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Planning Method of the Traffic Safety Activities in Transport Systems Based On Risk Management

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Abstract: *The article is devoted to the problems of economic justification for planning activities to ensure the necessary level of safety in transport systems. For Ukraine this problem became practical in connection with the appearance of a special road safety fund. It is known to achieve the "absolute safety" level may be not enough all finance of the transport company. There is brief description of safety state estimation of rail transport using the ALARP method in this paper. Attention is focused on the need of constant monitoring of four factors that determine technological safety in transport. They are people, vehicles, traffic management, environment (P.V.TM.E.). The principle of "bottleneck" and the method of statistical regularity (authors – Valerii Samsonkin and Valerii Druz') were proposed for determining the financing vectors. Three options for determining the direction of funding are proposed. The first option is the way that use the insurance business. The second one is the formation of a safety matrix using the formula "P.V.TM.E.". The third option is to identify "bottlenecks" in the activities of the transport company. This is possible on the basis of the systematization of traffic accident statistics in the space of eight parameters and the maintenance of a special database. The database is constantly analyzed and updated. As a result of the step-by-step analysis of the cause-effect relationships that are presented in the database, the most significant preconditions (or preliminary reasons) of accident statistics are identified. The of safety activities is to reduce the influence of the most significant preconditions.*

Keywords: *ALARP method, analysis, event planning, risk management, systematization, traffic safety, accident statistics, transport system.*

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I. Introduction

In our time, the concept of "safety" is a fundamental category for people and humanity. The problem of safety took the main place in the activities of the state and society in civilized countries. Safety indicators are above financial indicators in the value hierarchy.

One of the authors, having recently visited the UK, drew attention to the fact that safety has become the main principle of the life of the British. Here are impressions only inside the cities:

- organized young children and policemen are dressed in high-visibility jackets;
- the covering of pedestrian crossings in different color than roads;
- traffic lights are duplicated twice or thrice;
- there are no long pedestrian crossings in roads;
- changes in rectilinear motion are indicated by numerous warnings;
- the public transport has bright colors;
- a house number and street names are marked on the houses;
- very expensive simulators are being created to train drivers of vehicles. The list can be continued.

Of course, this is a consequence of a high life level. And yet the ideas themselves arose on the basis of understanding the importance of safety in the society life.

After all, money could be spent otherwise!

1.1 Problem Statements.

It is unnecessary to talk about relevance of the safety problem in transport. This is the central and socially the most important problem of modern society. The company's TOP-management and staff are engaged in providing of the traffic safety. There are large funds for safety in the world. It should be noted that the Road Safety Fund was established also in Ukraine. It will be concentrate around 1.5 billion UAH. The question arises: how to spend it? On what activity and in what proportion should be distributed these fund?

The question is not idle and is decided in different companies by different ways. But the common in these decisions is a strong influence of the human factor. This is also true, because objective methods for determining the notion of a "correct" or optimal solution for allocating funds for safety have not been spread. This is not surprising, because there are a huge number of portions and components of transport systems that determine traffic safety.

According to the Information Bulletin of the World Health Organization in November 2016, "Road Traffic Injuries":

- about 1.25 million people die every year as a result of road accidents;
- road accidents is the leading cause of death for young people aged 15 – 29 years;
- more than 90% of road deaths occur in low- and middle-income countries, despite the fact that these countries account for about half of all vehicles in the world;
- half of the people dying on the roads are pedestrians, cyclists and motorcyclists;
- the forecasts say that if there are no operations, the number of road accidents will increase, and by 2030 they will be the seventh most important cause of death [1].

1.2 Purpose of the article.

Propose a methodology for forming (supporting) optimal solutions for planning the costs of ensuring the traffic safety of vehicles.

II. Literature Review

In their study, Z. Yaghoubour and others [2] (2016) focus on assessing the risk of public transport. The authors propose three criteria for compiling a tree of failures: a person, a vehicle and a road. Losses and losses on urban roads can be limited to preventive measures, such as a permanent road safety assessment.

Gintautas Bureika and others in the monograph [3] (2016) identify such components of security: technical aspect, interoperability, infrastructure and signaling, technical equipment on the roads, traffic management, vehicle maintenance, staff training. To assess the risk associated with infrastructure objects, G. Bureika [4] (2015) proposes a safety risk assessment model using the regression method for ranking and assessing the safety of crossings. The proposed model can be easily adapted to other types of infrastructure.

