

# **Analysis of costs connected with occurrence of undesirable road events in the system of municipal transportation**

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*Abstract:* - Systems of road transportation are sociotechnical systems of the type Human-Technical Object-Environment <H-OT>E. In these systems undesirable events can be caused by Human H, Technical object TO and Environment E. The authors of this paper have undertaken an attempt to evaluate the costs involved in occurrence of undesirable events in such a system.

*Key-Words:* - operation, functioning, operation safety, road event

## **1 Introduction**

Systems of municipal transportation are such that provide transport services over an assigned area with the use of transport means. The basic requirements from transportation systems include:

- safety of provided transport services,
- efficiency of the company operation
- reliability of transport means,
- punctuality of transport services,

- appropriate frequency of available transport services,
- proper standard of provided services.

The operation scope of the municipal transportation system covers also suburban areas which, though performing functions analogical to those of the town districts, are situated outside the town administrative borders. The system of

municipal transportation is a sociotechnical system of the type Human –Technical Object-Environment <H-TO-E>. In this kind of system, the transport tasks are performed by an executive subsystem, consisting of elementary subsystems of the type: human-technical object-environment (driver - transport means) providing transport services in the system environment.

Municipal transportation meets the demands of city dwellers involving their need to move around. These needs are fulfilled by performing the following functions:

- consumption – fulfilling the transportation need by providing transport services,
- integration- enabling integration of people's social and cultural life of

Providing transport services by the municipal transportation system is not free from negative consequences such as occurrence of undesirable road events, which generate additional costs, thereby decreasing the system operation efficiency. Ensuring appropriate level of the system operation efficiency is connected with the necessity to eliminate undesirable events caused by the impact of factors connected with the transportation system operation, its environment and anthropotechnical ones.

## 2 The research object and subject

The research object is a system of municipal bus transportation whose main task is to provide safe, reliable and punctual transport services using transport means within the assigned quantitative and territorial range. However, the subject of the research covers the effects of occurrence of undesirable events and evaluation of the costs involved.

One of the primary tasks of decision makers is to minimize the costs involved in provision of transport services. For this reason, in this work, an analysis of the costs connected with occurrence of undesirable events has been undertaken in order to take rational actions for elimination of these events and their causes.

## 3 Identification of undesirable events

*An undesirable event must be understood as such a change of the system state which results in material losses, loss of health or life of people present in the system and its environment.*

On the basis of identification of undesirable events occurring in a transportation system there have been distinguished the following events:

- road traffic collision – which caused only material losses,
- road accident – events which occurred within the road space in result of which at least one person was killed or injured;
- vehicle devastation – purposeful acting of people (passengers) intended to damage the vehicle;
- damage to the vehicle during operation-exceeding permissible boundary limits which changes its suitability state into limited suitability on unsuitability state.

## 4 Experimental tests

Experimental tests were carried out in a real transportation system – Bus Transportation Company in a big urban agglomeration. The tests were performed as a passive and active experiment. They lasted from 1.01.2012 to 31.12.2012.

The program of experimental tests covered the following steps:

- Identification of the undesirable road events (road accidents, collisions, devastations and damage to the vehicle)
- obtainment of data on the number of road accidents and collisions which occurred within the analyzed period of time with involvement of the examined transportation system vehicles.
- obtainment of data on devastation and damage to transport means of the examined system.
- obtainment of data on the transport means repair costs,
- obtainment of data on the used materials and spare parts,
- obtainment of data on the transportation means standby periods in the subsystem providing maintenance services.

## 5 Selected results of experimental tests

The tests covered the operation and maintenance process of 186 buses of different types. During the tests undesirable events were identified whose types and numbers are presented in fig.1.

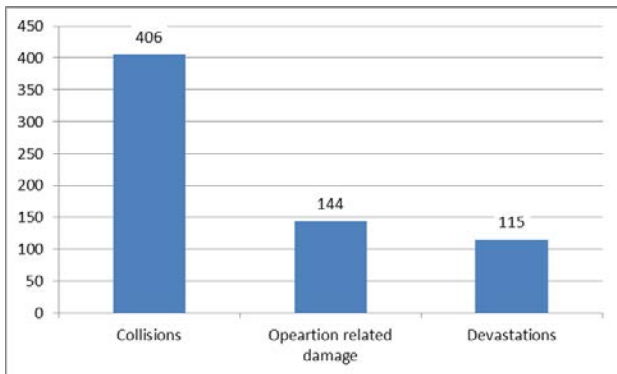


Fig. 1. Number of undesirable events which occurred in the examined transportation system within the considered time period.

Figure 2 shows the number of undesirable events which occurred in particular months in 2012. As it can be observed, most of the road collisions happened in months: January, February and December. 50% of the collisions were reported to have happened in these months.

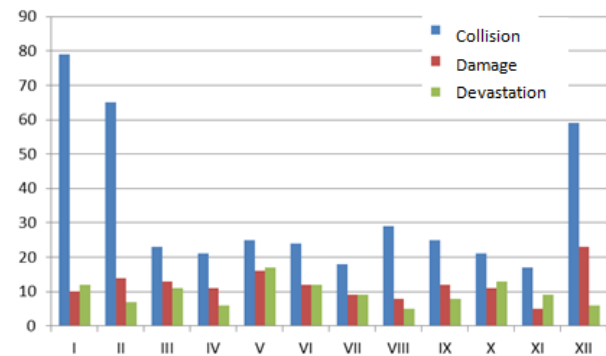


Fig.2 Number of undesirable events in particular months in 2012.

