Journal of Engineering Science *Vol. XXIX, no. 2 (2022), pp. 18 - 32*
Fascicle *Industrial Engineering* *ISSN 2587-3474*
Topic *Materials Science and New Technologies* *eISSN 2587-3482*

https://doi.org/10.52326/jes.utm.2022.29(2).02
UDC 656.1.086:614.864

PEDESTRIAN SAFETY ELEMENTS REGARDING CAR CONSTRUCTION

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Received: 01. 31. 2022
Accepted: 02. 25. 2022

Abstract. Almost a quarter of people killed in road accidents worldwide are the most vulnerable road users – pedestrians. Every year, more than 300000 pedestrians die on the world's roads, which is about 23% of the total number of people killed in road accidents. In addition, millions of pedestrians are traumatized, some of them becoming disabled for life. The article includes a brief description of the driver-pedestrian relationship, road accident statistics involving pedestrians in the Republic of Moldova and in different geographical areas of the globe, modern practices and technologies applied in car construction by manufacturing plants to ensure pedestrian safety.

Keywords: *pedestrian, pedestrian crossing, road accident, traffic accident, pedestrian safety, pedestrian collision, pedestrian collision.*

Rezumat. Aproape un sfert dintre cei decedați în accidentele rutiere din întreaga lume sunt cei mai vulnerabili participanți la trafic – pietonii. Anual pe drumurile lumii mor peste 300000 de pietoni, ceea ce constituie circa 23% din numărul total de persoane decedate în accidentele rutiere. În plus, milioane de pietoni sunt traumatizați, unii dintre ei devenind invalizi pe viață. Articolul cuprinde o descriere succintă a relației conducător-pieton, statistica accidentelor rutiere cu implicarea pietonilor în Republica Moldova și în diferite zone geografice ale globului pământesc, practicile și tehnologiile moderne aplicate în construcția automobilelor de către uzinele producătoare privind siguranța pietonului.

Cuvinte cheie: *pieton, trecere de pietoni, accident rutier, accident de circulație, siguranța pietonului, tamponarea pietonului, coliziunea pietonului.*

Pedestrian, according to the Road Traffic Regulations [1, 2], is considered the person who is on the road outside the vehicle and who does not perform works. Most pedestrians are people who walk, move to or from work, school, shop, etc., perform a physical activity, walk, drive a bicycle, moped, motorcycle, pull or push a car, a toboggan, a freight cart, strollers or wheelchairs for the disabled, carry in their arms, head, shoulders or back loads of different sizes and shapes, run or walk fast, sit or sit on the road platform so that all the world at some point is as a pedestrian, even if some only for short periods of time.

Walking is the most common form of movement, regardless of social groups, in the world. Virtually any route or walk begins and ends with walking. On some routes, walking is the only way to travel, regardless of distance.

It is known that walking has a beneficial effect on human health and contributes to the protection of the environment, as it increases physical activity, which in turn leads to a decrease in the frequency of cardiovascular disease and obesity-related diseases. In this regard, many countries have launched programs that encourage walking [3].

Unfortunately, the promotion and widespread use of pedestrian traffic can, in some cases, lead to an increase in the number of road accidents and injuries. Due to the rapid increase in the number of vehicles (1,2 billion in the world [4, 5], 1,2 million in the *Republic of Moldova* [5, 6]) and their frequency of use, as well as the general neglect of the need to build for pedestrians roads and landscaping, pedestrians are increasingly at risk of getting involved in road accidents. The vulnerability of pedestrians is further amplified in the conditions of unsatisfactory application of the Road Traffic Rules (*RTR*).

The higher share of vehicle-pedestrian conflicts is registered in the urban environment, where with the development of cities, the pedestrian traffic has also increased spectacularly. In urban areas, about half of road accidents occur due to non-compliance with pedestrian traffic rules [7].

According to estimates, more than 300000 pedestrians (about 180000 children) die in road accidents annually in the world, which is about 23% of the total number of deaths in road accidents (Figure 1).

