic accidents represent a significant safety challenge, and analyses in the Republic of Srpska show that one of the most common driver errors is improper overtaking and turning. These actions require high concentration, assessment of road conditions and correct decision-making, and their improper execution often leads to collision situations. Overtaking, in particular, is a complex action that includes numerous factors such as assessing speed, distance and the reactions of other road users. The aim of this paper is to determine, through a temporal-spatial analysis, who and to what extent contributed to the occurrence of a traffic accident in a case where vehicles performed turning and overtaking actions. Special emphasis will be placed on whether these actions were permitted in the specific circumstances, as well as on determining the causal factors that led to the accident. The analysis will be conducted through a review of the traffic and technical expertise of this case, taking into account relevant traffic regulations, technical aspects and the behavior of the participants in the accident. The results of this research can contribute to a better understanding of risk factors when performing overtaking and turning actions, and provide guidelines for improving traffic safety, both through improving regulations and by raising driver awareness of the risks associated with these maneuvers.

Keywords: expertise, traffic safety, vehicle operations.

INTRODUCTION

An estimated 1.19 million people died in road traffic accidents in 2021, a 5% decrease from 1.25 million deaths in 2010. More than half of United Nations Member States reduced the number of road deaths between 2010 and 2021. The modest overall decline in fatalities occurred despite the global vehicle fleet more than doubling, the road network expanding significantly, and the world population increasing by almost a billion people. This shows that efforts to improve road safety are yielding results, but they are still far from what is needed to achieve the goal of the United Nations Decade of Action for Road Safety 2021–2030, which envisages halving the number of deaths by 2030 (1).

In the period 2020–2024, 50,332 traffic accidents occurred on the territory of the Republic of Srpska, of which 460 were fatal, 11,198 were injured, and 38,674 were property damage.

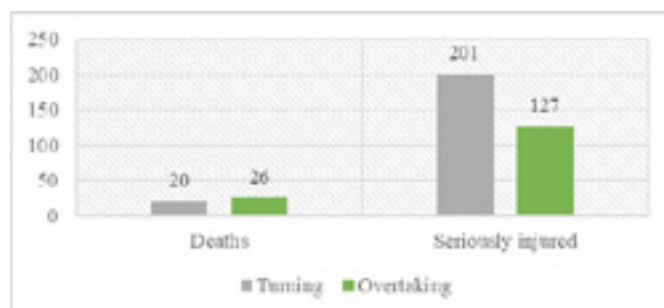


Chart 1. Overview of “Turning” and “Overtake” Errors Resulting in Traffic Accidents, Period 2020–2024

The graph shows the statistics of errors related to turning and overtaking in traffic accidents in the period from 2020 to 2024. In the category of fatalities, overtaking errors resulted in 26 cases, while turning was the cause of 20 cases. When it comes to serious bodily injuries, turning was the cause in 201 cases, which is significantly more compared to overtaking, which led to 127 cases. These data indicate that turning is a more common cause of serious injuries, while overtaking is slightly riskier in terms of fatalities.

The determination of liability has several important aspects. First of all, one of the key principles of both misdemeanor and criminal proceedings is to ensure a fair trial, which guarantees that innocent persons are not unjustly punished. In addition, the decision made in criminal proceedings may affect the civil process for compensation of damages. Although the civil court is not obliged to abide by the outcome of the misdemeanor proceedings, the burden of proof is often shifted from the injured party to the person who caused the damage. In contrast, in criminal proceedings, the liability established is binding on the civil court as to the existence of a criminal offence, but there is still the possibility of considering the contribution of the injured party, since civil liability covers a wider scope than criminal liability.

In order to accurately determine responsibility, it is necessary to conduct a detailed traffic and technical expertise, which allows for the analysis of the movement of participants in the traffic incident, the temporal and spatial examination of the event and the determination of relevant facts. After that, the relevant provisions of the Law on the Fundamentals of Traffic Safety in BiH, as well as other regulations regulating this area, are applied to the established circumstances.

LEGAL REGULATIONS REGARDING THE PERFORMANCE OF TURN AND OVERTAKE OPERATIONS

Overtaking is defined as passing another vehicle moving in the same lane and in the same direction. A driver who intends to overtake, turn, or perform any other action with a vehicle on the road must first ensure that he can do so without endangering other road users and property. In doing so, he is obliged to take into account the vehicle's position, direction, and speed.

