Enhancement of control processes of city buses' traffic safety

Kairatolla K. Abishev, Ojum T.Balabaev, Dauren K. Sarzhanov, Ruslan B. Mukanov, Anuar A. Spanov

***Abstract*—In this article authors present results of research work about enhancement of control of traffic safety of city buses. The article presents analysis for the Astana city buses safety and the system that would ensure the safe traffic of city buses. A new device includes driver vigilance alarm button. The alarm button is located in driver's cab. Currently, patent of the Republic of Kazakhstan of the developed device is pending. This device can effectively improve traffic safety of city buses on routes and prevent road traffic accidents, reduce crashes, injuries, deaths on the road etc.**

***Index Terms*—bus; traffic safety; driver's vigilance; road traffic accidents; traffic infraction; public transport; alarm button**

I. INTRODUCTION

Nowadays, Astana, being the capital of the country and a center of people attraction, is the most intensively developing city in the Republic of Kazakhstan. With the development of the city its population increases (for the last 10 years population has increased by 86.7%). As stated on January the 1st, 2016 population of Astana was 872 655 people, however, this number can be doubled when we take into account the unregistered citizens. Fast growth of population induces unexpected increase of passenger flow in public transport, which consequently implies bad impact to the safety of transportation in city buses.

Analysis of public transport road traffic accidents for the period from 01.01.2012 to 31.12.2015 was made to evaluate level of safety of city buses. This analysis was performed according to statistical data of Committee for Legal statistics and special accounts of the Prosecutor General's office of the Republic of Kazakhstan. Statistical data included road traffic accidents which caused injuries and deaths. Therefore, it doesn't reflect data about road traffic accidents, which didn't cause injuries and deaths, even though it can have economic and social consequences with negative impact on traffic situation in Astana and image of public transport.

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II. DYNAMICS OF ROAD TRAFFIC ACCIDENTS GROWTH AND PRESENCE OF INJURIES AND DEATHS

Statistical data of public transport road traffic accidents makes it possible to give a characteristics of traffic safety of city buses (for citizens). The statistical data focuses on the most problematic aspects of public transport in Astana functioning.

According to the data (seeFig. 1) the highest number of road traffic accidents occurred in 2013 and reached the value of 51 accidents. During the reported period minimal numbers of accidents were recorded in the years 2012 and 2015, which were 34 accidents per each year. From 2013 to 2014 the rates of accidents growth started to reduce. The observed dynamics says that the highest rates of growth were happening in 2013 (17 accidents more compared to the preceding year); the highest reduction rate was observed in 2014 (10 accidents less compared to the preceding year). Total amount of road traffic accidents for the reported period was 160 road traffic accidents of public transportation vehicles (city buses).

Maximum number of injured people in road traffic accidents with public transport was in 2014 and was equal to 61 people (see Fig. 2). Within a period from 2012 to 2014 an increase in human injuries rates was observed. In 2014 it reached maximum. When analyzing the accidents and severity of their impact, one should take into account several parameters, such as amount of accidents themselves, number of injured people, consequently, the financial and moral losses due to damages caused. Thus, per number of road traffic accidents, the year of 2013 was the most severe year (51 accidents – 57 injured people), but when evaluated per injuries the year of 2014 takes this place (41 accidents – 61 injured people). In 2015 amount of injured dropped to the level of 2012. The observed dynamics says that the highest rates of injuries were observed in 2013 (15 injuries more compared to

preceding year); the highest rates of reduction were observed in 2015 (18 injuries less compared to preceding year). Total amount of injured in road traffic accidents with public transport for the reporting period was 203.