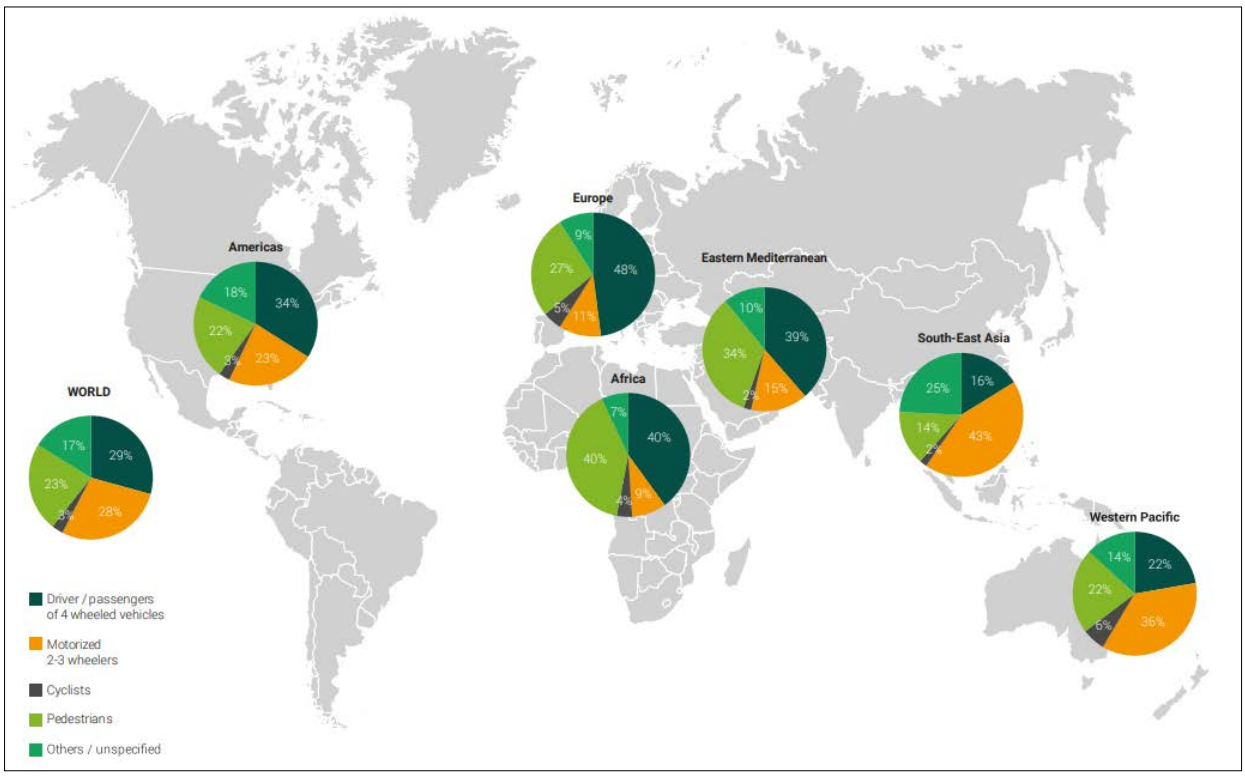

Figure 1. Distribution of deaths by categories of road users by *WHO* regions [11, 12].

29% of those who died in road accidents belong to drivers and passengers of cars, 28% to motorcyclists, and the remaining 20% – to other road users [3, 8-12]. The situation varies significantly between regions of the world. In most low- and middle-income countries, the percentage of road accident victims, such as pedestrians, cyclists, drivers and passengers of two- and three-wheeled motor vehicles, is significantly

higher than in high-income countries. For example, in the *WHO African Region*, 40% of all road accident deaths are due to pedestrians, and in the *WHO West Pacific Region* 36% are to motorcyclists, ie drivers and passengers of 2- or 3-wheel motor vehicles (Figure 1). Drivers and passengers represent between 16% of those killed in road accidents in the *South-East Asia Region* to 48% in the *European Region*.

The *WHO* regions with the highest share of pedestrian deaths in road accidents are the *African Region* with 40% and the *Eastern Mediterranean Region* with 34%, followed by the *European Region* with 27%, the *American Region* and the *Western Pacific Region* with 22% each, and the *Region Southeast Asia* with the lowest share of 14%.

Pedestrian collisions, like other road accidents, cause psychological and socio-economic damage, as well as damage to health. The traumas received as a result of road accidents consume the material resources necessary for the development of the country as a whole and the family in particular. There are no global estimates of the economic impact of road accidents involving pedestrians, but losses in road accidents are estimated at between 1% and 3% of *GDP* [2, 3, 7, 13].

Accidents with pedestrians affect people of all ages, although under certain conditions some age groups may be affected more than others. For example [3]:

- it was found that approximately 57% of pedestrians killed in road accidents in four cities in *South Africa* were between 20 and 44 years old;
- in the *USA* in 2009, the mortality rate among pedestrians over the age of 75 was 2,28 per 100000 inhabitants, which is higher than the mortality rate in any other age group;
- in *Hyderabad* (*India*), the age of 61% of pedestrians who suffered in traffic accidents was between 21 and 40 years;
- in the *Australian* state of *New South Wales* in 2010, 20% of pedestrians who died were under 21 years old, and another 29% – between 21 and 40 years old;
- the results of a study of road injuries among children and adolescents in *African* cities showed that 68% of cases went to pedestrians;
- a study in *Dar es Salaam* (*Tanzania*) found that 45% of traumatized pedestrians were adults.

It has been found that male pedestrians, both children and adults, are more often involved in road accidents with the involvement of pedestrians. For example, a study in the *US* showed that men accounted for 70% of pedestrian deaths, with a mortality rate of 2,19 cases per 100000 population, while in women the mortality rate was 0,91 per 100000 inhabitants. The results of a study conducted in *Mexico* showed that the pedestrian mortality rate was higher among men (10,6 per 100000 inhabitants) than among women (4 per 100000 inhabitants) [3].

Socio-economic status is one of the key determinants of pedestrian road trauma. As a rule, the representatives of the poorer groups of the population are exposed to a higher risk of trauma when walking. For example [3]:

- in the *UK*, the risk of trauma in road accidents in children from lower socio-economic groups was higher more than twice compared to children with a higher socio-economic position;
- in the *US*, in poor areas of *Orange County*, *California*, road accidents involving pedestrians occurred four times more often;
- In *Hyderabad* (*India*), children in the upper quartile of households by income level were much less involved in road accidents.