Overtaking and passing are permitted only if this does not impede the normal movement of vehicles from the opposite direction and if there is sufficient space on the road for safe performance of the action. The driver may not overtake in situations where, due to the characteristics of the road, existing traffic conditions or technical characteristics of the vehicle, this would endanger other road users. Overtaking is usually carried out on the left side, except when the vehicle on the roadway takes a position that clearly indicates that it is turning left, in which case overtaking may be carried out on the right side. Also, a vehicle moving on rails installed in the middle of the roadway may not be overtaken on the left side, but exclusively on the right, if there is a special traffic lane for this.

A driver who notices that another vehicle is overtaking him from the left is obliged to move the vehicle to the right edge of the roadway in order to enable safe overtaking. He must not increase his speed while over-

taking. If the roadway is too narrow or in poor condition, and overtaking is not possible without endangering traffic safety, the driver of the slower vehicle is obliged to move as far to the right as possible, and if that is not enough, to stop the vehicle in a suitable place to let faster vehicles pass.

There are clear situations in which overtaking is prohibited. A driver may not initiate overtaking of a convoy of vehicles, nor if the vehicle behind him has already initiated overtaking. He may also not initiate overtaking if the vehicle in front of him is preparing to overtake another vehicle or an obstacle on the road. Overtaking is also not permitted if the traffic lane he intends to overtake is not clear at a sufficient distance, as this could endanger safety or interfere with vehicles from the opposite direction. A driver may not initiate overtaking if, after completing the action, he would not be able to safely return to the original lane without endangering other road users. It is also prohibited to overtake using a lane intended for forced stopping of vehicles, directly in front of and in a tunnel with only one traffic lane in the direction of travel.

The overtaking driver is obliged to maintain a sufficient distance from the overtaking vehicle during this action, so as not to obstruct or endanger it. After overtaking is completed, as soon as possible and without obstructing other participants, the driver is obliged to return to the lane in which he was moving before starting the overtaking. On two-way roads, a driver may not overtake another vehicle in front of the top of a bend or on a curve when visibility is insufficient, unless there are several marked lanes intended for movement in the same direction.

Overtaking is also prohibited immediately in front of an intersection or at an intersection that does not have a roundabout, except in certain situations, such as overtaking a vehicle turning left from the right, overtaking a vehicle turning right without changing to the opposite lane, or when overtaking is carried out on a road with the right of way or when traffic at the intersection is regulated by traffic lights or signs of an authorized person. Also, overtaking immediately in front of or at a road crossing over a railway or tram line without a bumper or half-bumper is permitted only when traffic at the crossing is regulated by traffic lights.

A driver may not overtake another vehicle that is approaching a pedestrian crossing, crossing it, or has stopped to let pedestrians pass. Also, on roads with at least two lanes of traffic in the same direction, a driver may only change lanes to turn or park, while moving faster in one lane than in another is not considered overtaking.

Considering that in the expertise selected as a case study in this paper, the driver who performed the overtaking action was operating at a speed higher than the speed limit on the specified section. In addition to all of

the above, the driver, when performing the overtaking action, must take into account the speed limit on the road he is driving on, and comply with it.

When it comes to turning, a driver turning right must do so from the far right lane along the edge of the road, unless traffic signs prescribe otherwise. A driver turning left must make the turn from the far left lane along the center line of the road, following an imaginary or marked arc connecting the two center lines of the side roads. If it is a one-way road, a left turn is made from the far left lane along the left edge of the road, unless otherwise indicated by a traffic sign.

For performing actions, it is of great importance to convince the driver, with the previously fulfilled condition that the action is permitted. The general observation time is between 0.50 and 1.16 seconds. To transfer the gaze from the road in front of the vehicle to the instrument panel, read a certain index and turn the gaze back to the road, a time of between 1.5 and 1.9 seconds is required (2).

EXPERTISE OF TRAFFIC ACCIDENTS IN WHICH DRIVERS PERFORM TURN AND OVERTAKE

As stated in the introductory part of the paper, we can see that overtaking and swerving are widely represented in traffic accidents. Given the frequency of traffic accidents of this type, it is possible that in these cases both actions are permitted, that one of them is not permitted, or that both are prohibited. Therefore, the expert opinions of the aforementioned traffic accidents require special attention, and this paper will present the expert opinion of a traffic accident in which both participants performed the aforementioned actions, which were permitted in the specific situation.

