Regular Article

Rafał Wrona and Iwona Rybicka*

Errors in controlling cars cause tragic accidents involving motorcyclists

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Abstract: The article deals with the issue of road safety and the threats caused by unexpected maneuvers of passenger cars pulling into the opposite lane, directly in front of an oncoming two-wheeler. The first part discusses the legal regulations that apply to vehicle drivers. In the second part, road accidents are presented, while in the next part, examples of road accidents are analyzed in terms of their causes. The article deals with the causes of road accidents. The tragic consequences of the analyzed accidents require this problem to be addressed in research. This is especially true of the question of why car drivers usually notice only an oncoming car and not a two-wheeled vehicle?

Keywords: road safety, vehicle recognition, accidents, examples of road incidents

1 Introduction

The level of transport quality is normally assessed by the quality of the transport operation itself and road conditions. Transport is usually affected by the degree of road load (load factor) [1,2]. Efficient traffic survey analysis is a catalyst for achieving efficient, advanced transport planning and sustainable urban development [3]. In recent years, the world has experienced steady growth in motorization. This growth of motorization is also related to the increased requirement for motor vehicles to be energy efficient. Energy efficiency has become a key requirement in view of the global increase in the number of motor

vehicles in the twentieth century [4]. Road safety in the EU has improved significantly over the past decades, thanks to the effective action taken at the EU and national levels to address road user behavior, vehicles, and infrastructure. As a result, EU roads are the safest worldwide. This increased safety can, to a large extent, be attributed to the legislative requirements on the safety of vehicles that have been introduced to ensure road safety [5].

Every year, the number of registered vehicles and traffic density increases. More and more people get behind the steering wheel and become direct participants in road traffic. Except for undoubted advantages, this causes a great growth of traffic volume in the road network and a constantly increasing demand on traffic and its safety [6,7]. Possession of a driving license and active utilization of a motor vehicle becomes an essential part of an individual's daily life. However, this is closely related to the increased risk of traffic accidents, and unfortunately also those resulting in death. Road safety depends on many factors, including the efficiency of the technical system and behavior of the vehicle driver. Therefore, traffic accident rates represent a serious societal problem with a huge impact on people's lives and property. Hence, it requires special attention [8,9]. Therefore, road transport safety is a very complex issue, including the following factors: technical [10,11], environmental [12,13], psychological [14], legal [15], and socio-economic [16]. Besides, road transport safety is a subject concerning many states, social, and international institutions.

Road safety has an extremely important role in existing transportation systems. Drivers on the road are influenced by various factors (light and temperature conditions, visual smog, environmental surroundings, etc.) and driver's distraction represents the most common cause of road traffic accidents. In our previous studies, we found that visual smog has a negative influence on drivers on the road. However, the aim of placing traffic signs on the roads is to increase road safety, thus positively influencing the driver while driving. Driver distraction is one of the most common cause of traffic accidents in all countries [17,18]. Issues of road traffic accident related to biomechanics are a subject of multithreaded research and analysis and are

* **Corresponding author: Iwona Rybicka**, Lublin University of Technology, Faculty of Mechanical Engineering, Department of Sustainable Transport and Powertrain, Ul. Nadbystrzycka 36, 20-618 Lublin, Poland, e-mail: i.rybicka@pollub.pl

Rafał Wrona: Lublin University of Technology, Faculty of Mechanical Engineering, Department of Sustainable Transport and Powertrain, Ul. Nadbystrzycka 36, 20-618 Lublin, Poland, e-mail: r.wrona@pollub.pl

considered an interdisciplinary field that involves many areas of science: transportation, medicine, and engineering sciences [19,20].

In the past, traffic accident reconstruction was based on principle only on indirect methods that use accident marks and witness reports. These data were then used for the backward reconstruction of the event for determination of the motion status of the accident participants and expression of the desirable quantities such as initial velocities, impact velocities, distances travelled, and temporal conditions [21].

For analyzing road accidents the documentation of evidence at the place of the road accident is one of the most important steps in forensic practice. Based on the documentation at the place of a road accident, which is done by the police during the examination of the place itself, law enforcement authorities decide about culpability for a road accident. Next, it is necessary to decide about the breaking of traffic regulations by those involved in a road accident. All circumstances have to be judged, which are relevant for a correct understanding of the situation before, during, and after a road accident. These data are important inputs for forensic experts and their further examination. Documentation at the place of the road accident is a process through which the most important evidences are collected. It has to be processed in such a way, so that it will provide an exact overview about the entire situation at the place of the road accident. Documentation includes road accident protocol, topographic documentation (sketch, ground plan), and photography documentation or video documentation [9].

