

Directions of increase in safety of special motor transport operation in the city of Saint–Petersburg

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Abstract. The article considers the questions regarded to the expected approach to safety analysis of operation of special motor vehicles in conditions of urban environment of large modern city. As the key factor of the analysis, the authors consider the methodical basis of assessing possible consequences (economic, environmental and social risks) of occurrence of the emergency factors and the ways to increase the efficiency of functioning of special motor transport.

1. Introduction

The city is the main system of settlement and a structural way to organize the life processes of the modern society. The effectiveness and safety of urban processes are considerably characterized by the quality of transport provision, including various types of special vehicles [1].

The functioning of special vehicles is characterized by cooperation with public, freight and individual modes of transport comprising the city's unified transport system and is capable of creating factors of negative impact on the level of transport, social and environmental security.

2. Aim of the research

The present work is aimed at elaboration of an algorithm for assessing the risks of the operation of special vehicles, modeling the possible consequences of the development of an emergency during traffic on the road network of the city and finding ways to improve the efficiency and safety of the operation of special vehicles.

3. Problems of transport security in post-industrial cities (on the example of St. Petersburg)

An inappropriate geometric structure of street-road network of the modern postindustrial city (megalopolis) is a direct consequence of inexpedient topological layout of urban space, which was formed in the preindustrial and industrial periods of urban development. The transport system of St. Petersburg, especially of its historical part, has the following main problems and disadvantages [2]:

- lacking of metro network in some areas;
- unreliable and unstable work of surface public transport, poor technical condition of tramways, which is a hindrance to all vehicle traffic;
- congestion of the city center by individual motor transport, exhausting the capacity of bridges across the Neva river and a number of highways in the central areas and outskirts;
- lack of full-fledged bypasses for diversion of traffic bypassing the city center;



- unsatisfactory technical condition of the roads, which leads to premature deterioration of the vehicle fleet, lower speeds, increased accident rate;
- ineffective organization of urban transport: lack of advanced automated traffic management systems, disordered parking of individual vehicles.

Proceeding from the above said, it is reasonable to assume that the operation of various types of special vehicles (of any traffic intensity) can form risks for the functioning of the existing transport system of the city.

4. Methodological basis for risk assessment of special transport operation

The achievement of the required (normalized and/or prospective) indicators of transport (economic), environmental and social security is the main goal of operating special vehicles as part of the road transport system and is considered as a process managing risks and technical condition of vehicles and infrastructure facilities.

Figure 1 presents a general structural diagram oriented to a priori identification and modeling of hazards associated with assessing the possible consequences of the risks of an emergency situation during the movement of special vehicles on the road network of the city and determining the appropriate quantitative characteristics of the emergency factors.

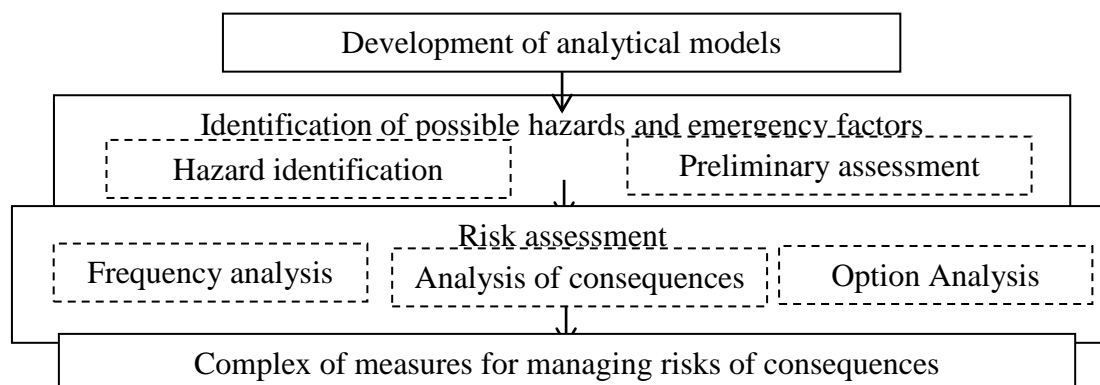


Figure 1. Structural diagram of modeling the risks of consequences of emergency situations

The use of the risk management algorithm in forecasting the possibilities of manifestation of emergency factors and consequences (emergency scenarios) of their development appears to be a promising method of ensuring the required (standard) level of safety in the operation of special vehicles [2,3]. The quantitative value of the risk, which is taken into account in analyzing the parameters of technological processes, indicators of functional efficiency and safety of operation of special vehicles, is called the design value of the risk. The value of the risk, which does not exceed a certain permissible severity level (function) of the consequences, is called a permissible (or acceptable) risk value [4].

The result of comparing the calculation of the permissible and design values of the risk of an accident of a process or an item of equipment is represented as:

$$R < [R]. \quad (1)$$

where: R is design value of risk;

$[R]$ is permissible (acceptable) value of risk.

The numerical value of the risks is determined by the following dependencies:

- for value $[R]$:

$$[R] = [p] \cdot F; \quad (2)$$

- for value R :

$$R = p \cdot F \quad (3)$$

where: F is the design value of the severity level (function) of consequences;

p — design value of probability of emergency factor occurrence;

$[p]$ — permissible probability of emergency factor occurrence.

