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Development of an Approach to Analysing Regional Road Traffic Accident Rates

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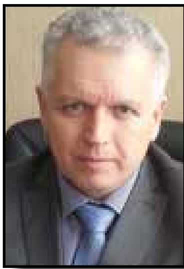

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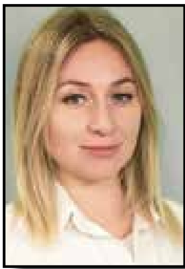

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ABSTRACT

The article examines the state of road traffic safety (RTS) in the Russian Federation for the 2012–2022 long-term period. The study has identified the main directions in the considered area, described the results of the on-going Safe High-Quality Roads national project, as well as analysed current federal projects, namely, the target indicators of the Road Traffic Safety federal project and the promising ways to achieve them.

To analyse regional road traffic accident rates, a necessity has been revealed to develop an approach based on a Big Data tool for processing large amounts of primary data. It has been also revealed that the available data presented in publicly available statistical databases do not allow us to fully assess the causes that result in road traffic accidents (RTA). Despite this, considering the available resources, namely the data presented in analytical information systems on the balance sheet of departmental organisations, it is possible to assess the RTA rate for an entire region, considering rates of RTAs without casualties, which are determined by a significantly larger volume of data. In this case, it is possible to carry out detailed specification of the causes and conditions of accidents, which allows for implementation of an integrated approach in the considered area.

In this regard, the main objective of the study is to develop an approach to analysing RTA rates in a region. The main methods for achieving this objective are mathematical and statistical analysis. Public databases, as well as the resources of a specialised automated information management system (AIMS), were used as research materials. The research has resulted in proposing an intelligent method of data analysis, which will subsequently make it possible to more effectively make decisions to increase road traffic safety, including through implementation of control and supervisory activity of the relevant authorities.

Keywords: *road traffic safety, primary data analysis, road traffic accident rate, decision making, intelligent method, complex search queries.*

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INTRODUCTION

Ensuring road traffic safety (RTS) is one of the conditions for achieving national development goals. To achieve the relevant target indicators, several strategic planning documents have been developed and are being implemented. Thus, the Strategy of Road Traffic Safety in the Russian Federation for 2018–2024[1], approved by the Order of the Government of the Russian Federation of January 8, 2018, No. 1-r, is the basis for development and implementation of state policy in the field of road traffic safety at the federal, regional, municipal and intersectoral levels. This Strategy includes the results of an analysis of the state of road traffic safety in the Russian Federation, as well as a set of system measures developed on their basis and aimed at increasing road traffic safety and reducing road traffic mortality.

One of the main directions for implementation of the Transport Strategy of the Russian Federation until 2030 with a forecast for the period until 2035, approved by the Order of the Government of the Russian Federation of November 27, 2021, No. 3363-r[2, 3] is to create conditions for improving the quality of life and health of citizens, as well as to implement potential of transport through rapid development of transport infrastructure and enhancement of access to safe and high-quality transport services. In this context, one of the fundamental areas of implementation of this orientation will be ensuring road traffic safety.

Over the previous period, road traffic safety in the entire country has improved, which is confirmed by annually recorded RTA rates, presented, among other things, on electronic resources, i.e., statistical databases[4, 5] and in the annual report of the Scientific Centre for Road Traffic Safety of the Ministry of Interior of the Russian Federation (SC RTS)[6] [1]. There is a decrease in RTA rates in terms of the total number of incidents with deaths and injuries (Pic. 1). Analysing the eleven-year period under consideration – from 2012 to 2022, it can be noted that on average the total number of incidents with deaths and injuries in the country has decreased annually by 4,5 %, the number of deaths – by 6,5 % and the number of injuries – by 5,5 % [2; 3].

The observed positive dynamics of reduction in the indicators' values under consideration (Pic. 1), especially since 2018, is largely due to implementation of a new approach to reducing road mortality – the concept of striving for zero fatality, the ideological basis of which can be deemed to be the Swedish concept of Vision Zero [4–8]. In accordance with this concept, it is necessary to ensure the safety of the road transport system, because a person (driver) as one of the links in the «driver – car – road – environment» (DCRE) system can commit an error. In this case, the components of the system must ensure safety, i.e., to prevent or minimise the severity of the consequences of an error. Considering this concept and a relatively new approach to the issue of road traffic safety, new projects aimed at improving safety of the road transport system have been at the legislative level. The approach is based on the Safe High-Quality Roads national project[7] [9; 10]. The project includes the construction of new and reconstruction of existing roads, bringing them to conditions conform to standards. Within the framework of this national project, federal projects «Regional and local road network», «Road traffic safety», «Development of public transport», «System-wide measures for development of road infrastructure», «Highways of the Ministry of Defence of Russia» and «Development of the federal highway network» are being implemented (Pic. 2).

Achievement of the goals of the Road Traffic Safety federal project is assessed by the main indicators «satisfaction with road traffic safety»

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[1] Order of the Government of the Russian Federation dated January 8, 2018, N 1-r «On approval of the Strategy of Road Traffic Safety in the Russian Federation for 2018–2024».

[2] Transport strategy of the Russian Federation for the period until 2030 with a forecast for the period until 2035, approved. by the Order of the Government of the Russian Federation of November 27, 2021, No. 3363-r.