In general, there are significant differences between countries in terms of places where road accidents involving pedestrians take place. While in high-income countries pedestrian collisions are more common in cities than in rural areas, in low- and middle-income countries the opposite legality is a feature. For example [3], about 70% of all pedestrian deaths in *European Union* countries and 76% in the *US* occur in urban areas. In the *UK*, young pedestrians have been involved in road accidents five times more often in cities than in rural areas, and the death rate has been twice as high. The results of a study conducted in *China* revealed the opposite trend: pedestrians in rural areas suffered more road injuries than pedestrians in cities. A study conducted among university students in *Cairo* (*Egypt*) showed that for those living in rural areas, the probability of suffering road injuries was significantly higher, compared to city dwellers.

Most pedestrian collisions occur when crossing the road. For example [3], a study in *Ghana* showed that 68% of dead pedestrians were hit by vehicles in the middle of the road. Information obtained from 73 pedestrians during a study in *Kenya* showed that 53 people (72,6%) were traumatized when they crossed the road, eight people (11%) – when they were on the sidewalk, six people (8,2%) – when walking along the road and six (8,2%) – in other situations, including when dealing with street trade.

In some countries, there are more road accidents involving pedestrians on weekdays than on weekends, while in other countries, on weekends, there are more fatal collisions with pedestrians. In the *United States*, in December, most pedestrian collisions occur during dusk and in the first hour after dark on all days of the week, and in June during dusk and in the first hour after dark on Fridays and Saturdays [3].

Although child pedestrians are given attention in road education, about one in ten deaths among people aged 5-15 are due to road accidents. Children are vulnerable pedestrians because they are more difficult to see in the driver's field of vision and, conversely, from their low visual position they do not observe or appreciate the movement of vehicles correctly. Also, children show mental lability and do not have the ability to correctly appreciate distances and walking speeds. The statistics of road accidents show that the percentage of elementary school students who died as a result of the impact with moving vehicles is three times higher than that of high school students [7].

The elderly are also the most common victims among pedestrians. They are particularly vulnerable, due to the decrease in their ability to observe approaching vehicles, as well as due to their low agility and speed to avoid vehicles or cross the road more quickly.

In relation to drivers, pedestrians have some essential characteristics:

- are more heterogeneous in terms of age and education on road traffic;
- are more numerous per unit of length or surface of the roads;
- underestimates the effects that their behavior can produce in the development of car traffic;
- know less about the traffic rules and give them less importance;
- are more difficult to follow and constrained to violate traffic rules and signs;
- age is a more important factor in road accidents, young pedestrians due to ignorance, and the elderly due to inattention.

These characteristics determine an unpredictable behavior of pedestrians, the measures of protection and disciplined, comfortable and safe organization of their traffic being much more difficult to achieve.

One of the main problems that arises is the behavior of pedestrians. Usually, when walking, people choose the shortest path, and if they go with a well-established goal they do not want to consume too much time, so they often follow the rules as much as they deem necessary. The shortest route does not require the obligatory use of pedestrian crossings or crossings, especially if this means an additional walking distance. They may also not follow the red traffic light signal if they wait longer. In addition, pedestrians tend to pay less attention to traffic on known routes than in unknown circumstances [14]. When the loss of time becomes substantial, pedestrians become impatient, especially children, and endanger themselves by trying to cross through inappropriate intervals between vehicles. The maximum delay that pedestrians accept must not be greater than that which would be the red signal of a traffic light located at the marked crossing.

An unthinking action of the pedestrian becomes a bad dream for the driver, because in 90% of cases for violations of the pedestrian is responsible to the driver. This happens because the law says the following: even if the pedestrian has violated, the driver must anticipate his actions and not allow the accident.

The main risk factors for pedestrians are well known and include: *the behavior of drivers*, especially in terms of speed and drunk driving; *the level of development of pedestrian infrastructure* in terms of the absence of sidewalks, walkways and elevated dividing lanes, etc.; *vehicle construction* – the presence of a solid and hard front, which does not attenuate and reduce the force of the impact on of the pedestrian and poor visibility of pedestrians. In many countries, emergency services needed to save the lives of traumatized pedestrians are also hampered by their poor functioning.

Other factors that contribute to pedestrian trauma are [3]:

- poor compliance with traffic rules;
- aggressive and unsafe driving;
- stealing the attention of drivers or pedestrians, including by using mobile phones;
- driver fatigue;
- the „*pedestrian-vehicle*" conflict at pedestrian crossings;
- reaction and slow walking speed in the elderly;
- the inability of children to properly assess the speed of vehicles, the distance to them and other appropriate information, which would allow them to cross the street safely without accompanying adults;
- lack of supervision of children, who are still too young to make their own decisions;
- the unwillingness or refusal of the drivers to respect the right and priority of pedestrians in the cases provided by law;
- technical condition of vehicles and their defects (eg defective brakes, poor lighting, damaged windscreen etc.);
- silent (electric) vehicles, the presence of which cannot be detected by hearing.

The following should also be mentioned [14]:

1. Pedestrians represent the largest category of traffic participants, which is characterized by disorganization.
2. Some pedestrians do not know the *Road traffic regulations*. Another part of pedestrians know *RTR* in an insufficient volume and consciously violates them.
3. The pedestrian, who crosses the road and suddenly notices the vehicle, usually gets lost and tends to turn back.