In Russia, standards for risk analysis of technical systems have been in force since 2002. Risk analysis is conducted to determine the likelihood and extent of adverse consequences. The risk analysis answers three questions: hazard identification, frequency analysis and impact analysis [5]. For the Russian railway transport, internal standards and recommendations for determining risks have been developed [6 – 7].

The article by Anjum Naweed and co-authors [8] (2013) suggests a method for identifying gaps and bottlenecks in the operational activities of railway transport. In the works of Samsonkin and Druz' [9] (2005), a method of statistical regularity for controlling traffic safety in transport is described. This monograph describes the basic principles for systematization of information of traffic safety violations. In the works of Samsonkin and Barchukov [10, 11, 12, 13] (2015, 2016), the issues of ensuring the traffic safety level in transport due to human factor monitoring were considered. In [14, 15] (2014, 2016) questions of application of the system approach at the analysis of technological activity of the transport company are considered.

In [16, 17, and 18] (2002, 2012, and 2015) issues of the strategy of technological safety due to introduction of risk management on the example of the Russian Railways were considered. This approach is based on the existing level of automation and management technology. It is applicable to transport systems of great complexity.

III. Materials and Research Methods

First of all, we will determine the main principles (theses) of the proposed method.

3.1 Unsubstantiated assertions (Facts not susceptible of proof).

Safety in rail transport has steadily enhanced over the years until 2013. However the number of accidents have increased in 2014 and 2015. On the contrary, the number of victims (killed or injured persons) continues its decline. For all participating countries EU-28, the most common type of accident with victims relates to accidents caused by rolling stock in motion or to those happening at level-crossings. In 2015, these two categories represented 97 % of the total number of victims and 99 % of the fatalities [19]. On 27.11.2012 Eurostat signed a Memorandum of Understanding with the European Rail Agency (ERA) whose role has significantly increased in the recent years regarding rail accidents data reporting [19]. In this part of article, we report the name and essence of the main statements, which are usefuled later in the text of the article. Here are presented both the generally accepted and author's statements.

- *Transport risk*: Transport accidents had existed, exist and will exist. They are a manifestation of an objectively existing transport risk. Finally we can not win the battle for absolute safety. Humanity can only reduce the level of danger to the objective risk.
- *Statistic Management*: Effective management of traffic safety requires the systematization of real accident statistics.
- *Principle of the contravention*: An information database about transport events should be taken as a basis of traffic safety. Disadvantages of technical means and technologies are most evident in transport events. While everything is going well, there are no shortcomings.
- *Safety can not be bought*.
- *Dynamics of the safety*: There is no panacea in the struggle to improve the level of traffic safety. It is necessary to constantly take into account the development of 4 traffic hazard factors (the "*P.V.TM.E.*" principle):
- Person (participants of traffic);
- Vehicles;
- Traffic management (management, control, infrastructure, technologies);
- Environment.

3.2 Models of estimating the amount of financing

1. Existing national or international (it is impossible to forget the theory of similarity and dimensions) standards.
2. Method ALARP (As Low As Reasonebly Practicable).
3. “Bottleneck” monitoring.

3.3 Method ALARP

This method is the method of risks management. In other words, it is the protection of material, financial and human resources from loss and destruction by the most cost-effective way.

The essence of the method ALARP is to identify 3 risk areas:

1 – Zone of standard (low) risk ($O < \rho < \rho_1$);

2 – Zone of reasonable risk / ALARP ($\rho_1 \le \rho \le \rho_2$);

3 – Zone of unreasonable risk ($\rho > \rho_2$).