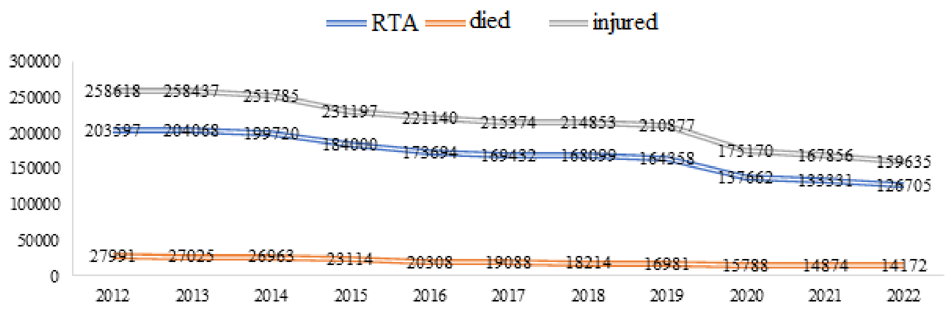
[3] Sokolov, M. Transport strategy of Russia for the period until 2030. *Transportanya strategia – XXI vek*, 2013, Iss. 22, pp. 7–9 EDN: VEEFDR.

[4] Road traffic safety indicators [Electronic resource]: http://stat.gibdd.ru/. Last accessed 05.09.2023.

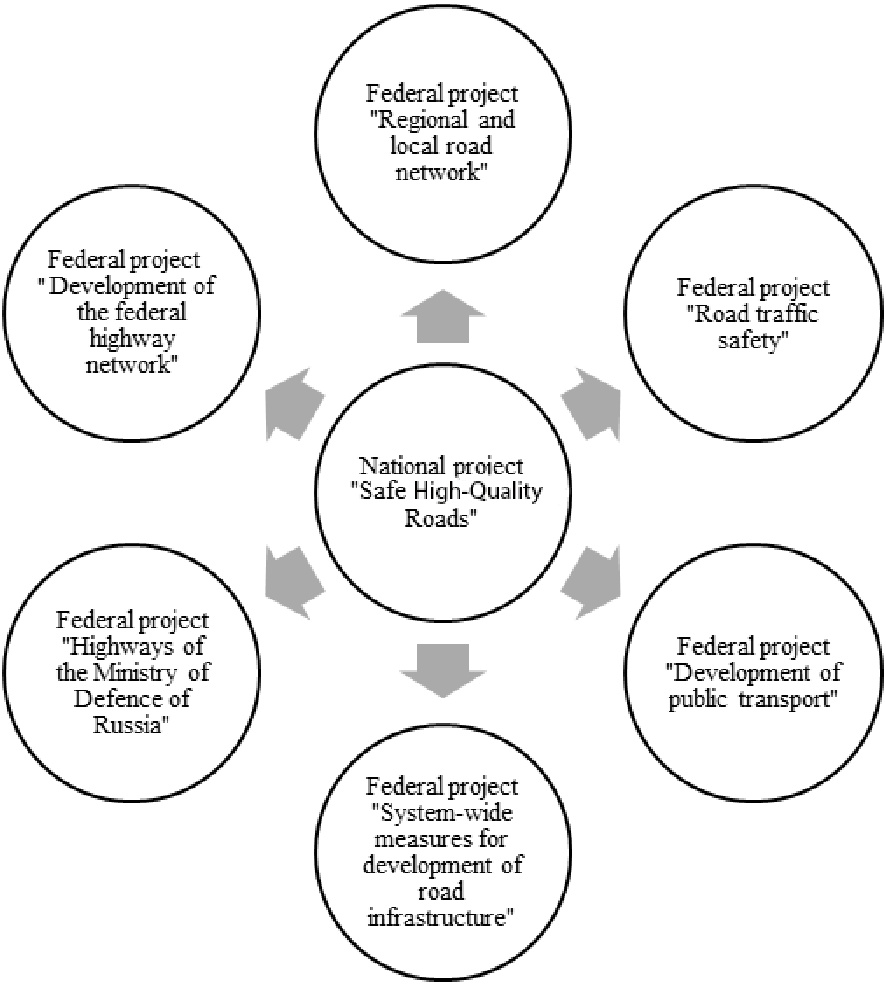
[5] Federal State Statistics Service [Electronic resource]: https://rosstat.gov.ru/. Last accessed 05.09.2023.

[6] Road traffic accident rate in the Russian Federation 2022. Information and analytical review report. Moscow, Federal budget enterprise «NC Road Traffic Safety Centre of the Ministry of Interior of Russia», 2023, 150 p. [Electronic resource]: https://media.mvd.ru/files/embed/5055549. Last accessed 10.08.2023.

[7] 16,5 thou km of Roads were Repaired in 2021 in Russia within the Framework of National Safe High-Quality Roads Project. *World of Transport and Transportation*, 2022, Vol. 20, Iss. 1 (98), P. 66.



Pic. 1. Main indicators of RTA rate in the Russian Federation for the period 2012–2022 [prepared by the authors based on an analysis of sources 4, 5, 6].



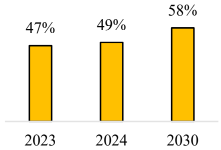
Pic. 2. Structural diagram of the main components of the Safe Quality Roads national project [prepared by the authors based on the analysis of source] [8].

and «number of deaths in road traffic accidents per 10 thousand vehicles», as well as by an additional indicator «number of deaths in road traffic accidents per 100 thousand population» (Pic. 3 *a-c*)[8].

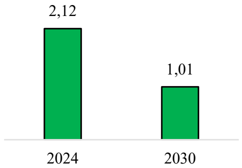
[8] Website of Safe Quality Roads national project [Electronic resource]: https://bkdrf.ru/about/SafetyRoads.