The total costs connected with restoring the vehicle roadworthiness after occurrence of an undesirable event are shown in table 1. According to the data contained in this table, the considered transportation system assigned 1070740PLN (341000\$) for repair of the vehicles, whereas 64% of the sum covered labor and the rest were reconnected with the materials and spare parts. Analyzing the costs in terms of the the reported road events it can be seen that post collision repair costs accounted for 74% of all the costs. Costs involved in vehicles operation and maintenance accounted for 15% of all costs, whereas costs connected with the vehicle devastation 11% of all costs involved in restoring roadworthiness of the vehicles of the analyzed research object.

Table 1. Costs of transport means repairs connected with occurrence of undesirable road events in 2012.

Kind of event	labor cost	cost of materials	total repair cost
Vehicle damage	32577	19180	51757
Devastation	23060	13592	36652
collision	162264	90327	252591
Accident	0	0	0
	217900	123099	341000

Mean values of unit undesirable events which occurred in the considered transportation system have been determined on the basis of data contained in table 1. They prove that a unit cost of post collision repair of a transport means is 622\$, of operation and maintenance related damage 360\$, whereas devastation nearly 318\$. Figure 3 shows the costs of undesirable events in particular months of 2012 year.

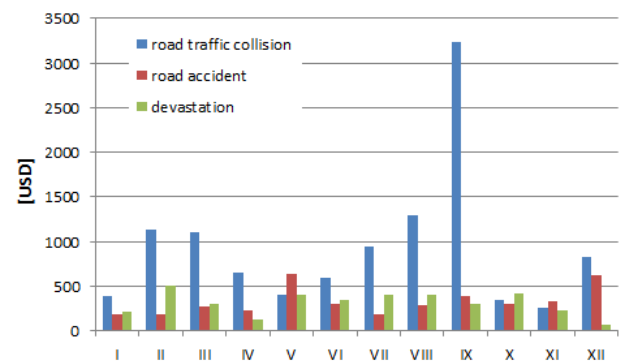


Fig. 3. Unit costs of undesirable events in particular months of 2012.

In result of occurrence of undesirable events buses do not perform transport services which generates losses for the company. Time spent on post collision repairs was defined in the course of the research. The results are presented in table 2. As the results show the longest periods of repairs are involved in post-collision repairs. The total time of bus repair connected with their collisions was 2741,5 h, which accounts for nearly 76% of the total repair time of vehicles damaged in result of road events. The least time consuming is a repair of devastation effects as it is easy to remove them.

Table 2.Repair time of buses in the subsystem of maintenance

Kind of event	[h] Bus repair time
Operation and maintenance related damage	543,5
devastation	313

collision	2741,5
accident	-
	3598

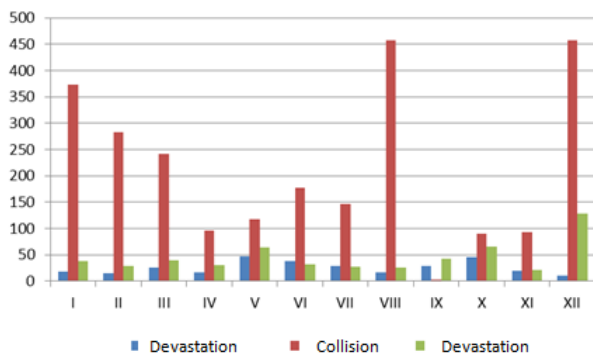


Fig. 4 Times of bus repairs connected with occurrence of undesirable events in 2012.

In figure 4 there are times of bus repairs connected with occurrence of undesirable road events in successive months. According to the data shown in this figure, the longest time is required for a bus to be repaired after a road traffic collision. It concerns mainly months VIII and XIII. The number of collisions which happened in these months should be discussed. In August, 29 accidents were reported, whereas in XII -59. Despite such a diversified number of road events which had occurred in those months, the times of their repairs were similar –fig.4, and it took 450 hour which means that 16 hours were spent for removing the effects of one collision in VIII and nearly 8h in month XII. Thus, the consequences of 29 collisions in VIII are more costly than those connected with 59 collisions in XII. This is due to the fact that during summer months drivers develop higher speeds.

## 6 Conclusions

From the data contained in figure 2 it follows that, road traffic collisions account for 61% of all the road events and their costs are equal to 250992 USD which is 75% of all the repair costs. It should be emphasized that despite being infrequent, some events can generate high repair costs which can reflect the effect of the events. This is illustrated by the number of collisions which occurred in month IX (25 collisions) and the costs connected with removal of their consequences 3232\$ (the highest throughout the year).

Another group of undesirable events are operation and maintenance related failures whose

total repair cost was nearly 3900 \$. These failures were caused by destruction processes occurring in the vehicle, inappropriate operation of vehicles or the impact of environmental factors connected with the road surface. Operation and maintenance related repair costs can be reduced by introducing additional job trainings for drivers or by improving the road surface in the considered agglomeration.

The last group of undesirable events generating costs in a given system are devastations of buses resulting from purposeful and conscious behavior of passengers. Despite being infrequent, events like devastations generate costs which could be eliminated by providing the busses with monitoring. Installation of such systems would allow to identify the offenders and enforce from them expenses involved in the repairs.

The results of the carried out research show the causes of occurrence of undesirable events and their consequences in particular months, which can provide the basis for developing guidelines for improvement of the operation and maintenance process efficiency.

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