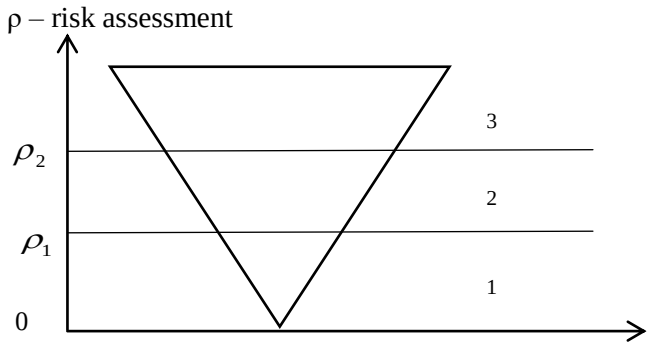

Figure 1: Risk assessment (Grade of risk)

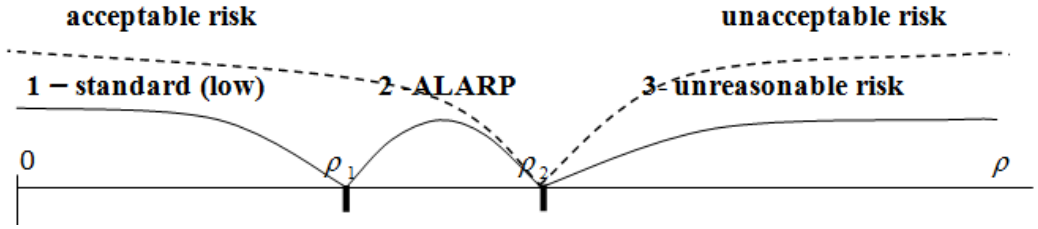

Figure 2: Grade of reasonable or unreasonable risk

For each method there should be a corresponding database not only about what happened (accidents), but also about almost happened incidents.

The way of manage risk in ALARP is the convert all risks into money:
- establishment of a general level of safety in the national system;
- economic principles are used to support (develop) the best solution;

- "the best" solution in economic efficiency is the "cost-benefit" ratio;
- limit value is the amount of money that someone agrees to spend for saving of human life (any amount of money for human life is wrong, but at least it's better than nothing).

Table 1: Definition of limit values ρ_1 and ρ_2 for railway companies

Country (Company)	Boundary value of the risks	
	ρ_1	ρ_2
Switzerland / The marginal value is 10 million swiss francs	Incident with frequency of 10^{-9} with the body count – 1000 per year	Incident with frequency of 10^{-3} with the body count – 10 per year
Netherlands		For the passenger – 0.15 deaths per billion passengers per year; For staff – 0.25 per year for 10,000 employers per year
United Kingdom	1 victim per 100,000 insured employers and passengers per year	1 victim per 10,000 insured workers and passengers per year

3.4 Decision-making on the financing of traffic safety

i. Profit Analysis for Decisions of traffic safety.

In many countries, insurance companies are involved in the financing of safety-related activities. This is the first direction in this research. Let's give an example of the approach of the insurance company to the issue of assessing the safety level and determining the amount of funding: "... There must be restrictions on profits. We believe that profits from risk reduction will increase by 4% per year. And then we will reduce the prices by 8%. And the effect of this will be that prices are reduced by 8%, and profits by 4%. The surplus value of the proposed boundaries can be collected for the duration of their operation".

ii. Creating of the Safety Matrix.

To determine the bottlenecks you need to systematize accident statistics. In this section (ii) it is proposed to use a safety matrix. This matrix is formed by analyzing the statistics of transport events in accordance with a certain classifier. An example of a safety matrix is shown in Table 2.

Table 2: The main sections (format) of the safety matrix

Risk group \ transport event	The factors of motion hazard				*TOTAL*:
	"P" (drivers, pedestrians, passengers)	"V" (equipments and vehicles)	"TM" (management, control, infrastructure, technologies)	"E"	
Collision					
Runover					
Fire					
Dangerous goods					
Overtopping					
Railroad crossing					
Defect of the railway road					
…….					
TOTAL:					

After filling the elements of the matrix, summation (TOTAL) is made for each row and column of the matrix. The management decision is made as follows: it is necessary to finance the safety factor (column), which has the maximum amount. Valuable information for the formation of a safety program is provided by those risk groups (rows) that have the largest amounts.

iii. Monitoring bottlenecks.

Section (iii) summarizes the main steps in identifying bottlenecks. The source of this information is the monograph of Samsonkin and Druz' (2005) [9].