PROBLEM STATEMENT, OBJECTIVE, METHODS AND MATERIALS

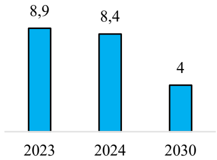
To achieve the target values of indicators, it is first necessary to assess the situation in three main directions – «as it was», «at the moment» and in the «future», using different periods and parameters for assessment. An accurate



a) satisfaction with road traffic safety



b) number of deaths in road traffic accidents per 10 thousand vehicles



c) number of deaths in road traffic accidents per 100 thousand population

Pic. 3. Indicators of the Road Traffic Safety federal project [prepared by the authors based on analysis of source [8]].

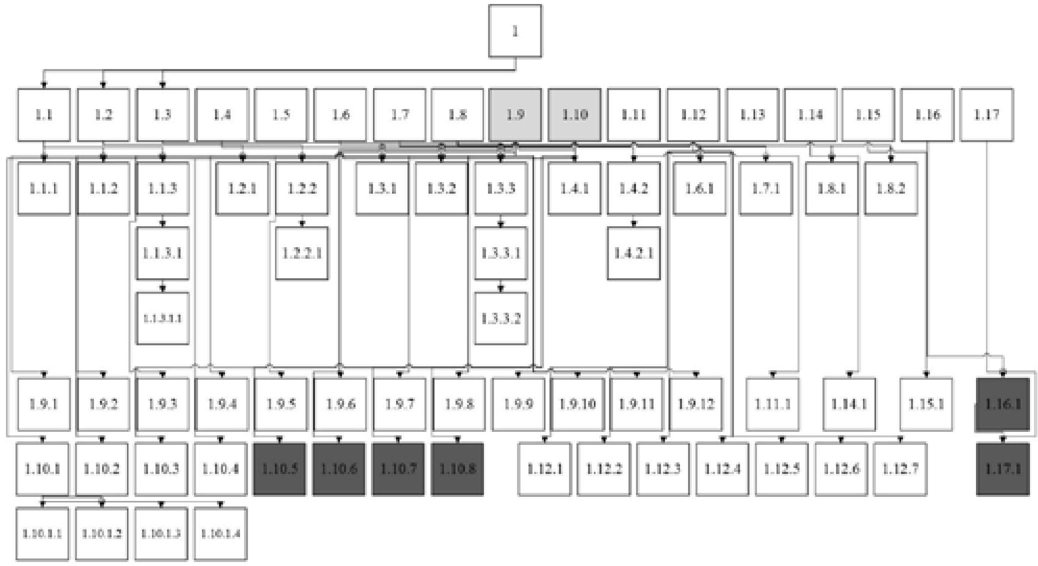
assessment allows forecasting changes in the situation and determining the main implementation directions to change the situation. Considering the available information analysis tool which is Big Data, it was necessary to develop an approach to the analysis of road traffic accident indicators, including those not presented in official sources, which determined the main *objective* of the conducted study.

When working with accident rates, to perform analytical procedures, a specialist directly involved in the scientific specifics of the activity has to work with official sources – statistical databases containing data on the number of road traffic accidents with fatalities and injuries. It should be noted that in official sources the information is structured, which allows sampling according to various indicators. In conformity with the DCRE system [11–13] which is laid into foundation of scientific research in the field of road traffic safety, the presented data can be attributed to the description of one of the elements or their connections. Working in the database is carried out by specifying simple search queries that allow us to analyse one indicator. For example, considering such an element of the DCRE system as «driver», it is possible to consider in detail the components of such an indicator as «Road traffic accidents and victims due to violation of traffic rules by vehicle drivers», which includes 16 subcategories or classifications of the indicator under consideration. It should be noted that some classifications include several components, which creates a complex hierarchical structure, presented as an example for the indicator in question (Pic. 4).

In the presented structure (Pic. 4), subsections that are not actually represented in the official database have a light gray fill, since it is impossible to set a search query for them, but for constructing the diagram they were included as a mandatory element that allows carry out classification. Blocks that were not presented in official sources before 01.01.2022 are filled in a dark gray shade but have been introduced since the mentioned date. It should be noted that for these indicators it is impossible to establish values before the specified date, due to the fact that they were previously not taken into account.

Analysis of the chart presented as a structure (Pic. 4) shows that when using the analytical research *method* and possible types of such a method – statistics, forecasting, data mining, optimisation, etc., it is possible to use only the first method – statistics. In this case, it is possible to implement only one direction, this is assessment of changes in dynamics, but considering the determined target indicators when working with road traffic accident data, it is necessary to develop a new approach to analysis and, accordingly, special tools that will allow implementation of intelligent data analysis and subsequently more effective decision-making to improve road traffic safety, including through implementation of control and supervisory activity of the relevant authorities. Thus, at this stage, the *analytical* research *method* was identified as suitable.

The main materials used are statistical databases. Following the analysis of available tools for development of the databases under consideration, special attention was paid to the process of primary processing of data carried out at the scene of RTA. It should be noted that today the process of entering basic information necessary for subsequent work is carried out in the automated information management system of the State Road Traffic Safety Inspectorate (AIMS SRTSI) [14–16]. The forms of the system are conventionally divided into two groups – necessary and sufficient ones. As part of the study, special attention was paid to data that includes the necessary information for



Pic. 4. Chart of the components of the indicator «Road traffic accidents and victims due to violation of traffic rules by vehicle drivers» [performed by the authors]:

1 – road traffic accidents and victims due to violation of traffic rules by vehicle drivers – total; 1.1 – by drivers of passenger cars; 1.1.1 – drivers were intoxicated; 1.1.2 – carriers have a license for transportation activities; 1.1.3 – vehicles are owned by individuals; 1.1.3.1 – drivers were intoxicated; 1.1.3.1.1 – carriers have a license for transportation activities; 1.2 – by truck drivers; 1.2.1 – drivers were intoxicated; 1.2.2 – vehicles are owned by individuals; 1.2.2.1 – drivers were intoxicated; 1.3 – by bus drivers; 1.3.1 – drivers were intoxicated; 1.3.2 – carriers have a license for transportation activities; 1.3.3 – vehicles are owned by individuals; 1.3.3.1 – drivers were intoxicated; 1.3.3.2 – carriers have a license for transportation activities; 1.4 – by motorcycle drivers; 1.4.1 – drivers were intoxicated; 1.4.2 – vehicles are owned by individuals; 1.4.2.1 – drivers were intoxicated; 1.5 – by drivers of mopeds and equivalent vehicles; 1.6 – by tram drivers; 1.6.1 – drivers were intoxicated; 1.7 – trolleybus drivers; 1.7.1 – drivers were intoxicated; 1.8 – by drivers of tractors and other self-propelled machinery; 1.8.1 – drivers were intoxicated; 1.8.2 – vehicles are owned by individuals; 1.9 – age of drivers; 1.9.1 – drivers whose age is from 0 to 10 years; 1.9.2 – drivers whose age is from 10 to 14 years; 1.9.3 – drivers whose age is from 14 to 16 years; 1.9.4 – drivers whose age is from 16 to 18 years; 1.9.5 – drivers whose age is from 18 to 21 years; 1.9.6 – drivers whose age is from 21 to 25 years; 1.9.7 – drivers whose age is from 25 to 30 years; 1.9.8 – drivers whose age is from 30 to 40 years; 1.9.9. – drivers whose age is from 40 to 50 years; 1.9.10 – drivers whose age is from 50 to 60 years; 1.9.11 – drivers whose age is from 60 to 70 years; 1.9.12 – drivers whose age is over 70 years; 1.10 – experience; 1.10.1 – with driving experience of up to 2 years; 1.10.1.1 – in a state of intoxication; 1.10.1.2 – those who refused to undergo a medical examination; 1.10.1.3 – by male drivers; 1.10.1.4 – by female drivers; 1.10.2 – with driving experience from 2 to 5 years; 1.10.3 – with driving experience from 5 to 10 years; 1.10.4 – with driving experience from 10 to 15 years; 1.10.5 – with driving experience from 15 to 20 years; 1.10.6 – with driving experience from 20 to 25 years; 1.10.7 – with driving experience from 25 to 30 years; 1.10.8 – with driving experience of over 30 years; 1.11 – by drivers who are citizens of foreign countries; 1.11.1 – by drivers who are citizens of CIS countries; 1.12 – drivers were intoxicated; 1.12.1 – road traffic accidents that occurred on Mondays; 1.12.2 – road traffic accidents that occurred on Tuesdays; 1.12.3 – road traffic accidents that occurred on Wednesdays; 1.12.4 – road traffic accidents that occurred on Thursdays; 1.12.5 – road traffic accidents that occurred on Fridays; 1.12.6 – road traffic accidents that occurred on Saturdays; 1.12.7 – road traffic accidents that occurred on Sundays; 1.13 – drivers refused to undergo a medical examination; 1.14 – vehicles of individuals; 1.14.1 – drivers were intoxicated; 1.15 – vehicles of legal entities; 1.15.1 – drivers were intoxicated; 1.16 – by male drivers; 1.16.1 – drivers were intoxicated; 1.17 – by female drivers; 1.17.1 – the drivers were intoxicated.

generating RTA report forms. One of the main positive aspects of working in this system is availability of more complete information about the RTA, the ability to set complex search queries, as well as availability of information on the number of accidents without injuries. According to the working hypothesis of the study, which assumes that to make a decision on reducing the number of accidents in a region, it is necessary, together with RTA rates with casualties, to assess RTA rates without casualties, this information is important and necessary for the analysis of RTA rates and, accordingly, as well as it a specific tool for developing decision-making actions. Thus, the main materials used in this study were statistical databases and AIMS SRTSI.

RESULTS

To develop an approach to assessing RTA rates in accordance with the sections of AIMS SRTSI, complex search queries were formulated (Table 1) that allow to obtain data on the number of RTAs with and without injuries and based on which to further perform an analysis and compare the results obtained. It should be noted that the structure of the system includes seven main sections:

Table 1

Formulated complex search queries [prepared by the authors]

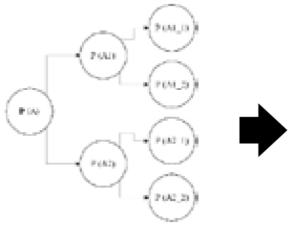
Query name		General formulation of a search query
«Query 1»		
Number of RTA in IL	with victims	number of RTA in IL with victims
Number of RTA in IL	without victims	number of RTA in IL without victims
«Query 2»		
Number of RTA OL	with victims	number of RTA OL with victims
Number of RTA OL	without victims	number of RTA OL without victims
«Query 3»		
Number of RTA in IL – section of the road	with victims	number of RTA on the section of road in IL with victims
Number of RTA in IL – section of the road	without victims	number of RTA on the section of road in IL without victims
«Query 4»		
Number of RTA in IL–CPC	with victims	number of RTA at CPC in IL with victims
Number of RTA in IL–CPC	without victims	number of RTA at CPC in IL without victims
«Query 5»		
Number of RTA in IL-UPC	with victims	number of RTA at UPC in IL with victims
Number of RTA in IL-UPC	without victims	number of RTA at UPC in IL without victims
«Query 6»		
Number of RTA in IL–CI	with victims	number of RTA at CI in IL with victims
Number of RTA in IL–CI	without victims	number of RTA at CI in IL without victims
«Query 7»		
Number of RTA in IL-UCI	with victims	number of RTA at UCI in IL with victims
Number of RTA in IL-UCI	without victims	number of RTA at UCI in IL without victims
«Query 8»		
Number of RTA in IL-UCPR	with victims	number of RTA at UCPR in IL with victims
Number of RTA in IL-UCPR	without victims	number of RTA at UCPR in IL without victims
«Query 9»		
Number of RTA in IL-UIR	with victims	number of RTA at UIR in IL with victims
Number of RTA in IL-UIR	without victims	number of RTA at UIR in IL without victims