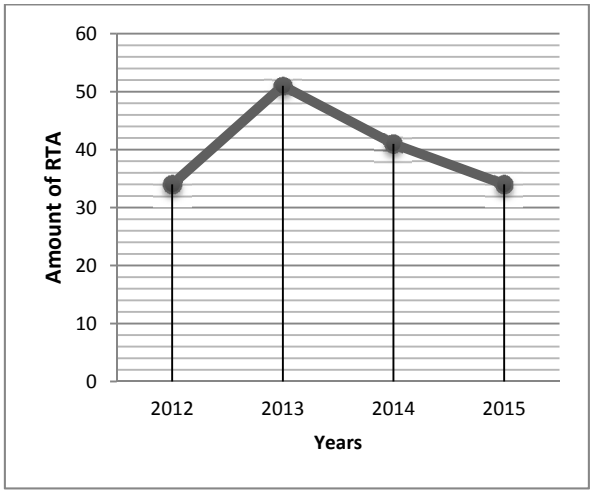

Fig. 1. Amount of road traffic accidents from 2012 to 2015

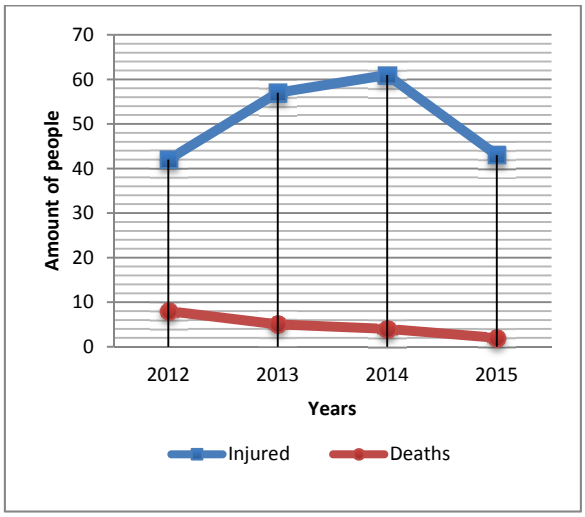

Fig. 2. Amount of injured people and deaths in road traffic accidents

Maximum amount of deaths in road traffic accidents with public transport was reached in 2012, number of deaths was equal to (see Fig. 2). During next years there reduction of mortal outcomes of public transport accidents is observed. In 2015 it reached minimum and was equal to 2 people. The observed dynamics states that during the reported period fatalities have reduced. In 2013 negative dynamics reached maximum (3 mortalities less compared to preceding year); and in 2014 it was minimum (1 mortality less compared to the preceding previous year). Total amount of deaths in road traffic accidents with public transport for the reported period was 19.

III. Classification of Road Traffic Accidents

According to statistical data road traffic accidents can be subdivided into 2 types (seeTableI): automobile-pedestrian accidents and motor accidents. Under the notion "automobile-pedestrian accident" a collision of automobile with a pedestrian or a bicyclist is understood. Under the notion "motor accident" a road traffic accident with car crash which caused driver's or passenger's injuries or deaths is understood.

During the reported period total amount of road traffic accidents was equal to 160. 63, number of motor accidents – 97, i.e. automobile-pedestrian accidents were 39% of total amount and motor accidents – 61% (see Fig. 3). Thus, for the reported period, amount of motor vehicle accidents was greater than automobile-pedestrian accidents by 22%.

TABLE I
Classification of Road Traffic Accidents

Year	Automobile-pedestrian accidents	Motor accidents
2012	21	13
2013	20	31
2014	13	28
2015	9	25
Total	63	97

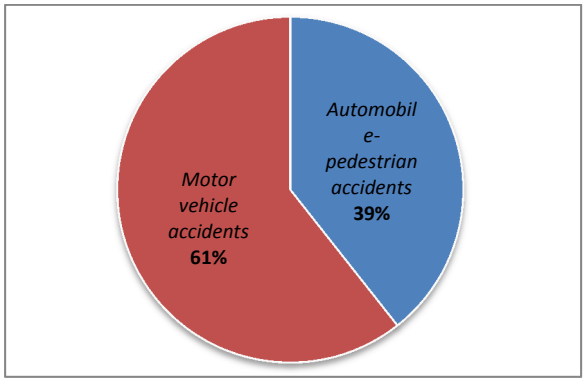

Fig. 3. Classification of road traffic accidents for reported period

Given classification characterizes separation of two types of road traffic accidents for the period from 2012 to 2015.

According to classification of road traffic accidents (see Table I), in 2012 amount of automobile-pedestrian accidents was greater than motor accidents per 24%. Since 2013, a share of motor accidents in total amount of road traffic accidents was greater than share of automobile-pedestrian accidents: in 2013 – per 22%, in 2014 – per 36%, in 2015 – per 46%. Reducing amount of automobile-pedestrian accidents is a result of community outreach, installation of controlled pedestrian crossings and construction of underground and over ground pedestrian crossings. In 2013, growth of motor vehicle accidents was caused by growth of population due to migration processes in the country. Consequently, this leads to necessity of increase in quantity of private vehicles, which complicates transport situation in city. Authorities of Astana manage to hold upcoming growth of road traffic accidents of public transport by taking measures involving improvements of the bus fleet: renewal of vehicles, rising driver competency, modernization of route network etc. Implementing wide range of actions reduced quantity of motor accidents to 3 accidents per year from 2013.