4. Older people are characterized by reduced mobility, poor hearing and sight, delayed reaction and react inappropriately to the dynamic characteristics of vehicles.
5. The group of pedestrians, waiting to cross the road in case of intense transport flow, presents a greater danger than a lone pedestrian.
6. If there are children at the side of the road, it must be taken into account that they are impatient and inattentive.
7. The field of vision of children is one third of the field of vision of adults, and often incorrectly assesses the direction and speed of vehicles.
8. Children can cross the road directly in front of the vehicle, looking only in front of it.
9. The use of umbrellas by pedestrians and the presence of hoods on the head limits visibility and the noise of rain disturbs the noise of vehicles.
10. In winter, pedestrians hear the noise of vehicles worse. They can also slip unexpectedly on the slippery road.
11. Drunk pedestrian behavior is unpredictable. They may suddenly change direction or fall.

Road accidents involving pedestrians in the *Republic of Moldova* constitute about 40% (period 2000-2018) of the total number of accidents (Table 1) [2, 7, 12, 14-22]. Most accident situations happen in localities. They are created in places where pedestrians frequently appear: at pedestrian crossings, road vehicle stations, intersections, markets, places often frequented by children etc.

Every ninth road accident was caused by pedestrians (5357, or 10,75% of the total number of road accidents).

Table 1

Frequency of road accidents (2000–2018)

The year	Total road accidents	Road accidents involving pedestrians	% of the total number of road accidents	Road accidents involving children	% of the total number of road accidents
2000	2580	1269	49,19	491	19,03
2001	2666	1237	46,40	496	18,60
2002	2899	1369	47,22	518	17,87
2003	2670	1289	48,28	440	16,48
2004	2447	1122	45,85	373	15,24
2005	2289	1041	45,48	342	14,94
2006	2298	1006	43,78	316	13,75
2007	2437	1054	43,25	360	14,77
2008	2875	1079	37,53	635	22,09
2009	2755	1066	38,69	536	19,46
2010	2930	1071	36,55	544	18,57
2011	2826	1006	35,60	564	19,96
2012	2712	935	34,48	557	20,54
2013	2603	980	37,65	485	18,63
2014	2564	886	34,56	411	16,03
2015	2527	831	32,88	357	14,13

Continued Table 1

2016	2479	835	33,68	387	15,61
2017	2640	997	37,77	371	14,05
2018	2613	946	36,20	414	15,84
Total	**49911**	**20019**	**40,19**	**8597**	**17,26**

The violations committed by pedestrians that led more frequently to road accidents were:

- crossing the street without being insured beforehand;
- crossing the street in forbidden places;
- irregular driving on the road;
- unexpected exit from vehicles, obstacles.

The number of road accidents in which children suffered is 8597 or 17,26% of the total number of road accidents, as a result of which 602 or 8,11% of the total number lost their lives, and 8757 children were traumatized or 14,46% (Figure 2).

Due to the children's own fault, there were 1810 road accidents (Figure 2). 114 of them died and 1682 children were traumatized.

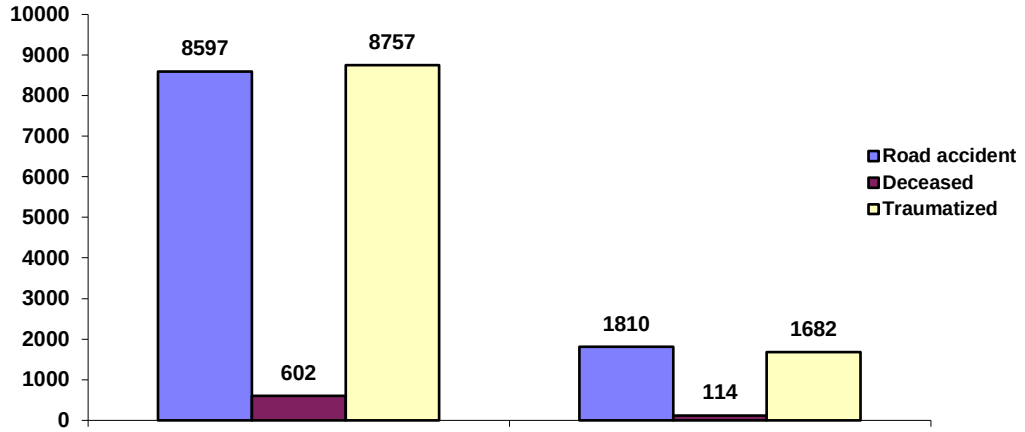

Figure 2. Children who suffered in road accidents (2000–2018).