Participants in a traffic accident

The following people participated in the analyzed traffic accident:

- Golf 4 passenger car
- Golf 3 passenger car

Road and weather information

At the scene of the accident, the roadway is constructed of an asphalt pavement, 6.70 m wide, divided by a dashed dividing line into two traffic lanes, with the left traffic lane being 3.30 m wide. On the left side of the roadway, viewed from the indicated direction, there is a ditch 0.60 m wide, a grassy area 1.80 m wide, and a path intended for pedestrians 1.50 m wide. On the left side of the main road, there is a turn to the bakery parking lot. On the right side of the roadway, there is a sandy extension 3.00 m wide, which is connected to the installed elements of concrete cubes in the form of a wall that form the fence of the yard.

The speed limit for motor vehicles on the specified section of road is regulated by a traffic sign in a populated area at 50 km/h.

At the time of the traffic accident, as well as at the time of the investigation, it was night, the weather was cloudy, the roadway was dry, and the place was illuminated by street lights.

Vehicle data and vehicle damage

The inspection report does not list the damage to the vehicles involved in the collision, but only states that the vehicles sustained significant material damage.

From the photographs of the "Golf 4" vehicle, it is visible that the entire front part of the vehicle is damaged, with the front left end being slightly more pressed towards the middle of the vehicle than the front right part of the vehicle. On the "Golf 3" vehicle, the entire rear part of the vehicle is damaged in such a way that it is pressed towards the middle part of the vehicle.

Based on the damage to the colliding vehicles, it can be concluded that the front of the Golf 4 collided with the rear of the Golf 3.

Determining the location of the collision and the position of the accident participants

Based on the damage to the colliding vehicles, it can be concluded that the contact occurred between the front, slightly more to the left, part of the "Golf 4" vehicle and the rear part of the "Golf 3". At the time of the collision, the longitudinal axes of the colliding vehicles were almost parallel. After the contact, the "Golf 4" vehicle, as a vehicle with a significantly higher speed of movement, which means kinetic energy, continued to move in the direction of Banja Luka, turning to its right side and stopping after contact with the wall, while the "Golf 3" vehicle, as a result of the kinetic energy gained by the impact by the "Golf 4" vehicle, was thrown forward and to the left side with the vehicle rotating in an anti-clockwise direction.

Immediately before the accident, a passenger vehicle of the brand "Golf 3" was moving from the direction of Gradiška towards Banja Luka, and it can be concluded that it was in the phase of turning into a parking lot on the left side of the road, having moved completely into the left lane. At the same time, a passenger vehicle of the brand "Golf 4" was also moving from the direction of Gradiška towards Banja Luka, having moved completely into the left lane.

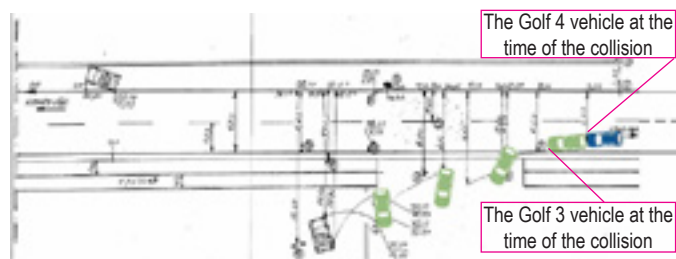


Figure 1. Vehicle Position at the Moment of the Collision

Determining the speed of the accident participants

Based on the data from Spis, it was not possible to determine the speed of the Golf 3 at the time of the collision. However, considering that the vehicle was in the process of turning into a parking space, which is usually done at lower speeds, its speed can be estimated with sufficient accuracy at 20 km/h.

The kinetic energy possessed by the passenger car "Golf 4" at the moment of contact was spent on the deformation of the vehicle during the collision, on the ejection of the vehicle "Golf 3" and on its movement to the point of stopping. The speed of the vehicle "Golf 4" immediately before the accident can be determined using the following physical equation:

$$\frac{m_{G4} \cdot v_{G4s}^2}{2} = m_{G4} \cdot b_{k1} \cdot S_{k1} + \frac{m_{G4} \cdot v_{G4s}^2}{2} + m_{G3} \cdot b_{G3z} \cdot S_{G3z} - \frac{m_{G4} \cdot v_{G4s}^2}{2} + m_{G4} \cdot b_{kr} \cdot S_{kr} \quad (1)$$

The speed of the Golf 4 vehicle lost to deformation was determined using the energy raster diagram shown in the following figure.