IV. Traffic Interactions Caused by Road Traffic Accidents

According to statistical data (seeTableII) non-compliance to the traffic rules for passing the intersection, or the pedestrian crossings were the most frequent road traffic offences, which were the causes of road traffic accidents. At the same time in this accidents the biggest quantity of people suffered: 38 injured and 6 deaths.

TABLE II
Traffic Infractions and Its Characteristic

Cause of road traffic accidents	Amount of accidents	Amount of injured	Amount of deaths
Noncompliance with order of passage, foul rules of crossroad passage	24	38	6
Foul rules of passenger transportation	23	23	0
Maneuvering	20	36	1
Passage across pedestrian crossing	21	19	2
Pedestrian's passage across carriageway in unauthorized places	16	13	3
Exceeding the speed limit which was established by rules or road signs	13	14	1
Other infractions of traffic rules	10	9	1
Noncompliance with distance	9	12	2
Noncompliance with control signals, road signs or marking	7	13	1
Foul rules of public transport's stop	7	7	0
Entrance to oncoming lane	7	9	2
Fatigue, sleeping behind the wheel	2	8	0
Driver was intoxicated	1	2	0
Total	160	203	19

The second frequent road traffic offence type was not following the rules of passenger transportation. Though no mortal accidents were caused. Number of injured people equals to 23.

The third frequent road traffic offence was maneuvering behavior, but it takes the second place in rate of injured (36 people). There was 1 case of death.

During the reported period traffic infractions, which were caused by neglecting the rules of passenger transportation, fouling rules of stop, fatigue, sleeping behind the wheel, driver's intoxication, were nonlethal.

In 65% of road traffic accidents cases road surface was evaluated as dry (seeFig. 4), i.e. the biggest part of accidents wasn't caused by icing, rain or other weather conditions.

In another 35% road surface was unfavorable. It could be thus taken as a factor that triggered the accident or influenced its impact.

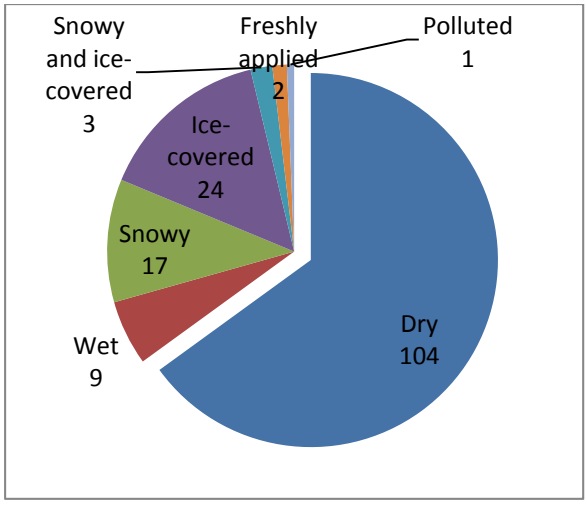

Fig. 4. Condition of road surface in road traffic accident.

V. Conclusion of Analysis of City Buses' Traffic Safety in Astana

Therefore, analysis of city buses traffic safety in Astana revealed that road traffic accidents with public transport to be more dangerous than accidents with personal cars. However, quantity of accidents and, consequently, amounts of injuries and deaths in road are reducing, despite the growing population of the city. It demonstrates results of work and complex of actions, which were performed by city authority and bus fleet. Also it shows results of community outreach among pedestrians and users of public transport. However, these methods don't fully solve problem of city buses traffic safety in Astana. Thus, nowadays development of technical methods for ensuring traffic safety of city buses is a pertinent issue.

VI. Patent Retrieval

An existing device is an on-board device which observes movement of vehicle. The goal of the device is to ensure the save vehicle movement. Its basic components are a control unit, GPS and speed sensor, and the others [3]. The disadvantage of this construction is that is provides low traffic safety of bus on route, which leads to road traffic accidents.

Another existing device is with automatic control of vehicle traffic safety, it is equipped with control unit, cruise control, GPS, speed sensor, and a sensor reading the red and yellow (orange) signals of traffic lights [4].The observed disadvantage of this construction is ensuring comparatively (to the suggested device) traffic safety of vehicles due to absence an element that would allow blocking the vehicle from driving under the conditions of decrease of driver level of vigilance, dangerous health condition, tiredness, sleepiness and so on. Driver vigilance is a very important for reliability of human-machine interaction. A comprehensive research is to be performed to determine the level of vigilance at which driving

the vehicle should not be allowed. One of such methods is experimental study of EEG signal of human brain [7] during experiments on driver simulators [8].