In order to minimize the number of victims in road accidents, pedestrians are urged to follow some simple but very useful traffic rules [1, 2, 22]:

- make sure at all times, even when you are on the crosswalk, that the crossing can be done safely (vehicles are stopped before marking);
- at pedestrian crossings, drive to traffic light signals for pedestrians, vehicles or traffic officers;
- once engaged in crossing, do not slow down or stop for no reason;
- wait for the route vehicles in the station, on the footway, or on the sideways, as the case may be, on the shelter;
- on undirected crossings, exit the road only when you are convinced of the safety of the crossing even if you have priority over drivers;
- if there are no pedestrian crossings within the visibility limits of 100-150 meters, cross the road only after making sure that no vehicles are approaching;
- move on the right side of the footways, and in their absence – on the sidewalk;
- outside the localities, drive on the left side of the road to meet the flow of vehicles;
- when traveling at night or in low visibility conditions, wear clothing with fluorescent-reflective elements;

- if you are a parent or educator and accompany children – do not allow their unattended exit on the road, and while driving, drive on the outside of the sidewalk or sidewalk;
- children should not be allowed to cross alone – they are unpredictable and cannot appreciate distances and speeds correctly. Do not forget! – children imitate the road behavior of adults.

Pedestrians are also forbidden to engage in road crossing [1, 2, 22]:

- directly in front or behind vehicles stopped or parked on the road;
- on road sectors with limited visual field;
- if a vehicle with a priority traffic regime is approaching, which emits light and sound signals;
- to cross the tracks at level crossings, when the light signal or the position of the barrier prohibits the crossing.

At the same time, in order to avoid road accidents involving pedestrians, drivers are urged to reduce their speed and drive more carefully [22]:

- when approaching the pedestrian crossing, so that it can stop and give priority;
- in the area of educational institutions, socio-cultural or economic objectives, where there is a large flow of pedestrians, especially children;
- when approaching the stations of road vehicles, especially those that are not provided with pedestrian shelters, where some pedestrians can engage in crossing in front of the means of transport;
- when approaching one or more pedestrians moving on the roadway, regardless of the direction of travel.

In order to increase pedestrian safety, attention must be paid to the construction of vehicles, road infrastructure, means of road traffic control, in particular speed limitation, and the application of rules and regulations relating to road traffic.

In the context of the above, car manufacturers since 1960 have set themselves the goal of building vehicles that would reduce the damage and injury to both drivers, passengers and pedestrians in traffic accidents. Since 1967, *General Motors* has used shock-resistant windows. This solution reduced the survival rate for the driver and passengers, but reduced the damage to pedestrians when they collided. The dangers of pedestrian collisions are obvious, and the windshield is one of the most „*favorable*" areas with which it can come into contact.

The impact between the vehicle and the pedestrian is currently a very important issue regarding the active and passive safety of motor vehicles. Data collected from around the world indicate that much more pedestrians die in road accidents than vehicle passengers. A pedestrian bumped at a speed of 60 *km/h* is very likely to die, regardless of the safety solutions incorporated in the vehicle. The separation of pedestrians from road traffic through road infrastructure is the biggest contribution in the field of pedestrian safety, technology having an important word in this area. Currently, car manufacturers are developing equipment to prevent collision, based on radar or ultrasound, which brakes the vehicle in the event of the danger of colliding an obstacle, including a pedestrian, pedestrian protection in the event of a collision, during night hours etc.

The pedestrian protection system [5, 23] is designed to reduce the consequences of a pedestrian collision with the car in the event of a road accident. The system (Figure 3) is developed by *TRW Hodings Automotive* (*Pedestrian Protection System, PPS*), *Bosch* (*Electronic*

Pedestrian Protection, EPP), *Siemens* and since 2011 is installed in series on the cars of European manufacturers. The systems listed have an analog construction.

The principle of operation of the pedestrian protection system is based on the opening of the hood at the collision of the pedestrian with the car, which achieves the increase of the space between the hood and the engine parts and correspondingly the reduction of the pedestrian trauma. In fact, the raised hood participates as a safety cushion.

In addition to the system presented on cars for pedestrian protection, the following constructive solutions are used, that reduce collision trauma:

- „*soft*" hood;
- brushes without housing;
- „*soft*" bumper;
- inclined hood and windshield;
- increased distance between engine and bonnet.

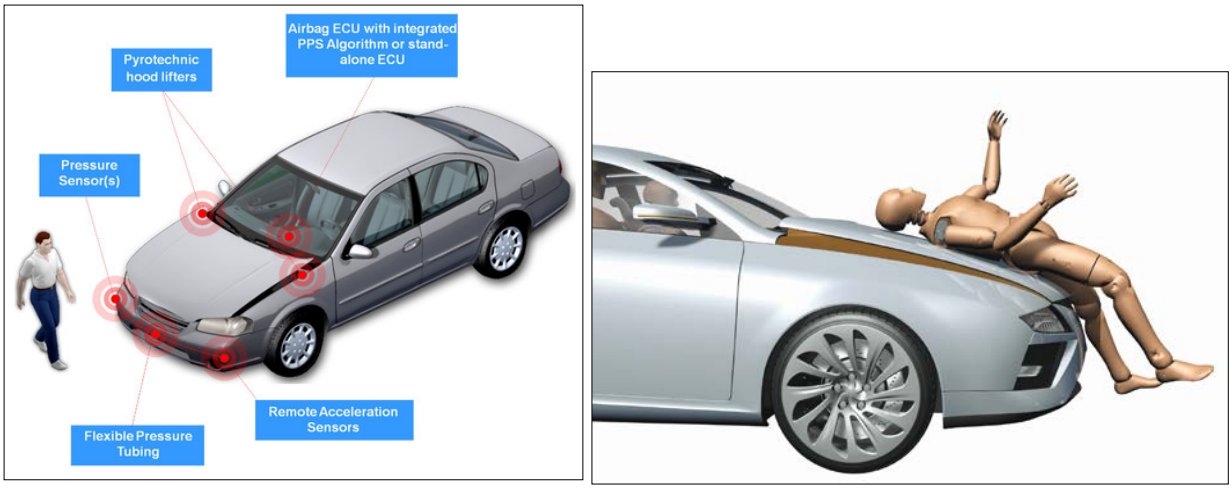

Figure 3. Pedestrian Protection System, PPS.