Notes: RTA – road traffic accident; IL – inhabited localities; OL – outside inhabited localities; section of the road – the section where traffic intensity and number of vehicles do not change more than by 15 % each; CPC – controlled pedestrian crossing (pedestrian light controlled crossing); UPC – uncontrolled pedestrian crossing; CI – controlled intersection (traffic light controlled intersection); UCI – uncontrolled intersection (intersection of equivalent roads, i. e. of roads where no road is a priority road); UCPR – uncontrolled intersection of roads where there is a priority road; UIR – uncontrolled intersection with a roundabout.

1. General information.
2. Street-and-road network and RTA sketch.
3. Road conditions.
4. Actions at the scene of RTA.
5. Information about the vehicles involved in RTA.
6. Information about participants in RTA.
7. Additional information.

Each of the presented sections includes a sufficient list of parameters that allows, for the period under review, to carry out a primary analysis of the causes and conditions for occurrence of RTA in a region. Of course, the occurrence of RTA is influenced by many factors, which requires an in-depth analysis, but within the framework of this study it is proposed to develop a mechanism for initial assessment of existing indicators to carry out further analysis of the identified dominant search request, for example, according to the «street-and-road network object» indicator.

Despite the fairly wide range of information presented in publicly available information



Pic. 5. Illustration of the components of overall statistical probability [prepared by the authors].

Table 2

Obtained probability values [developed by the authors]

Year	2016	2017	2018	2019	2020	2021	2022
P (A)	1	1	1	1	1	1	1
P (A1)	0,97	0,97	0,95	0,97	0,97	0,96	0,95
P (A2)	0,03	0,03	0,05	0,03	0,03	0,04	0,05
P (A1_1)	0,05	0,06	0,07	0,08	0,08	0,07	0,06
P (A1_2)	0,92	0,91	0,89	0,89	0,89	0,89	0,89
P (A2_1)	0,02	0,02	0,02	0,02	0,02	0,02	0,02
P (A2_2)	0,01	0,01	0,03	0,01	0,02	0,02	0,03

resources, the main disadvantages of their use include the lack of detailed data, for example, classification by «street-and-road network objects» and the lack of data on the number of road traffic accidents without casualties regarding all the indicators. It is also worth noting a feature of AIMS SRTSI, i. e., the inaccessibility of the system for users not belonging to departmental structures, for example, researchers in the field of road traffic safety. However, despite the existing number of problems, based on the official request, quantitative data were obtained on the formulated requests (Table 1), which made it possible to analyse the data received.

The first priority for developing the approach is the transition to relative indicators – probabilistic values of occurrence of an event. It should be noted that work in the probabilistic field makes it possible to assess the most significant values that have the greatest «weight» regarding the statistical probability of occurrence of events, which makes it possible to plan basic measures to reduce RTA rates for a specific constituent entity of the Russian Federation.

As an example, this study examines RTA rates for Belgorod region for the period 2016–2022, obtained based on setting formulated search queries (Table 1) in AIMS SRTSI system. At the initial stage, to move into the area of probabilistic values, the work was carried out according to «query 1» and «query 2», where it was accepted that P (A) is the overall statistical probability of an RTA, determined using the formula:

$$P(A) = P(A1) + P(A2), \quad (1)$$

where P(A) is overall statistical probability of occurrence of an event (RTA);

P(A1) – statistical probability of occurrence of a RTA in an inhabited locality;

P(A2) – statistical probability of RTA outside inhabited locality.

$$P(A1) = P(A1\_1) + P(A1\_2), \quad (2)$$

where P(A1) – statistical probability of a RTA in an inhabited locality;

P(A1_1) – statistical probability of RTA with victims in an inhabited locality;

P(A1_2) – statistical probability of RTA without victims in an inhabited locality.

$$P(A2) = P(A2\_1) + P(A2\_2), \quad (3)$$

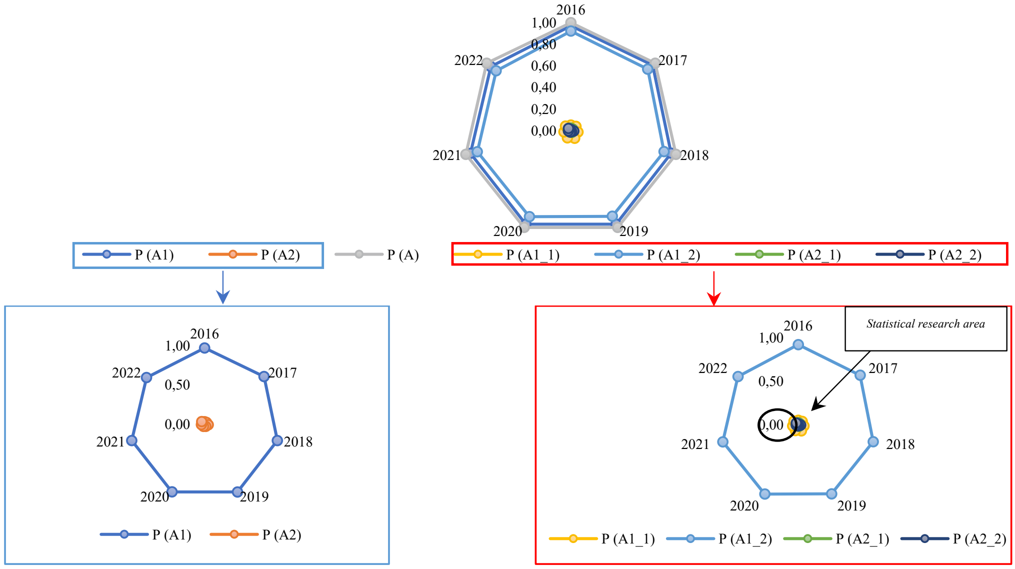
where P(A2) – statistical probability of RTA outside inhabited locality;

