ASSESSMENT OF THE INFLUENCE OF THE HUMAN FACTOR ON SAFETY OF THE TRANSPORTATION PROCESS

OCENA WPŁYWU CZYNNIKA LUDZKIEGO NA BEZPIECZEŃSTWO PROCESU TRANSPORTOWEGO

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Abstract: *Safety of the transport process is a criterion of top priority for a transportation system operation and maintenance. It is of special importance in case of public municipal transportation. Systems of this type operate in specific road conditions: increased intensity of traffic during a day and night, a big number of pedestrians as well as drivers of other vehicles. In such conditions the human factor and its impact on the transport system operation is of key importance. A human can be involved in the transportation system as a driver, passenger, pedestrian, or in another way (cyclist, motorcyclist). Improper behavior of people account for 36% - 46% of road accident causes defined as undesirable events occurred within the space of the road. In this paper there has been mad an attempt to evaluate the transportation system from the point of view of people present in the transportation system and its environment.*

Keywords: *safety working, undesirable event*

Streszczenie: *Bezpieczeństwo realizowanego procesu transportowego jest priorytetowym kryterium działania systemów transportowych. Szczególnie ważne jest to w przypadku systemów zbiorowego transportu miejskiego. Systemy tego typu podlegają szczególnym warunkom ruchu: wzmożone natężenie ruchu w ciągu doby, duża liczba pieszych uczestników ruchu drogowego jak również kierowców pojazdów obcych. W takich warunkach szczególnie istotnym jest czynnik ludzki i jego oddziaływanie na system transportowy. Człowiek w systemie transportowym usytuowany może być jako kierowca pojazdu, jego pasażer, pieszy w otoczeniu lub inny uczestnik ruchu (rowerzysta, motocyklista). Niewłaściwe oddziaływanie ludzi stanowią 36% a 46% przyczynę powstawania zdarzeń drogowych definiowanych jako zdarzenia niepożądane zaistniałe w obszarze przestrzeni drogowej. W pracy podjęto próbę oceny systemu transportowego z punktu widzenia działań ludzi usytuowanych w systemie i jego otoczeniu.*

Słowa kluczowe: *bezpieczeństwo działania, zdarzenie niepożądane*

1. Introduction

Transportation systems are socio-technical systems whose operation safety depends on different forcing factors. In literature [1,2,3] these factors are divided into three sets: 1-those which are connected with the vehicle technical state, 2 - external ones, connected with the environmental impact, 3 – anthropotechnical factors related to the behavior of people involved in the system and its environment. The role of humans in the systems of municipal transportations is of key importance due to the functions they perform. According to the role people play in the transportation system, they may be divided into:

- dispatchers – decision makers responsible for accomplishment of the transportation process,
- diagnostician – whose task is to maintain or return the vehicle to the desirable state.
- driver – directly responsible for safety of the transported passengers.
- passenger – using the services provided by a transportation system.

People are also present in the transportation system environment which means that they do not belong to the system but they remain in a given relation with it. The people who are present in the system are classified into:

- users of other transport means (vehicles, motorbikes, bicycles, and others),
- pedestrians and people waiting at bus stops.

Safety of the transportation process depends on the behavior of these people. Behaviors of people can be divided into two subsets 1 - conscious and intended, 2 – unconscious, resulting from individual traits and mental and physical health. The authors have made an attempt to identify human behaviors and evaluate the impact of their actions on the transportation process safety.

2. Analysis of selected threats connected with the behavior of humans.

Improper behaviors of people involved in transportation systems cause undesirable events, the effect of whose are material losses and loss of health or life of people who are participants of the traffic. In table 1 there are results of probability values of occurrence of undesirable events caused by improper actions of people. As the presented data shows the improper behaviors of vehicle drivers are featured by the highest probability of causing an undesirable event. In table 2 there are values of probabilities of occurrence of an undesirable event whose result is death or injury of a road traffic participant. As the data contained in table 2 shows, also the actions of drivers are characterized by the highest probability value of an undesirable event occurrence.