The further development of the pedestrian protection system is the *Pedestrian Airbag System*, introduced by *Volvo* in 2012 [5, 24]. The system is designed to reduce the degree of pedestrian trauma in a collision with the car. The air cushion (Figure 4) inflates outside the car and covers the bottom of the windscreen and side brackets. At the same time, the rear of the bonnet is raised when the front bumper of the car detects the impact with a pedestrian. Together, the air cushion and the raised hood ensure a significant reduction in trauma to the pedestrian's collision with the car. The pedestrian air cushion works in tandem with another *Volvo* system – the *Pedestrian Detection system*.

The pedestrian air cushion operates at a speed of 20 to 50 *km/h* and cannot be deactivated by the driver. According to statistics, the majority (75%) of road accidents involving pedestrians take place at speeds of up to 40 *km/h*.

The pedestrian detection system [5, 26] is designed to prevent collisions with pedestrians. The system recognizes people near the car, automatically decelerates the car, reduces the impact force and even avoids the collision with the pedestrian. The use of the system allows a 20% reduction in pedestrian mortality, and in the case of road accidents and a 30% reduction in the risk of serious trauma.

The pedestrian detection system was first used in 2010 on *Volvo* cars. The system currently has a number of changes:

Figure 4. Pedestrian Airbag System, PAS [5, 25].

- *PDS (Pedestrian Detection System)* from *Volvo* (Figure 5)*;*
- *APDS (Advanced Pedestrian Detection System)* of the *TRW* (Figure *6*);
- *ES (Eye Sight)* from the *Subaru* (Figure 7).

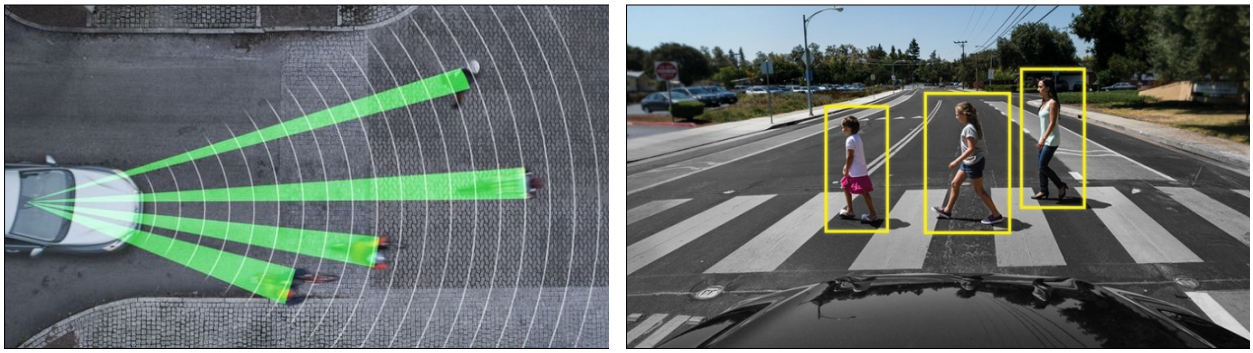

Figure 5. Pedestrian Detection System, PDS [5, 27].

The following interdependent functions are performed in the pedestrian detection system: pedestrian detection, collision warning and automatic braking.

To detect pedestrians, a video camera and a radar are used (two video cameras at *Subaru*), which actually operate at a distance of up to 40 *m*. If the pedestrian is detected by the video camera and the result is confirmed by radar, the system tracks pedestrian movement, predicts subsequent displacement and estimates the probability of a collision with the car. The detection results are displayed on the multimedia system screen. The system also reacts to cars, which are parked or moving in the same direction.

Figure 6. *Advanced Pedestrian Detection System, APDS* [5, 28].

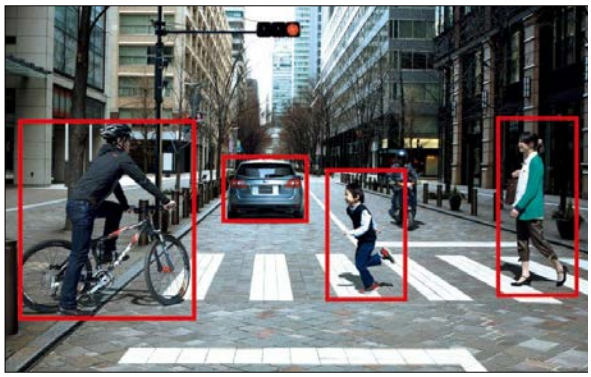

Figure 7. Eye Sight, ES [5, 29].