Stage 1. All traffic accident statistics are systematized in the space of eight parameters

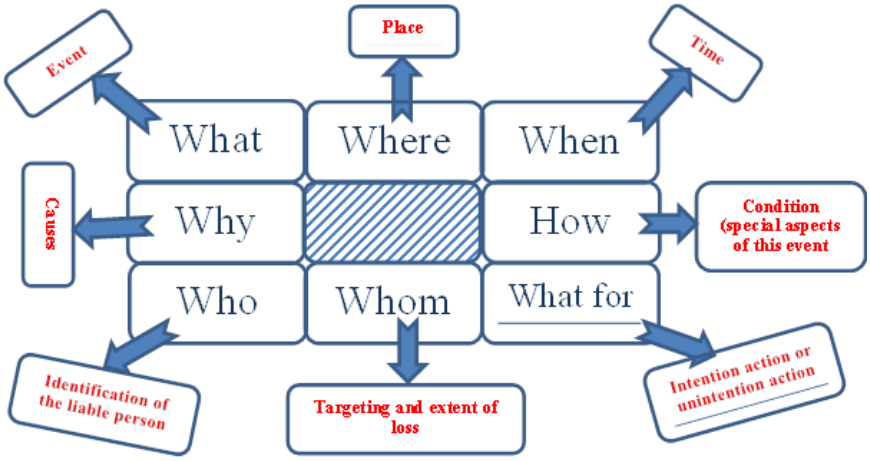

Figure 3: The space of eight parameters

Stage 2. Analysis of the dynamics:
a) variations of separate parameters (WHAT, WHERE, WHEN, ...) in time;
b) in the space of two or three parameters (WHAT – WHEN, WHY – WHERE, ...).
Stage 3. Identification of regularities:

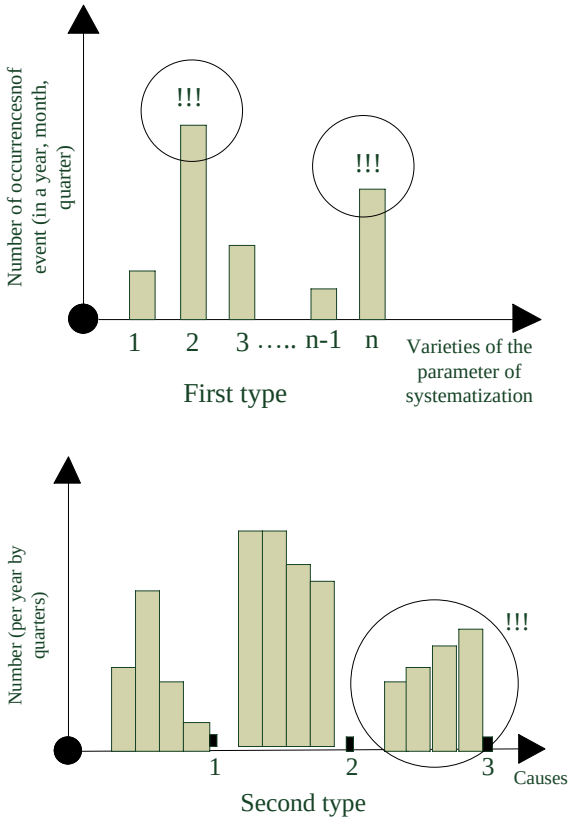

Figure 4: Two types of identification of regularities

IV. Conclusion and Recommendations

1. Safety should be managed in real time on the basis of information that is the same for the company or the state as a whole (accidents). The use of different sources (as is the case in Ukraine for road transport) leads to uncertainty and unreliability of the results.
2. To management (monitoring) of safety, should be used the ALARP method. At the same time, it is necessary to determine and legitimize the levels of standard and acceptable risk for a sufficiently long time. It is advisable to adopt the main principle of ALARP on transferring all losses from accidents to the financial sphere.
3. To develop "right" (effective) solutions for financing programs to maintain the required level of safety, can be used two methods:

A. Identification of funding directions by forming a safety matrix. This can be done in those countries and companies in which special classifiers of accidents and transport incidents are legalized.
B. Using the method of regularities identifying will provide an opportunity to identify the preconditions of transport events and make the process of allocating financial resources purposeful.
4. The application of the approach presented in the article makes it possible to measure and formally substantiate the financing of the most necessary transport safety measures at the moment.

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