One of the ways for reducing road traffic accidents is implementation of intelligent transport systems (ITS) on the chosen part of communication [22–24]. Dangers related to heavy goods vehicles carrying different loads and operating in different conditions as well as during the braking process can be simulated in a wind tunnel. In order to increase vehicle transport safety, complex mechatronic systems such as passive and active safety systems have been fitted in all new vehicles [23,25,26].

It has been observed that even in good daytime conditions, motorcyclists or cyclists coming from the opposite direction are not spotted by car drivers. Most often in such cases, the vehicles collide, which results in serious injury or death of the driver of the two-wheeler, who is not protected by the metal structure of the vehicle body the way the car driver is. Such situations are not infrequent on roads, and they occur often on national, provincial, and local roads, where sometimes there is no horizontal marking on the road pavement. In addition to collisions that occur during overtaking maneuvers

[27], particularly dangerous are road incidents involving two-wheelers in which the driver of a car intends to turn left and enters the lane along which a two-wheeled vehicle is approaching. In such situations, it is often unclear why the driver of the car has not noticed the oncoming motorcyclist or cyclist. The reason is often the fact that the duration of the hazardous event is shorter than the time of the driver's psychomotor reaction [3,28]. Analysis of such road incidents is also hampered by the lack of testimony of the driver of the two-wheeler, who most often does not survive the accident. Very often, car drivers state that they did not notice the motorcycle approaching from the opposite direction. In such cases, it is difficult, and sometimes even impossible, to determine why the two-wheeler was not seen.

2 Analysis of the legislation and rules governing road traffic

The obligations of road users are laid down in road traffic regulations, which are mainly contained in Article 3, section 1 of the Road Traffic Law Act, which stipulates as follows [29]:

“Road users and other persons on the road are obliged to exercise caution or – when the law requires it – special care and avoid any action that could endanger the safety or order of road traffic, impede this traffic or disturb peace or public order and expose anyone to harm in connection with traffic. Action also means omission.”

Article 16, section 1. “The driver of the vehicle must drive on the right.”

Article 16, section 4. “The driver of the vehicle is obliged to drive as close as possible to the right edge of the road. If lanes on the road are marked, the vehicle must not occupy more than one lane” [30].

The above-mentioned basic provisions of the Road Traffic Law, which regulate the conduct of road users, do not exhaust all the obligations of the driver; however, they relate to the issues raised in this article. Seemingly easy road situations that occur when vehicles move past one another on a two-way road become a threat to road safety if any of the vehicles' drivers does not constantly control their own driving path or intends to change the direction without properly signaling this intention and making sure it is safe to do so. Examples of such situations include inattention of a driver who intends to enter a parking lot located on the left side of the road or temporarily ceases to observe the space in front of their vehicle, concentrating, instead, on their satnav, telephone, or other

objects inside the vehicle (e.g. a child) or outside it (e.g. advertisements or insects trying to get into the vehicle) [31–33]. Below are some examples of road incidents that relate to the aforementioned problem, i.e., road safety hazards arising as a result of a car driver's late reaction or failure to notice an oncoming two-wheeler.

3 Examples of traffic incidents

3.1 Case study one

The accident occurred in December 2016 in a built-up area. The speed limit is 50 km/h, in conditions of insufficient visibility (night and dense fog), on a straight and flat section of the road whose asphalt roadway was 6.6 m wide. On one side, the road was bordered by a cobblestone pavement, 1.9 m wide, and on the other a grassy roadside, 6.4 m wide. At the scene of the incident, street lights were lit, and the road surface was wet, clean, and smooth. The accident was a frontal impact of a Romet Division 125 motorcycle, which was driven by an 18-year-old rider, into the right front corner of an Audi A3 car, which was coming from the opposite direction and whose driver was turning left in an attempt to pull into a parking lot in front of a store. The parking lot was located on the left side of the road, when looking in the direction the Audi A3 car was initially traveling. As a result of the collision, the motorcyclist suffered severe injuries. The event was recorded by a stationary monitoring camera, which showed the single light of the approaching motorcycle. Then it hit the right front corner of the car turning in front of it, which had the low-beam headlights turned

on. The vehicle speed determined during the reconstruction of the event was 9–12 km/h for the turning Audi car, and 60–70 km/h for the motorcyclist.

3.2 Case study second

The accident occurred in the afternoon in June 2016 on a national road, located in an undeveloped area, where the speed limit was 70 km/h. The road at the incident scene (both directions) is shown in Figure 1.