If the system has determined that a collision with a pedestrian is unavoidable due to the current nature of the car's movement, the driver receives an audible warning. Then, the

system evaluates the driver's reaction to the warning – changing the character of the car's movement (braking, changing direction). If the reaction is missing, the pedestrian detection system automatically stops the car. In this situation, the pedestrian detection system is a derivative of the automatic emergency braking system.

The pedestrian detection system allows complete avoidance of collision at speeds of up to 35 *km/h*. At higher speeds, the system cannot completely prevent the accident, but it can reduce the consequences for the pedestrian by decelerating the car before the collision. The statistical data show that the probability of pedestrian death following the collision with the car at a speed of 65 *km/h* is 85%, 50 *km/h* – 45%, 30 *km/h* – 5%.

The automatic emergency braking system creates partial or maximum braking pressure without the involvement of the driver, ie automatically.

Emergency automatic braking systems include [5, 30]:

- *PSB* (*Pre-Safe Brake*) on *Mercedes-Benz* cars;
- *CMBS* (*Collision Mitigation Braking System*) on *Honda* cars;
- *CBC* (*City Brake Control*) on *Fiat* cars;
- *ACS* (*Active City Stop*) on *Ford* cars;
- *FA* (*Forward Alert*) on *Ford* cars;
- *FCM* (*Forward Collision Mitigation*) on *Mitsubishi* cars;
- *CEB* (*City Emergency Brake*) on *Volkswagen* cars (*figure 8*);
- *CWAB* (*Collision Warning with Auto Brake*) on *Volvo* cars;
- *CS* (*City Safety*) on *Volvo* cars (*figure 9*);
- *PEBS* (*Predictive Emergency Braking System*) from *Bosch*;
- *AEW* (*Automatic Emergency Braking*) of the *TRW*.

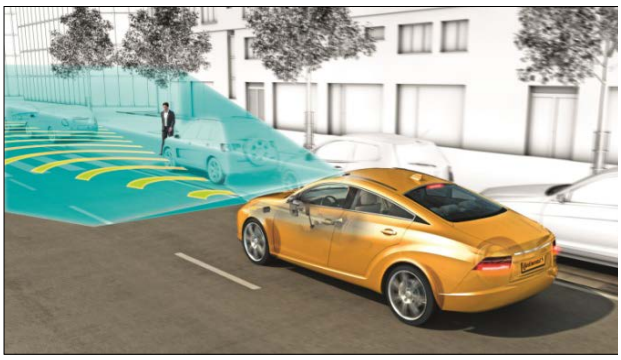

Figure 8. City Emergency Brake, CEB.

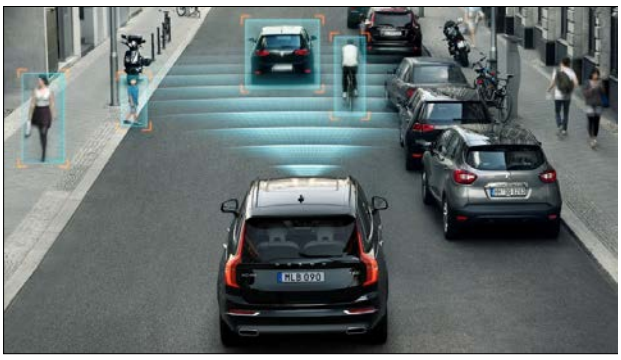

Figure 9. City Safety, CS [5, 31].

Volvo City Safety is an autonomous emergency braking technology that allows you to avoid bumps at low speeds or reduce their consequences. At speeds of 3,6 to 30 *km/h* it uses a transducer, which operates at a distance of up to 10 *m*. If it determines the possibility of an accident, the system prepares the brakes. If the driver does not react, the car's brakes are applied. From a speed of 15 *km/h* the car is able to decelerate to a complete stop. At high speeds it is not possible to avoid buffering, but it will be less serious. In case, if the driver persists to avoid the accident, *City Safety* disconnects.

The night vision system [5, 32] is intended to provide the driver with information on night traffic conditions. The system allows the recognition of all kinds of obstacles, traffic participants, pedestrians on an unlit road, as well as the subsequent trajectory of the road. The system helps to remove the load from the driver in low visibility conditions and thus

ensures an increase in traffic safety. Currently, the night vision system is installed as an option for premium class cars.

The principle of operation of the system is based on fixing the infrared (thermal) radiation of objects with a special camera and projecting it on the screen as a gray scale image.

There are two types of night vision systems: *active* and *passive*. Active systems use an additional car-mounted infrared light source. They are characterized by a high resolution image and an operating length of 150-250 *m*.

Known active night viewing systems are:

- *Night View Assist* from *Mercedes-Benz* (Figure 10);
- *Night View* from *Toyota*.

Passive night vision systems do not have their own source of infrared radiation. The thermal chamber (thermal mirror) captures the infrared radiation of objects at a distance of up to 300 *m*. They have a high level of contrast and a low image resolution.

Passive night vision systems are:

- *Night Vision Assistant* from *Audi* (Figure 11);
- *Night Vision* from *BMW*;
- *Night Vision* from *General Motors*;
- *Intelligent Night Vision System* from *Honda*.

Figure 10. Night View Assist [33].