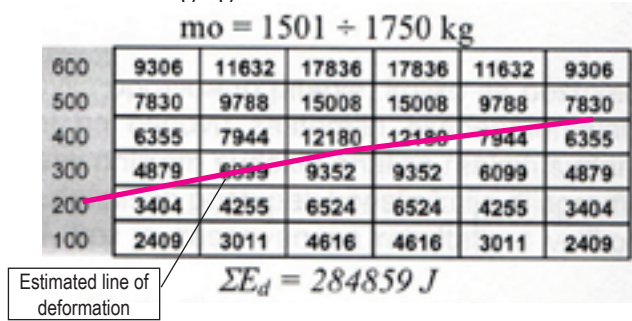


Figure 2. Energy Layout Diagram

where is it,

E_{G4d} – deformation energy (86464 Nm),

K_{G4gp} – coefficient of the year of production (1999,1,038),

m_{G4} – mass of the vehicle "Golf 4" with driver and passengers (1540 kg).

Now we can calculate the speed of the Golf 4 at the time of the collision using the following formula.

$$v_{G4s} = \sqrt{v_{G4z}^2 + 2 \cdot \frac{m_{G3}}{m_{G4}} \cdot b_{G3z} \cdot S_{G3z} - \frac{m_{G3}}{m_{G4}} \cdot v_{G3z}^2 + 2 \cdot b_{kr} \cdot S_{kr}} = 19,4 \frac{m}{s} \approx 70 \frac{km}{h} \quad (2)$$

where is it,

m_{G3} – mass of the "Golf 3" vehicle with passengers (1030 kg),

S_{G3z} – length of the skid marks of the "Golf 3" vehicle (34.00 m),

b_{G3z} – deceleration of the "Golf 3" vehicle along the drift tracks (4.00 m/s²),

v_{G3s} – speed of the vehicle "Golf 3" (20 km/h),

S_{kr} – the length of the path of the "Golf 4" vehicle after the collision (56.50 m),

b_{kr} – deceleration of the "Golf 4" vehicle on the road after the collision (1.0 m/s²),

t_3 – deceleration increase time (0.2 s).

Therefore, the speed of the "Golf 4" vehicle at the time of the collision was 70 km/h. The driver of the "Golf 4" vehicle, in his statement, among other things, states: "at that moment I tried to avoid contact with the vehicle but I failed and hit the rear of his vehicle with the front

left side of my vehicle". The driver of the "Golf 4" vehicle does not state what action he was taking, but it could have been braking or swerving to the left or right. If the "Golf 4" vehicle was braked before the accident, then the speed of this vehicle immediately before the accident was greater than 70 km/h, but this cannot be determined based on the data from the Record. It should be noted here that even if the Golf 4 had been braked intensively, as a rule, no brake marks would have remained because this vehicle has an ABS braking system that has been standardly installed in Golf vehicles since 1996. Given this fact, the possibility cannot be ruled out that the Golf 4 had been braked after the collision, which would represent a normal driver reaction, and which would certainly affect the calculation of the speed of this vehicle, i.e. the speed would be greater than 70 km/h.

Temporal-spatial analysis of the course of a traffic accident

The time taken for the Golf 4 to avoid the dividing line to the point of contact was:

$$t_{G4dz} = 2,51 \cdot \sqrt{\frac{B_p}{\mu_{kr} g}} = 2,6 s \quad (3)$$

where is it,

B_p – lateral displacement of the vehicle (2.7 m),

The evasive distance of the "Golf 4" vehicle from the dividing line to the point of contact was :

$$S_{G4dz} = v_{G4s} \cdot t_{G4dz} = 51,0 m \quad (4)$$

Taking into account the collision position of the two vehicles, and "returning" the "Golf 3" vehicle back in the direction of movement it had at the time of the collision, I determined that the distance traveled by the "Golf 3" vehicle from the dividing line to the point of contact was approximately 25 m. The speed of the "Golf 3" vehicle at the beginning of the 25 m avoidance distance was:

$$v_{G30} = \sqrt{v_{G3z}^2 + 2 \cdot b_{G3k} \cdot S_{G3kr}} = 12,5 \frac{m}{s} \approx 45 \frac{km}{h} \quad (5)$$

where is it,

b_{G3k} – deceleration of the vehicle "Golf 3" (2.5 m/s²),

S_{G3kr} – the path of movement of the “Golf 3” vehicle from the dividing line to the point of contact (25 m).