During the event, it was sunny without wind, rainfall, or fog, and the ambient temperature was 25°C. The accident occurred at an intersection of a national road with a subordinate road not regulated by traffic lights. The two-way asphalt roadway of the national road had one traffic lane in each direction. The total width of the roadway was 6.3 m. The road surface was dry, clean, and smooth. There were grassy gravel roadsides, 2.5 and 2.15 m wide, on both sides of the road. The accident involved a motorcyclist, who was riding a Suzuki GSX 750 motorcycle and a FIAT Siena driver who was approaching from the opposite direction. When the drivers were just about to go past one another, the driver of the FIAT Siena started turning left from the national road onto the subordinate road. The motorcyclist hit the left front corner of the FIAT Siena turning in front of him head-on.

3.3 Case study three

The event took place in October 2017 on a regional road in a built-up area with a speed limit of 50 km/h. The

Figure 1: View of the road at the incident scene.

accident took place at around 1:00 PM on a flat and straight section of the road. The two-way asphalt roadway was 6.0 m wide. The road was lined on both sides by soft shoulders, 2.0 m wide each. During the event, the sky was completely cloudy. It was raining slightly, there was a light wind, and the ambient temperature was around 11°C. At the time of the incident, the road surface was wet, clean, and smooth. A motorcyclist was riding a Yamaha 125 motorcycle, and a Peugeot 106 car was coming from the opposite direction. As the vehicles were coming closer toward each other and were about to pass each other, the driver of the Peugeot 106 pulled into the opposite lane right in front of the motorcyclist. The vehicles collided head-on. After the impact, the vehicles swerved to the left side of the road, looking in the original traveling direction of the Peugeot car, which then frontally collided with an electric traction pole pushing the Yamaha motorcycle in front of it. The position of the vehicles after the collision is shown in Figure 2.

4 Forensic examination of the scene of the incident

Forensic examination of the scene of the accident is a tactical and technical activity carried out as part of the criminal investigation process, consisting of systematic and detailed observations, research, and analysis at a given place, aimed at reconstructing the course of the event, recording and securing traces and sources of information in order to comprehensively and objectively explain the event and its circumstances, determine (detect) the perpetrator and collect relevant evidence for the purpose of

criminal proceedings. The term “reconstruction” in practice is commonly understood as forensic reconstruction commonly referred to as technical reconstruction, the essence of which is to reconstruct the course of the accident on the basis of forensic and technical-physical evidence.

The purpose of the reconstruction is:

- reconstruct the course and circumstances of the accident;
- verify and check the truthfulness of the versions of the accident given by its participants and witnesses;
- fill in the gaps and ambiguities in the information given by these people, resulting from the discontinuity of their observations, misjudgments or mistaken impressions, and associations.

The typical method of reconstruction is generally a “rewind” of the tape of time and events. It can be divided into three basic steps:

1. Starting from the post-accident situation, we reconstruct the movement of vehicles after the collision – so as to obtain the parameters of their motion, i.e., when the vehicles separate and begin their independent movement after the collision.
2. We reconstruct the change of parameters of motion during the event itself in order to determine the parameters of motion just before the event (strictly: in the first moment of contact between the vehicles).
3. On the basis of the traces of movement of the vehicles before the collision (e.g. traces of braking), we reconstruct the movement of the vehicles during the phase of formation of the accident risk state.

The last mentioned stage is the stage when the participants reacted (or should have reacted) to the danger. The ultimate goal of the reconstruction is to determine whether they reacted correctly, if and what mistakes they

Figure 2: Positions of the Peugeot 106 car and the Yamaha 125 motorcycle after the accident.

Figure 3: Sketch illustrating the collision of the car with the motorcycle.

made, and whether they could have avoided the accident [34].

4.1 Case one

An analysis and reconstruction of the course of the event demonstrated that the hazard that was decisive in causing the accident was perpetrated by the Audi car driver, who did not give way to the oncoming motorcyclist (1) [28]. The results of the investigation indicate that the driver of the car was too late in noticing the motorcyclist approaching from the opposite direction and, despite an attempt to brake, crashed head-on into the two-wheeled vehicle. The situation before the collision indicates that the dense

fog may have slightly hindered early recognition of the approaching motorcyclist. No other objective or technical reasons for not noticing the rider were disclosed except for the mistake by the driver of the Audi A3.

The situation of the accident is shown in Figure 3.

4.2 Second case

As a result of the injuries he sustained, the motorcyclist died at the scene of the accident. The effects of the accident and the post-collision displacement of the motorcycle pointed to the high dynamics of the collision, which was influenced in particular by the speed of the motorcycle, which, after the collision, traveled a distance of

Figure 4: Damage to the Fiat Siena passenger car.