It must be emphasized that the probability of occurrence of a fatal traffic accident due to improper behavior of passengers is almost two times higher than the probability of sustaining injury by road traffic participants.

Table 1. Probability of occurrence of a road accident due to improper behavior of people present in the transportation system or its environment.

Improper behaviour	Probability of occurrence of traffic accident
Vehicle drivers	0,8164
Pedestrians	0,1811
Vehicle passengers	0,0024

Table 2. Probability of occurrence of a fatal road accident or sustaining injuries by people involved in it.

Improper behavior	Fatalities	Injured
Vehicle drivers	0,8005	0,8663
Pedestrians	0,1961	0,1320
Vehicle passengers	0,0034	0,0018

Causes of occurrence of undesirable road events due to improper behavior of vehicle drivers

On the basis of data collected for the study [5], the values of probabilities of occurrence of undesirable road events have been calculated. The most frequent causes of road accidents by fault of drivers have been presented in table 3 and in fig. 1. As the data shows, the most frequent cause of traffic accidents is improper behavior of the vehicle drivers involving: failing to adjust speed to road conditions, failing to give way, and wrong attitude toward pedestrians.

The data contained in table 3 can be divided into two subsets of causes of improper behavior of drivers that is:

- improper steering the vehicle ($1 \div 3$, $6 \div 16$), described by the probability of occurrence of event $P(A_1)$,
- improper health condition of the driver ($4 \div 5$), with a probability of $P(A_2)$ occurrence.

As it can be seen, the probability of occurrence of an undesirable road event due to improper behavior of drivers, resulting from their poor health condition is 0.027, and is approximately 36 times lower than the probability of occurrence of an undesirable road event as a result of improper vehicle steering $P(A_1) = 0,973$. This involves a necessity to take up actions aiming at improving the drivers' skills.

Table 3 The most frequent causes of occurrence of undesirable traffic events by fault of drivers.

No.	Improper behavior of drivers	P (A)
1	Disrespecting traffic signs and signals	0,0032
2	Sudden braking	0,0037
3	Driving without required lighting	0,0045
4	Limited psychomotor efficiency	0,0133
5	Tiredness, falling asleep	0,0137
6	Disobeying traffic lights	0,0150
7	Improper reversing	0,0194
8	Improper passing from the opposite direction	0,0207
9	Improper passing stationary objects	0,0322
10	Driving on the wrong side of the road	0,0326
11	Improper turning	0,0464
12	Failing to keep safe distant from other vehicles	0,0501
13	Improper overtaking	0,0798
14	Improper behavior toward pedestrians	0,1026
15	Disobeying the priority of way	0,2533
16	Failing to adjust speed to road conditions	0,3096

Fig. 1 Values of probability of occurrence of undesirable events due to drivers' behavior.

Causes of occurrence of undesirable events due to improper behavior of the passengers.

Improper behaviors of the transport means passengers are rarely the cause of occurrence of traffic accidents in transportation systems. These behaviors are as follows:

- a. distracting the driver's attention
- b. aggression toward the driver,
- c. jumping out of the vehicle
- d. improper behaviour on the bus while riding,
- e. other reasons

The above presented behaviours of passengers refer to public transportation systems. Apart from the above listed improper behaviours of passengers in systems of public transportation, there can be distinguished purposeful and conscious behaviours intended to damage the means of transport (devastation). In public transport means devastations account for approximately 30% of all undesirable events and generate nearly 20 % of all the repair costs.

Causes of occurrence of undesirable events due to improper behavior of pedestrians.

In the environment of a transportation system the humans can perform the function of drivers, cyclists, pedestrians and those who wait at bus stops. Improper behavior of pedestrians account for the second group of causes of occurrence of traffic accidents. In result of improper behaviors of pedestrians as many as 25 of them die in 100 traffic accidents.

In table 4 there are values of probabilities concerning the causes of occurrence of undesirable events due to improper behavior of pedestrians. According to the data from table 4, improper behaviors of pedestrians which most frequently lead to undesirable events include: reckless entering the road in front of a riding bus, improper crossing the street and thoughtless entering the road from behind a vehicle or another object.