P(A2_1) – statistical probability of RTA with victims outside inhabited locality;

P(A2_2) – statistical probability of RTA without victims outside inhabited locality.

Graphically, the relationship between the indicators has the form shown in Pic. 5. As a result of the calculation, data on the established probabilities were obtained, which are clearly presented in Table 2.

The results obtained make it possible to present the data in a conditional probability field, which clearly reflects that most events occur in inhabited localities. When compared with absolute indicators' values, it is worth noting that, despite the decrease in overall quantitative values of indicators, the situation in the region under consideration for the period under review remains unchanged (Pic. 6). Further analysis shows that the largest number of RTA in inhabited localities, which varies from 0,89 to 0,92, occurs without victims, while the statistical probability of RTA with victims varies from 0,05 to 0,08. Conventionally, during the period under review in Belgorod region, of the total number of accidents occurring annually, an average of approximately 7 % of RTA causes fatalities or injuries. According to regulations and the concept of «zero vision», in the long term, especially such events are given special attention, since because of them harm was caused to human health or life. However, considering the results obtained, constant monitoring of changes in



Pic. 6. General view of the area of probability of occurrence of events [developed by the authors].

data characterising the number of RTA without victims is also required.

The data provided in Pic. 6 shows that in the entire region, the situation with statistical distribution of accidents remains unchanged. Due to the focus of the road safety policy on reducing the number of fatalities, special attention in this study is paid to such components of the probability area as P(A1_1) and P(A2_1), which are highlighted in the black segment.

To analyse an established strategically important segment, it is proposed to take the P(A1) indicator as a general indicator of the statistical probability of occurrence of events, equating it to the new P(B) indicator, which allows us to move into a new probabilistic area:

$$P(A1) = P(B). \quad (4)$$

In this case, special attention will be paid to all the accidents that occurred in inhabited localities, considering quantitative values of RTA indicators with and without victims. To continue further research, search queries 3–9 (Table 1) were considered, making it possible to identify the street-and-road network objects most susceptible to RTA across the region under consideration. In this case, the general mathematical form for determining the probability of occurrence of events in inhabited localities has the form:

$$P(B) = P(B1) + P(B2) + P(B3) + P(B4) + \\ + P(B5) + P(B6) + P(B7) + P(B8), \quad (5)$$

where P(B) – statistical probability of occurrence of RTA in an inhabited locality;

P(B1) – statistical probability of occurrence of RTA on the section of the road;

P(B2) – statistical probability of occurrence of RTA at a controlled pedestrian crossing;

P(B3) – statistical probability of occurrence of RTA at an uncontrolled pedestrian crossing;

P(B4) – statistical probability of occurrence of RTA at a controlled intersection;

P(Б5) – statistical probability of occurrence of RTA at an uncontrolled intersection of roads without priority road;

P(B6) – statistical probability of occurrence of RTA at an uncontrolled intersection of roads with a priority road;

P(B7) – statistical probability of occurrence of RTA at an uncontrolled intersection with a roundabout;

P(B8) – statistical probability of occurrence of RTA at other street-and-road network objects.

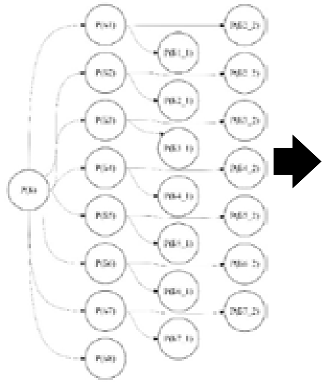
$$P(B1) = P(B1\_1) + P(B1\_2), \quad (6)$$

where P(B1_1) – statistical probability of occurrence RTA with victims on the section of the road in an inhabited locality;

P(B1_2) – statistical probability of RTA without victims on the section of the road in an inhabited locality.

$$P(B2) = P(B2\_1) + P(B2\_2), \quad (7)$$

where P(B2_1) – statistical probability of occurrence of RTA with victims at a controlled pedestrian crossing in an inhabited locality;



Pic. 7. Image of the components of the probability of RTA in populated areas P(B) for certain street-road network objects. [developed by the authors].