Figure 5: Damage to the Suzuki GSX 750 motorcycle.

about 40 m along the shoulder of the road. The damage the vehicles sustained during the accident is shown in Figures 4 and 5.

The reconstruction of the course of the crash allowed preparation a graphic showing the place of the collision and the respective positions of the vehicles at the time of the impact (Figure 6). Time–space analysis shows that the motorcyclist was travelling at a speed of about 75 km/h, while the car was moving at about 16–18 km/h.

The collision speed of the motorbike was calculated according to the formula (1).

$$\begin{aligned} V_m &= \sqrt{2 \times 0.55 \times 9.81 \times 40.0} \\ &= 20.7 \text{ m/s} \quad (74.5 \text{ km/h}), \end{aligned} \quad (1)$$

0.55 – adhesion coefficient, 9.81 m/s^2 – acceleration of gravity, 40 m – the section of road the motorbike was travelling on when it collided with the car.

The speed of the Fiat car was assumed.

Personal evidence also revealed that the driver of the Fiat Siena had not stopped before turning left; however, before starting the maneuver, he looked to see whether a car was coming and being sure that there was none, he turned left. The weather conditions did not obscure vision. The car driver testified that he had not seen the motorcyclist before the collision and had no idea where the motorcyclist had suddenly come from.

4.3 Case three

The time–space analysis and the collision situation are illustrated in Figure 7.

Based on personal evidence, it was established that before entering the opposite lane of the road ahead of the

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Figure 6: Accident reconstruction sketch.

Figure 7: The time-space analysis and the collision situation.

moving motorcycle, the driver of the Peugeot 106 had been readjusting the position of the outside mirror in the car she was driving through the open left front door window.

Upon initial impact, the motorcyclist was ejected from his seat and suffered fatal injuries. Traces found at the scene of the incident clearly showed that the vehicles had collided in the motorcyclist's lane. It was determined during a reconstruction of the course of the accident that the collision speed of the Peugeot had been about 46–50 km/h, while the motorcycle had been traveling at about 50 km/h.

The velocity of the motorbike dissipated after the impact was according to the formula (2).

$$V_{pm} = \sqrt{2 \times 7.0 \times 4.5} = 7.9 \text{ m/s}, \quad (2)$$

7.0 m – post-accident displacement of a motorbike, 4.5 m/s^2 – average deceleration of the moving motorbike.

Assuming comparable vehicle speeds and masses (3),

$$V_{mpr} = 7.9 \times \frac{220}{825} = 2.1 \text{ m/s}. \quad (3)$$

The images below show what damage the vehicles sustained. The parameters of the movement of the vehicles involved in the accident were determined on the basis of a time-space analysis of the collision, collision displacements of the vehicles, and deformations of the vehicle bodies. Accident damage sustained by the car and the motorcycle is shown in Figures 8 and 9.

Figure 8: Accident damage to the Peugeot 106 car.

Figure 9: Accident damage to the Yamaha 125 motorcycle.

5 Conclusion

Accidents involving motorcyclists are most often caused by inattentive car drivers – it has always been going on and as always in such cases there is a bit of truth on each side. Motorcyclists accuse car drivers of not looking in the mirrors, disregarding the road, forcing them to take priority, and are often downright malicious and aggressive. On the other hand, car drivers justify themselves with the fact that they cannot see motorcyclists, that they drive too fast and too aggressively. The most common cause of accidents involving motorcyclists was failure to give right-of-way motorcyclists. Priority was not given to other motorcyclists, but to motorcyclists. A frequent cause of accidents was the mismatch between speed and traffic conditions. Here, the perpetrators of the problem are car drivers. In road accidents involving motorcyclists, side collisions definitely predominate. The next ones are rear collision of vehicles, hitting a pedestrian, and vehicles overturning. Conclusions from the analyzed road accident cases:

1. The analysis of the discussed road incidents indicates that they were all caused by cars entering the opposite lane in front of an oncoming motorcyclist, who was, objectively speaking, visible, and recognizable as a road user.
2. However, the reasons why the car drivers pulled to the opposite lane were different; and so, in the first case, the driver of the car was too late in noticing the approaching motorcycle, possibly due to the thick fog; in the second case, the driver did not see the motorcyclist before the collision for unknown reasons, and in the third example, the driver concentrated on other activities, instead of looking carefully at the road in front of the vehicle she was driving.

3. The discussed road incidents would not have happened if the drivers of the cars had followed the provisions of the road traffic law and focused their attention on the road and other road users, in this case two-wheelers.
4. The collisions led to serious injuries or death of the motorcyclists, who did not in any way contribute to the accidents with their conduct on the road.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

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