Table 4. The most frequent causes of road accidents by fault of people present in the environment of the transportation system

Lp.	Improper behaviour of pedestrians	P (B)
1	Walking on the track age	0,00162
2	Jumping into a moving vehicle	0,00238
3	Walking on the wrong side of the road	0,03711
4	Leaving children without care	0,06058
5	Reckless entering the road from behind a vehicle or another object.	0,10861
6	Improper crossing the street	0,31826
7	Reckless entering the road in front of a riding bus.	0,47144

In fig. 2 there are presented values of probability of occurrence of undesirable events due to improper behavior of people present in the environment of a transportation system. As the data shows, improper behaviors of pedestrians with the highest probability value include improper crossing the street, the sum of which being $P(B5) + P(B6) + P(B7) = 0,898$, and account for nearly 90% of causes of occurrence of undesirable events by fault of pedestrians.

Fig. 2. Values of probability of occurrence of undesirable events due to improper behaviors of pedestrians

Causes of occurrence of undesirable events due to improper behaviors of people present in the subsystem of ensuring efficient operation of vehicles.

According to works [1.3], the technical state of a vehicle has an influence on the safety of transport tasks. In systems of public transportation, maintenance of vehicles is the responsibility of people who work in the subsystem ensuring efficient operation of vehicles - diagnosticians and mechanics. Their duties include performance of scheduled and current services and repairs of transport means. A repair is a series of organizational –technical activities aiming at maintenance of vehicles through regulation and exchange of damaged elements.

According to work [3] the repair related errors are the main cause of occurrence of a vehicle failure. The failures impair the vehicle technical state which accounts for nearly 30% of occurrence of undesirable traffic events in transportation systems. In

work [3] there have been presented the most frequent repair errors such as:

- application of unsuitable material,
- regulation errors,
- repair technology errors,
- application of mismatched spare part,
- application of a damaged part.
- application of a part made of unsuitable material,
- application of a part with a hidden defect,
- application of a part with wrong dimensions,
- montage errors,
- post repair pollution.

3. Improper actions of drivers as factors leading to occurrence of undesirable traffic events.

The extent to which the behavior of people affects a transportation system and the tasks it performs, depends on the position they occupy in the system. In figure 3 there are examples of improper behaviors of drivers leading to occurrence of an undesirable traffic event.

Fig.3 Graphic presentation of the impact of an elementary event on occurrence of an undesirable event.

In fig.3. there has been presented an influence of one of possible behaviors of a driver on occurrence of an undesirable event. As it can be seen, an undesirable event UE happened in result of improper behavior of a human H. The cause of the event was improper behavior of a driver H1 which occurred in result of his/her poor mental condition H1.2, which in consequence led to breaking traffic regulations H1.2.3. Breaking traffic regulations involved failing to adjust speed to road conditions H1.2.3.4.

Elementary events are such which initiate occurrence of undesirable events (accidents and collisions). In the figure there has been presented one 'path' from elementary event (H1.2.3.4) to a top event (TE). It results from the fact that a collision/ accident occurred in the effect of breaking traffic regulations by a driver and failing to adjust speed to road conditions. Each of the elementary events is matched with the probability of its occurrence $P(C1.2.3.4) = 0,3096$. The top event can be initiated by a few simultaneous elementary events connected with the driver's state of health and disrespecting by him/her traffic regulations.

In fig. 3 the following denotations have been accepted:

- UE – undesirable event (road accident in the analyzed transportation system),
- H – the cause of the event was improper behavior of people,
- OT – the cause of undesirable event was impaired technical condition of a vehicle,
- O – the cause of undesirable event was the impact of external factors

Causes of occurrence of undesirable events due to improper behaviors:

H1 Drivers and their:

H1.1 Physical condition:

H1.1.1 Impaired vision

H1.1.2 Impaired hearing,

H1.1.3 Disease

H1.1.3.1 Raised body temperature,

H1.1.3.2 Raised blood pressure,

H1.2 Mental condition:

H1.2.1 Level of intelligence,

H1.2.2 Driving while being in poor mental condition,

H1.2.3 Improper behaviors including :

H1.2.3.1 driving while being under the influence of alcohol,

H1.2.3.2 driving while being under the influence of drugs,

- H1.2.3.3 driving while being intoxicated by medicines impairing motoric abilities,
- H1.2.3.4 failing to adjust speed to the conditions on the road,
- H1.2.3.5 failing to give way,
- H1.2.3.6 improper overtaking,
- H1.2.3.7 improper passing stationary objects,
- H1.2.3.8 improper passing from opposite direction,
- H1.2.3.9 improper going through zebra crossings,
- H1.2.3.10 improper turning,
- H1.2.3.11 improper braking and parking,
- H1.2.3.12 improper reversing,
- H1.2.3.13 driving on the wrong side of the road,
- H1.2.3.14 entering a crossroads at red light,
- H1.2.3.15 disrespecting traffic regulations and signals,
- H1.2.3.16 failing to keep safe distance from other vehicles,
- H1.2.3.17 sudden braking,
- H1.2.3.18 driving without required lighting,
- H1.2.3.19 driving a vehicle with impaired serviceability,

H2 Passengers and their:

- H2.1 Physical health:
 - H2.1.1 impaired vision,
 - H2.1.2 impaired hearing,
 - H2.1.3 health disorders:
 - H2.1.3.1 raised body temperature,
 - H2.1.3.2 raised blood pressure,
- H2.2 Mental health:
 - H2.2.1 level of intelligence,
 - H2.2.2 improper behavior in the vehicle,
 - H2.2.3 aggression toward the driver,
 - H2.2.4 distracting the driver's attention,
 - H2.2.5 limiting the driver's visibility,

H3 Pedestrians and their:

- H3.1 Physical health:
 - H3.1.1 impaired vision,
 - H3.1.2 impaired hearing ,

H3.1.3 health disorders:

H3.1.3.1 raised body temperature,

H3.1.3.4 raised blood pressure,

H3.1.4 impaired physical condition after consumption of:

H3.1.4.1 alcohol,

H3.1.4.2 intoxicants,

H3.2 Mental condition:

H3.2.1 level of intelligence,

H3.2.2 improper behavior in the environment of the road:

H3.2.2.1 standing, lying on the road,

H3.2.2.2 walking on the wrong side of the road, entering the road on red light,

H3.2.2.3 reckless entering the road in front of an oncoming vehicle,

H3.2.2.4 reckless entering the road from behind a vehicle,

H3.2.2.5 crossing a street in a forbidden place,

H3.2.2.6 moving on the road without proper caution signs,

H3.2.3 aggression toward the driver,

H4 People present in the maintenance subsystem:

H4.1 Improper actions of diagnosticians:

H4.1.1 Incorrect diagnosis,

H4.1.2 Improper result of diagnosis,

H4.2 Improper actions of mechanics:

H4.2.1 application of unsuitable materials,

H4.2.2 errors of regulation,

H4.2.3 incorrect technology of repair,

H4.2.4 application of unsuitable spare part,

H4.2.5 application of a faulty element,

H4.2.6 application of a part made of unsuitable material,

H4.2.7 application of a part with hidden technological defect,

H4.2.8 application of a part with mismatched dimensions,

H4.2.9 montage errors,

H4.2.10 post repair pollution,

4. Summary

In order to determine the most frequent undesirable actions of vehicle drivers and behaviors of pedestrians, called initiating events, probabilities of their occurrence need to be determined. Determination of these probabilities will allow to establish the most common initiating events and taking actions in order to find out their influence on occurrence of undesirable events (top event).

According to the results of carried out tests, the most common causes of occurrence of undesirable road traffic events are improper behaviors of vehicle drivers and pedestrians. In order to eliminate improper behaviors of pedestrians it is advisable to identify places where in consequence of these behaviors, undesirable road events take place most frequently. It will allow to develop guidelines for modernization of infrastructure which would limit or entirely eliminate occurrence of improper behaviors of pedestrians.

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