Table 3

Obtained probability values for P(B) [developed by the authors]

Year	2016	2017	2018	2019	2020	2021	2022
P(B)	1,000	1,000	1,000	1,000	1,000	1,000	1,000
P(B1)	0,111	0,085	0,080	0,088	0,118	0,121	0,117
P(B1_1)	0,007	0,008	0,013	0,013	0,016	0,012	0,014
P(B1_2)	0,104	0,077	0,068	0,075	0,102	0,109	0,104
P(B2)	0,007	0,007	0,006	0,010	0,013	0,015	0,014
P(B2_1)	0,004	0,003	0,003	0,004	0,004	0,003	0,005
P(B2_2)	0,003	0,004	0,003	0,005	0,009	0,011	0,010
P(B3)	0,026	0,025	0,025	0,025	0,032	0,031	0,023
P(B3_1)	0,009	0,012	0,012	0,013	0,014	0,013	0,013
P(B3_2)	0,016	0,013	0,013	0,012	0,018	0,018	0,011
P(B4)	0,050	0,059	0,059	0,066	0,076	0,073	0,066
P(B4_1)	0,006	0,006	0,007	0,010	0,010	0,007	0,008
P(B4_2)	0,044	0,053	0,052	0,055	0,066	0,066	0,059
P(B5)	0,010	0,010	0,008	0,011	0,016	0,012	0,013
P(B5_1)	0,001	0,001	0,001	0,002	0,003	0,001	0,001
P(B5_2)	0,009	0,009	0,007	0,009	0,013	0,011	0,011
P(B6)	0,070	0,076	0,073	0,102	0,121	0,118	0,103
P(B6_1)	0,008	0,010	0,012	0,019	0,017	0,018	0,015
P(B6_2)	0,062	0,066	0,061	0,083	0,103	0,100	0,088
P(B7)	0,008	0,014	0,015	0,018	0,014	0,014	0,009
P(B7_1)	0,001	0,001	0,000	0,002	0,002	0,001	0,001
P(Б7_2)	0,007	0,013	0,015	0,016	0,012	0,013	0,008

P(Б2_2) – statistical probability of occurrence pf RTA without victims at a controlled pedestrian crossing in an inhabited locality.

P(B3) = P(B3_1) + P(B3_2), (8)

where P(B3_1) – statistical probability of occurrence of RTA with victims at an uncontrolled pedestrian crossing in an inhabited locality;

P(B3_2) – statistical probability of occurrence of RTA without victims at an uncontrolled pedestrian crossing in an inhabited locality.

P(B4) = P(B4_1) + P(B4_2), (9)

where P(B4_1) – statistical probability of occurrence of RTA with victims at a controlled intersection in an inhabited locality;

P(B4_2) – statistical probability of occurrence of RTA without victims at a controlled intersection in an inhabited locality.

P(B5) = P(B5_1) + P(B5_2), (10)

where P(B5_1) – statistical probability of occurrence of RTA with victims at an uncontrolled intersection of equivalent roads (of roads where no road is a priority road) in an inhabited locality;

P(B5_2) – statistical probability of occurrence of RTA without victims at an uncontrolled intersection of equivalent roads in an inhabited locality.

P(B6) = P(B6_1) + P(B6_2), (11)

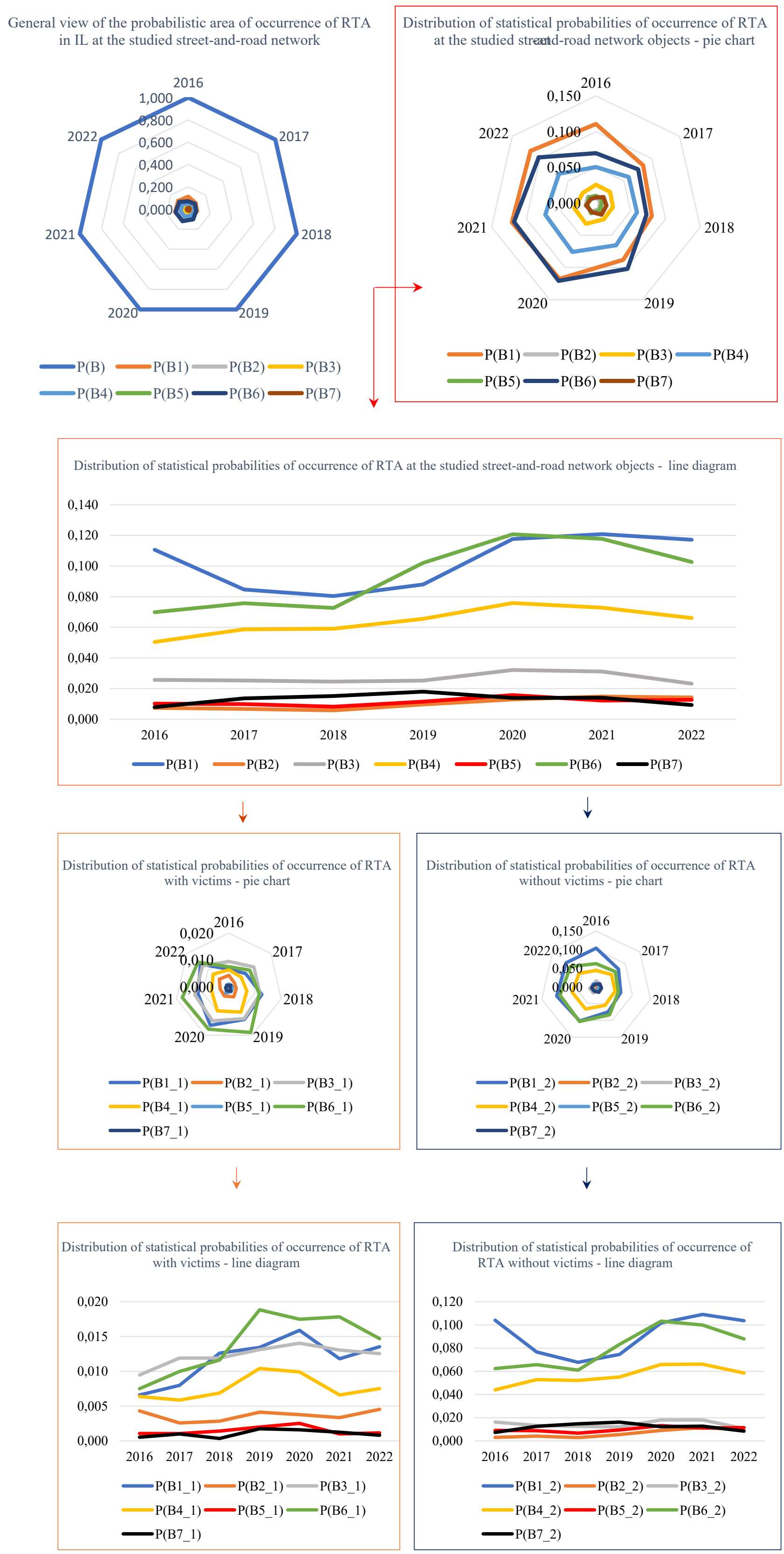
where P(B6_1) – statistical probability of occurrence of RTA with victims at uncontrolled intersection of roads when there is a priority road in an inhabited locality;