To assess the risks of appearing of emergency factors, probability analysis, a systematic approach and mathematical modeling of negative consequences are provided.

5. Mathematical model of the analysis of the consequences of the emergency situation development during the movement of special vehicles on the street and road network of the city

Figure 2 shows the mathematical model of probability analysis of the development of an emergency situation involving special vehicles, presented as an event tree.

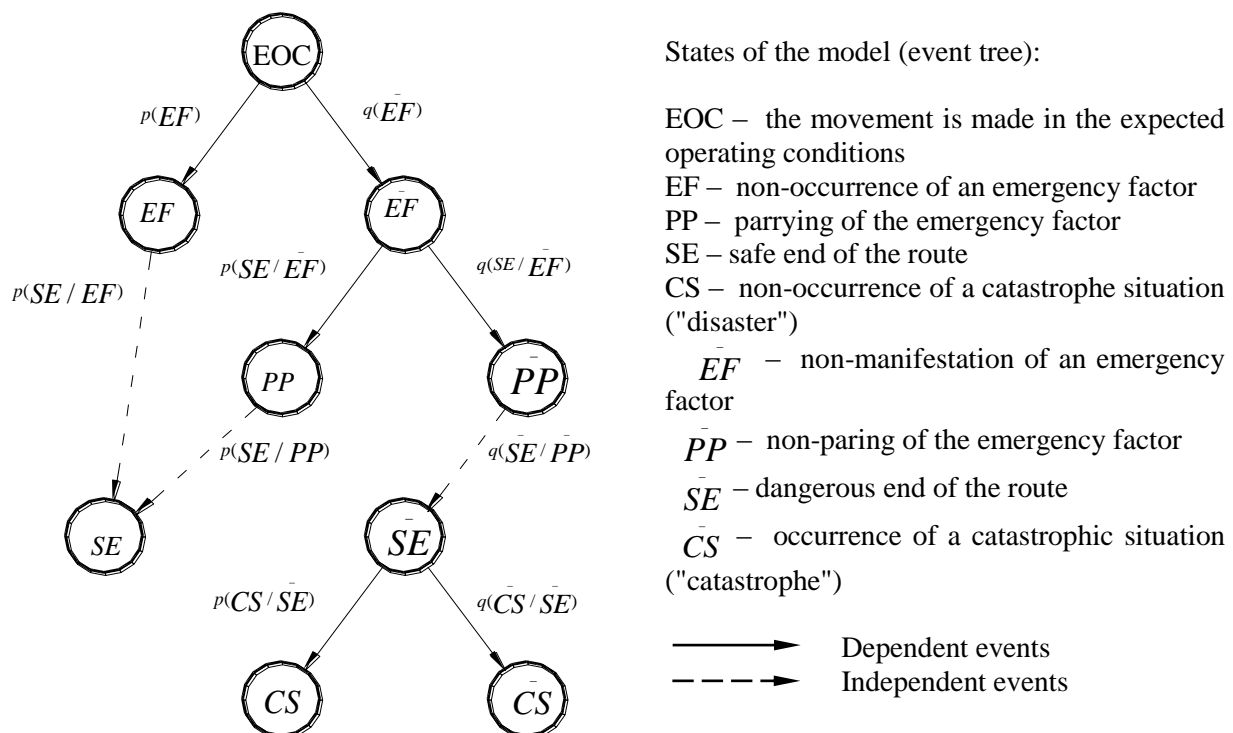


Figure 2. Model of the consequences of emergencies ("catastrophe" risks)

Using the mathematical model under consideration (Figure 2) it is possible to obtain a probabilistic criterion for assessing safety during the operation of special vehicles.

The event tree designed to analyze the sequence of the development of the emergency includes the initial state of the urban transport system that corresponds to the operating conditions (route of traffic and the condition of the transport infrastructure facilities used). To analyze the consequences (movement and possible emergencies of the type of special transport under consideration), several final dependent and independent states (or development paths) are taken, among which the following options are considered:

- successful end of the special transport movement along the established route;
- unsuccessful end of the special transport movement due to the manifestation of some emergency factor and the corresponding consequences of its manifestation in the formats: the offensive or the non-occurrence of a catastrophic situation (the state of "catastrophe") [5].

As an emergency factor that can lead to an emergency (see event \bar{EF} , Figure 2) are considered the following scenarios: the deviation of special transport from the envisaged route; loss (partial or complete) of spatial orientation and/or work capacity of the driver (personnel); reduction of the design (operational) characteristics of the vehicle; unsatisfactory technical condition of the used transport

infrastructure facility; manifestation of an accidental negative (emergency) factor. The possibility (or probability) of parrying an alarm factor with passive and active safety measures (technical devices and skilled actions of the driver and / or vehicle personnel) is assessed by the probability of realizing the accepted (possible) final states (Figure 2) and forms a quantitative safety assessment of the type in question. Preventing the transition to an irreversible (or catastrophic) state requires high professional skill of the personnel and an adequate state of the transport system objects that ensure the operation of special vehicles.

6. Results of the study and Conclusion

The result of the present investigation is the concept of permissible and design values of risks arising from the operation of special vehicles and a mathematical model for assessing the development of emergency situations with possible manifestation of negative factors.

The application of the risk management algorithm is a promising direction of activity aimed at increasing the level of safety in the operation of special vehicles in the modern urban environment.

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