The travel time of the Golf 3 vehicle from the dividing line to the collision site was:

$$t_{G3kr} = \frac{V_{G3kr} - V_{G3s}}{a_{G3kr}} = 2,78 \text{ s} \quad (6)$$

In a time of 2.78 s, the “Golf 4” vehicle traveled the following distance:

$$S_{G4iz} = V_{G4s} \cdot t_{G3kr} = 54,50 \text{ m} \quad (7)$$

The longitudinal distance between the rear of the “Golf 3” vehicle and the front of the “Golf 4” vehicle, at the moment the front of the “Golf 3” vehicle crossed the dividing line, was:

$$S_{uo} = S_{G4iz} - S_{G3kr} = 29,50 \text{ m} \quad (8)$$

Based on the analysis conducted above, it can be concluded that the drivers of the colliding vehicles began their left-hand swerve action within a very short time interval of 0.18 s, so it can be said that it was approximately simultaneous.

Now we will check whether the driver of the “Golf 4” vehicle had the conditions to safely perform the overtaking action. The overtaken vehicle, a “Golf 3” vehicle, was moving at a speed of 45 km/h immediately before starting the left turn. At the scene of the accident, the speed limit is 50 km/h. The driver may move at the maximum permitted speed only if the road conditions, visibility, clearness, atmospheric conditions, traffic density and other circumstances allow it. In all other cases, the driver is obliged to adjust the speed to the specified circumstances and move at a speed lower than the permitted speed. The driver may not move the vehicle at a speed higher than the permitted speed. In the specific case, the driver of the “Golf 4” vehicle could have undertaken the overtaking action by moving at a speed of up to 50 km/h. Now we will check what the overtaking distance and time would be if the “Golf 4” vehicle was moving at the permitted speed of 50 km/h:

$$S_{50pr} = \frac{V_{50} \cdot (L_{G3} + L_{G4} + L_3 + L_4)}{V_{50} - V_{G3s}} = 580 \text{ m} \quad (9)$$

$$t_{50pr} = \frac{S_{50pr}}{V_{50}} = 42 \text{ s} \quad (10)$$

where is it,

V_{50} – permitted speed (50 km/h),

L_{G3} – length of the vehicle “Golf 3” (4.0 m),

L_{G4} – length of the vehicle “Golf 4” (4.0 m),

L_3 – distance between the vehicles “Golf 4” and “Golf 3” before the start of overtaking (25 m),

L_4 – distance between the vehicles “Golf 4” and “Golf 3” at the end of overtaking (25 m),

Therefore, the driver of the “Golf 4” could have overtaken at a speed of 50 km/h, which would have taken him 42 s to perform, and during that time the vehicle would have traveled a distance of 580 m. Objectively, given that this is a very busy road, it would be difficult to expect the left lane to be free for a length of 580 m and a time of 42 s. Summarizing the analysis conducted above, it was concluded that the main failure of the driver of the “Golf 4”, which is directly related to the creation of a dangerous situation and the occurrence of a traffic accident, is reflected in the overtaking action at a speed of 70 km/h, which was 20 km/h higher than the permitted speed. These actions by the driver with the vehicle are most likely a consequence of the psychophysical state in which he was, or the degree of alcoholism.

When it comes to the driver of the “Golf 3” vehicle, the situation is as follows. When turning left, the actions that the driver should first perform are as follows:

- turn on the left turn signal,
- look ahead to check whether another vehicle is possibly moving towards the vehicle he is driving, which would mean that the left lane is not free,
- looks in the left side mirror and makes sure whether a vehicle moving behind his vehicle has already started overtaking, or has announced this action by giving the appropriate direction indicator,
- Start turning left, possibly by first shifting the transmission to a lower gear.