The closest to proposed technical solution at achieved technical result is device of automatic control of vehicle safety, which includes a control unit, cruise control, GPS, speed sensor, sensor of determine prohibiting signals of traffic lights [5]. However, this construction does not control situation when bus drivers faint unexpectedly (sudden loss of consciousness, blurred in the eyes and other cases in which driver isn't able to drive vehicle), which reduces safety of vehicles. Some of the developed technologies that are already in use, as well as more methods for following driver drowsiness and sleepiness are described here [9].

The disadvantages of constructions mentioned here wouldn't allow a desired improvement in traffic safety of city buses.

VII. Device of Controlling Traffic Safety of City Buses

As a result of work aiming to improve controlling city buses traffic safety, patent of the Republic of Kazakhstan for useful model was developed and its approval is pending [6]. The invention relates to transport techniques and can be used to increase traffic safety of public transport.

Problem which must be solved by the proposed invention is to enhance devices of city buses' traffic safety through installing alarm button of driver's vigilance in the bus cabin.

The expected result of proposed invention is increase of traffic safety of city buses. The supposed improvement is expected to be ensured by the enhanced existing technology (which includes a control unit, cruise control, GPS, speed sensors, sensor of determine prohibiting signals of traffic lights) with the introduced change, namely, the alarm button of driver vigilance installed in driver cabin.

Device of city buses traffic safety includes (seeFig. 5): control unit 1, GPS 2, speed sensors 3, sensor of determine prohibiting (red, yellow) signals of traffic lights 4, cruise control 5, and alarm button of driver's vigilance 6.

Device of city buses traffic safety operates in the following way (see Fig. 5): while driving the bus by driver is under general control of control unit 1, which controls speed limit and observes driver's vigilance through GPS connected to it 2, speed sensors 3, sensor of determine prohibiting signals of traffic lights 4; speed limitation of bus controlled by control unit according to route and compliance to traffic rules through speed sensor 3; if driver fails to follow the speed limit set by of control unit, speed sensor sends signal to cruise control 5, which blocks acceleration of bus; route of bus movement recorded in control unit's memory and, if driver drives off the route (determined by sensor 2), goes to oncoming lane (determined by sensor 2), exit at pavement (determined by sensor 2), drives during prohibiting signals of traffic lights (determined by sensor 4), alarm button of driver's vigilance 6 will be activated and it gives a signals (sound and light) into driver's cab; at this time control unit blocks bus acceleration with its following stop after 3 seconds through activation brake cylinders; mentioned situations can occur when driver's health deteriorates (sudden loss of consciousness, changed in eye behavior and other cases in which driver isn't able to drive vehicle); if driver is able to drive the bus, he can stop the process of blocking acceleration through pushing alarm button during 3 seconds since process was started.

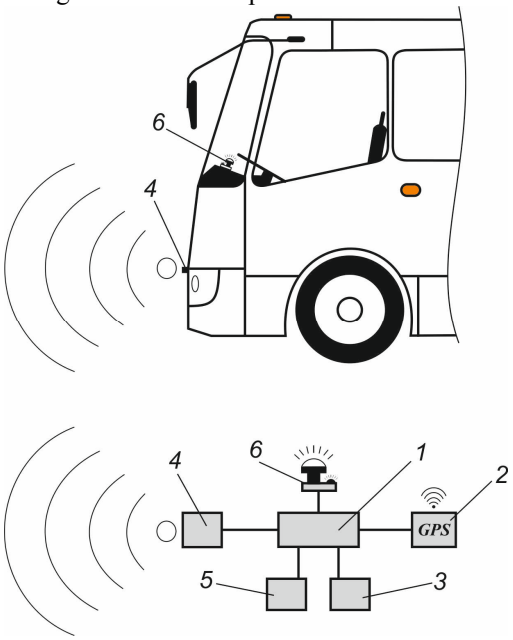

Fig. 5. Device of city buses traffic safety.

VIII. Conclusion

1) The developed device can effectively improve traffic safety of city buses and prevent road traffic accidents, reduce crashes, injuries, deaths on the road etc.

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