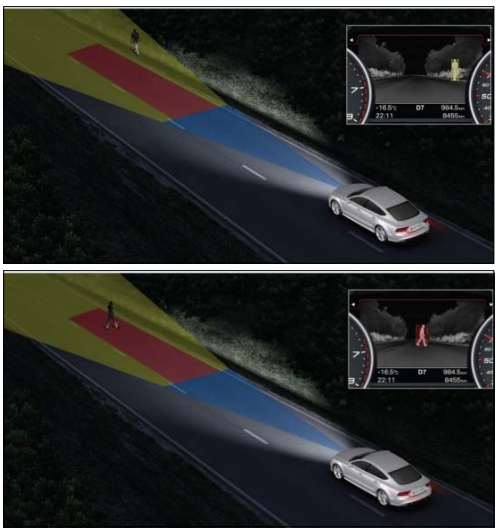

Figure 11. Night Vision Assistant [34].

The most technical and functional night vision system is the latest achievement of *Mercedes-Benz* – the *Night View Assist Plus* system. In addition to the standard driver information functions, the system warns pedestrians of a potential danger. The algorithm of the program is performed at a speed higher than 45 *km/h* and the location of pedestrians at a distance not exceeding 80 *m*.

BMW went further in this direction, presenting an intelligent night-vision system for detecting pedestrians in the immediate dangerous vicinity of the road. The *Dynamic Light Spot* system with the help of heart rate sensors determines the presence of living beings at a distance of up to 100 *m* from the car. For *BMW* cars, the *Dynamic Light Spot* system is also installed in the *Night Vision* viewing system.

Another car manufacturer that draws more attention to the health and life of pedestrians is *Ford* [5, 35]. The latest generation of *Ford Focus* benefits from sophisticated

safety systems designed to prevent or reduce the effects of a road accident on passengers and pedestrians. These systems include a technology especially appreciated by *Euro NCAP*: *Pre-collision Assist* with *Pedestrian and Cyclist Detection*. This system can detect pedestrians and cyclists on or near the road and could intersect the trajectory of the car's movement, applying the brakes automatically, if it detects a potential collision and the driver does not respond to warnings. Detection is now possible at night, with the help of headlights.

The level of protection offered by the car to pedestrians, in case of a frontal impact with them, is 72%. The front parts of the car are soft and if a person is taken on the hood, he will not suffer serious injuries, unless he hits his head in the lower part of the uprights.

Dynamic Light Spot [5, 36], which literally means a „*spot lighting*" dynamic lighting system. The name speaks for itself: automation detects the pedestrian and directs light towards him (Figure 12), thus indicating to the driver the potential danger. Moreover, the hint appears earlier, so that the object appears in the light of the passing headlights. As a result, the driver receives an advantage of a few seconds or tens of meters, which are often not enough to brake or bypass the pedestrian safely.

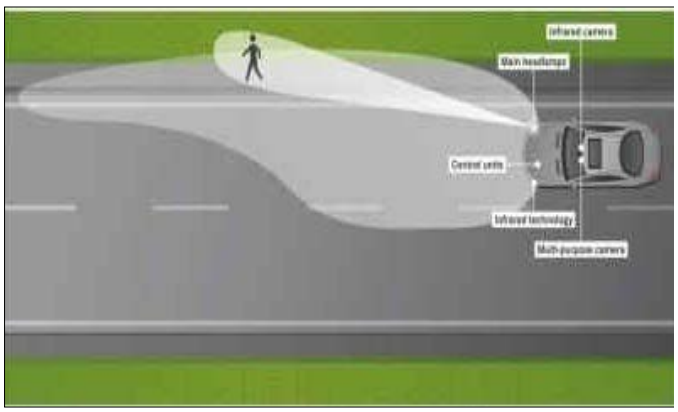

Figure 12. Dynamic Light Spot.

Figure 13. *„Night Guide"* lamp [5, 37].

„*Night Guide* – 3 in 1" lamp – multispectral lamp (Figure 13), which combines the properties of three types of lamps: „*Vision Plus* + 50%", „*Blue Vision*" and „*Weathervision*". The light from this lamp on the road is scattered in three areas:

- in front – white light with 50% amplified brightness, which allows the illumination of the roadway at a distance greater by 10–20 *m*, compared to a halogen lamp;
- on the left – yellow light, which does not blind drivers in the opposite direction;
- on the right – the area with blue daylight, which illuminates well, in particular, the road signs and the sidewalk.

Conclusion. In the end we can conclude that no car manufacturer, no passive or active safety system, no matter how sophisticated it can be, cannot replace man, and to avoid the number of such road accidents. Both drivers and pedestrians must comply with the *RTR*, meet the requirements of traffic behavior, crossing dangerous road areas so as not to endanger his life and health.

Until recently, the driver of the car was fully to blame for road accidents involving pedestrians, thus exempting the pedestrian from legal consequences, which led to an aggressive behavior on the part of pedestrians compared to drivers when crossing the road in forbidden places, sometimes even a few, meters of pedestrian crossings, unlit, without a fluorescent vest or at least some light source, which would make them visible. A draft law is

currently being prepared in several countries for approval, which would provide that in such cases, pedestrians should bear both legal and material liability for the violation of the *RTR* resulting in the tamponade of pedestrians. The neighboring country of the *Republic of Moldova* this year has implemented such a project, if such a law will be reached in the *Republic of Moldova* it remains a question.

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