A driver turning left is required to drive the vehicle along an imaginary circular arc connecting the center line of the roadway and the center line of the side road. The time-space analysis showed that the driver of the “Golf 3” crossed the dividing line with the front left end of the vehicle 25 m before the point of contact, that is, that he made the left turn in such a way that he moved to the left lane before the point of the turn, with the intention of turning left from the left lane into the parking lot next to the roadway. If the driver of the “Golf 3” had made the left turn while driving the vehicle along an imaginary circular arc connecting the center line of the roadway and the center line of the side road, he would have been able to see the “Golf 4” in the rearview mirror, which would be in the left lane, at the beginning of the turn. Based on the above, the conclusion is that the driver of the “Golf 3” vehicle also made a certain mistake related to the occurrence of the traffic accident, which is reflected in the fact that he made the left turn, instead of moving along the circular arc connecting the dividing line of the roadway and the center line of the side road, by previously changing lanes to the left traffic lane from which he intended to

make the left turn into the parking lot.

Based on the data from Spis, it was not possible to determine whether the drivers of the colliding vehicles announced the actions of turning, or overtaking, by giving the appropriate direction indicator and whether this was done in a timely manner.

CONCLUSION

The main fault of the driver of the "Golf 4", which is directly related to the creation of a dangerous situation and the occurrence of a traffic accident, is reflected in the overtaking action at a speed of 70 km/h, which was 20 km/h higher than the permitted speed. Such actions with the vehicle by the driver are most likely a consequence of the psychophysical state in which he was, or the degree of alcoholism.

The driver of the "Golf 3" vehicle made a certain error that was related to the occurrence of the traffic accident, which is reflected in the fact that, instead of moving along the circular arc connecting the dividing line of the roadway and the center line of the side road, he performed the action of turning left by previously aligning himself with the left traffic lane from which he intended to make a left turn into the parking lot.

The speed of the "Golf 4" vehicle at the time of the collision was 70 km/h. If the "Golf 4" vehicle was braked before the accident, then the speed of this vehicle immediately before the accident was greater than 70 km/h, but this could not be determined based on the data from the Spis.

Based on the data from Spis, it was not possible to determine the speed of the Golf 3 at the time of the collision. However, considering that the vehicle was in the phase of turning into a parking space, which is usually done at lower speeds, its speed can be estimated with sufficient accuracy at 20 km/h. The speed of the Golf 3 at the beginning of the evasive path was 45 km/h.

FINAL CONSIDERATIONS

The paper is based on the need to analyze in detail critical actions in traffic that often lead to accidents, such as turning and overtaking. The introductory part of the paper emphasizes the importance of the topic in the context of increasingly frequent traffic accidents and the need for precise identification of the causes and circumstances that lead to them. The theoretical framework included a review of legal provisions, traffic rules, as well as previous studies and models of driver behavior in critical situations. The methodological approach is based on a case study, through the expertise of a specific traffic accident.

An analysis of the specific traffic accident concluded that the key factors that led to the collision were failure to comply with traffic regulations. The reconstruction of the event showed that the time intervals and speeds of

both vehicles played a decisive role in the occurrence of the traffic accident. It was determined that the accident occurred due to overlapping actions – one was overtaking, while the other was turning.

Given the limitations of a single case as a data source, future research should include a larger number of similar traffic accidents in order to identify regularities and recurring patterns in driver behavior. It is desirable to include an analysis of the impact of factors such as weather conditions, lighting, road conditions and signal visibility. The use of advanced technologies, such as driving simulators and GPS data, could provide valuable insights into the real behavior of drivers in turning and overtaking situations. In addition, surveys and qualitative research among drivers of different categories could contribute to a better understanding of their decision-making in such situations. The goal of such research should be to formulate recommendations for improving regulations, training and infrastructure solutions in order to reduce risks and increase the safety of all road users. One of the important aspects when it comes to performing actions is persuasion. When we talk about turning, what the driver needs to do is to first make sure that the action can be performed without endangering other road users or property, taking into account the vehicle's position and direction and speed. Persuasion is usually performed using mirrors, inside and outside the vehicle, and it takes a certain amount of time, which is up to 1.9 seconds. Considering that in the above case study the time between the initiation of the actions was 0.18 s, the question arises as to what is an acceptable time between the initiation of the actions in question, and that the actions can be considered to have started simultaneously. The above question can serve as a basis for further research into this type of accident, as well as for improving the performance of traffic and technical expertise.

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