P(B6_2) – statistical probability of RTA without victims at uncontrolled intersection of roads when there is a priority road in an inhabited locality.

P(B7) = P(B7_1) + P(B7_2), (12)

where P(B7_1) – statistical probability of occurrence of RTA with victims at uncontrolled intersection with a roundabout in an inhabited locality;

P(B7_2) – statistical probability of occurrence of RTA without victims at an uncontrolled



Pic. 8. Diagrams of the components of the probabilistic area of road traffic accidents in inhabited localities at the studied street-and-road network objects [developed by the authors].

intersection with a roundabout in an inhabited locality.

P(B8) = P(B8_1) + P(B8_2), (13)

where P(B8_1) – statistical probability of occurrence of RTA with victims at other street-and-road network objects in an inhabited locality;

P(B8_2) – statistical probability of occurrence of RTA without victims at other street-and-road network objects in an inhabited locality.

It should be noted that the interface of AIMS SRTSI software makes it possible to subdivide street-and-road network objects into 29 types, for example, overpass, gas station, courtyard area, etc. As part of this study, a detailed analysis was performed regarding the main objects presented in the table of search queries (Table 1), the rest in this case are classified as other objects. In the future, the general structure will be expanded and similarly analysed in detail.

As a result of the calculation, the values of the statistical probabilities of occurrence of RTA were determined, provided in Table. 3. The relationship between the components of the probability of occurrence of RTA in inhabited localities P(B) for certain street-and-road network objects is shown in Pic. 7.

In this case, as part of the analysis (Pic. 7, Table 3), a new probability area P(B) was considered, which was a full-fledged working field with a probability value equal to 1. The general view of the results obtained is shown in Pic. 8.

The analysis of the presented data allows us to determine that in the region under consideration over a long period (2016–2022), the most accident-prone areas in terms of the total number of incidents are sections of roads (P(B1)), controlled intersections (P(B4)) and uncontrolled intersections of equivalent roads (R(B6)). Despite the general decrease in the number of RTA with victims, which is reflected in the official statistical database, the RTA rate at these facilities remains at a high level in comparison with other street-and-road network objects. According to the results of the analysis of the number of RTA with fatalities and injuries, the most accident-prone areas also remain sections of roads (P(B1)), controlled intersections (P(B4)), uncontrolled intersections of equivalent roads (P(B6)), but here a high RTA rate is also observed at uncontrolled pedestrian crossings (P(B3)). One of the positive aspects of the transition to the probabilistic area is assessment of the general dynamics of changes in the RTA rate of the objects under study, which shows that the proportion of RTA characteristic of some of the studied street-and-road network objects varies in a relatively narrow range, for example, for controlled pedestrian crossings (P(B2)), uncontrolled intersections of equivalent roads (P(B5)) and uncontrolled intersections with roundabouts (P (B7)).

CONCLUSION

The analysis resulted in presenting the basis of the developed approach to assessing accident rates using an expanded range of data, allowing one to take into account the indicators of accidents without victims. Considering the course actively implemented in all constituent entities of the Russian Federation without exception and the focus on the concept of «zero mortality», this allows considering parameters of indicators referring to reduction in the total number of RTA. In this regard, the developed approach with subsequent detailing of all indicators presented in a publicly accessible statistical database and data reflected in AIMS SRTSI, by specifying complex search queries and converting absolute indicators into relative ones using probabilistic models, will allow us to determine the weight of data in the overall system and establish a list of recommended measures to reduce RTA for a region under study.

In turn, subsequent automation of the presented analysis allows us to optimise the procedures of processing values of RTA indicators, considering the addition to the analytical model of factors that influence changes in the indicators under consideration, such as:

– level of motorisation in a region;

– length of paved roads in a region;

– provision of a region with intelligent transport systems, considering the level of technological maturity;

– socio-economic situation of a region and inflation rate;

– population size of a region and its migration activity and mobility;

– demographic indicators, etc.

Analysis of these indicators in conjunction with road traffic safety indicators will make it possible to predict achievement of targets set out in national projects and strategic planning documents, as well as to assess the degree of influence of certain factors during development of public policy in relevant areas. When forecasting changes in the situation in an entire region, long-term planning can be used for implementation of main development directions and application of measures aimed at the effective use of existing resources and formation of specialised requests addressed to the federal level to receive new elements, for example, executive elements of ITS, software and hardware systems, at the performance of certain types of activity contributing to the improvement of road traffic safety and at the implementation of other activities which together will become the basis for digital transformation.

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