Artículo de investigación

Creation background of the Yakutsk city intelligent transport system

ПРЕДПОСЫЛКИ ВНЕДЕРЕНИЯ ИНТЕЛЛЕКТУАЛЬНОЙ ТРАНСПОРТНОЙ СИСТЕМЫ ДЛЯ ГОРОДА ЯКУТСКА

Fondo de creación del sistema de transporte inteligente de la ciudad de Yakutsk

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Abstract

Damage to human health and life, material damage caused to the economy due to accidents on highways is one of the most serious socio-economic problems. Currently, this issue is becoming especially acute due to the still low culture of road users, the increase in the number of cars and high public demand for ensuring the safety of all road users. One of the significant reasons for the high accident rate in the city is the existing disproportion between the development of the street road system and the growth of the vehicle fleet, which leads to worsening traffic conditions, congestion, increased delays and increased harmful emissions into the atmosphere, environmental degradation, and social discomfort. Obviously, the modern technical equipment and the state of the organization of traffic do not allow ensuring the safety of traffic entities, and the growing level of motorization of the population and the existing labor migration traffic create an enormous load on the street-road network of the city agglomeration. The above factors generally do not stimulate accelerated social reproduction and are expressed in negative consequences such as an increase in travel time, an increase in the number of vehicle stops, an increase in the loss of time for legal entities and individuals, accelerated wear of the road surface, increased fuel consumption, and environmental degradation. The article presents the results of an analysis of the existing traffic light regulation, statistics of traffic accidents, a sociological

Аннотация

Ущерб здоровью и жизни людей, материальный урон, наносимый экономике вследствие аварийности на автомобильных дорогах, является одной из серьезнейших социально-экономических проблем. В настоящее время данный вопрос приобретает особую остроту в связи со все еще невысокой культурой участников дорожного движения, ростом количества автомобилей и высоким общественным запросом в обеспечении безопасности всех участников дорожного движения. Одной из существенных причин высокого уровня аварийности в городе является сложившаяся диспропорция между развитием уличной дорожной системы и ростом автопарка, которое приводит к ухудшению условий движения, заторам, росту задержек и увеличению вредных выбросов в атмосферу, ухудшению экологической обстановки, социальному дискомфорту. Очевидно, что современная техническая оснащенность и состояние организации дорожного движения не позволяют обеспечить безопасность субъектов движения, а растущий уровень автомобилизации населения и существующий трудовой миграционный трафик создают колоссальную нагрузку на улично-дорожную сеть городской агломерации. Перечисленные факторы в целом не стимулируют ускоренное общественное воспроизводство и

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survey, shows the grouping of intersections by hazard and congestion criteria, and offers the option of covering intersections of the city of Yakutsk with an intelligent transport system. The factors of a negative impact on safety and traffic management are listed, the prerequisites for the introduction of an intelligent transport system in the territory of the city agglomeration of Yakutsk are identified.

Key words: Street-road network, intelligent transport system, intersection, traffic light, mode of operation, road traffic accidents, safety.

выражаются в таких негативных последствиях как, увеличение времени на поездки, рост количества остановок транспортных средств, рост потерь времени юридических и физических лиц, ускорение износа дорожного покрытия, увеличение расхода топлива, ухудшение экологической обстановки. В статье приведены результаты анализа существующего светофорного регулирования, статистики дорожно-транспортных происшествий, проведенного социологический опроса, показана группировка перекрестков по критериям опасности и загруженности, предложен вариант охвата перекрестков города Якутска интеллектуальной транспортной системой. Перечислены факторы негативного влияния на безопасность и организацию дорожного движения, выявлены предпосылки внедрения интеллектуальной транспортной системы на территории городской агломерации Якутска.

Ключевые слова: улично-дорожная сеть, интеллектуальная транспортная система, перекресток, светофор, режим работы, дорожно-транспортные происшествия, безопасность.

Resumen

El daño a la salud humana y a la vida, el daño material causado a la economía debido a accidentes en las carreteras es uno de los problemas socioeconómicos más graves. Actualmente, este problema se está volviendo especialmente agudo debido a la baja cultura de los usuarios de la carretera, el aumento en el número de automóviles y la alta demanda pública para garantizar la seguridad de todos los usuarios de la carretera. Una de las razones importantes de la alta tasa de accidentes en la ciudad es la desproporción existente entre el desarrollo del sistema de carreteras y el crecimiento de la flota de vehículos, lo que conduce a un empeoramiento de las condiciones del tráfico, la congestión, el aumento de los retrasos y el aumento de las emisiones nocivas en el atmósfera, degradación ambiental e incomodidad social. Obviamente, el equipo técnico moderno y el estado de la organización del tráfico no permiten garantizar la seguridad de las entidades de tráfico, y el creciente nivel de motorización de la población y el tráfico de migración laboral existente crean una enorme carga en la red de calles y carreteras. La aglomeración de la ciudad. Los factores anteriores generalmente no estimulan la reproducción social acelerada y se expresan en consecuencias negativas, como un aumento en el número de paradas de vehículos, un aumento en la pérdida de tiempo para las personas jurídicas y las personas, el desgaste acelerado de la superficie de la carretera, mayor consumo de combustible y degradación ambiental. El artículo presenta los resultados de un análisis de la regulación de semáforos existente, estadísticas de accidentes de tráfico, una encuesta sociológica, muestra la agrupación de intersecciones por criterios de peligro y congestión, y ofrece la opción de cubrir las intersecciones de la ciudad de Yakutsk con un dispositivo inteligente. sistema de transporte Se enumeran los factores de un impacto negativo en la seguridad y la gestión del tráfico, se identifican los requisitos previos para la introducción de un sistema de transporte inteligente en el territorio de la aglomeración de la ciudad de Yakutsk.

Palabras clave: Red calle-carretera, sistema de transporte inteligente, intersección, semáforo, modo de operación, accidentes de tránsito, seguridad.

Introduction

About 75% of road traffic accidents (hereinafter referred to as traffic accidents) occur in cities, with more than half being concentrated at intersections. Therefore, the problem of organization and traffic safety is the most important task, the quality and reliability of the functioning of the entire urban transport system and the possibility of implementing the necessary engineering and technical solutions, including reducing traffic accidents, depend on the correct solution (Information materials of the official).

Analyzing the current situation and trends, we can assume that the current state of traffic management, the level of technical equipment and the quality of roads largely do not meet the requirements and do not ensure the safety of road users. One of the problems of ensuring traffic safety is a rapid increase in traffic intensity, an increase in the number of young inexperienced drivers, and an increase in traffic density. All this leads to an increase in the number of accidents and the severity of their consequences, which translates the problem into the category of urgent and subject to priority decision. So, taking into account the need to ensure the economic and national security of the country, the implementation of its progressive demographic policy in January 2018, the Road Safety Strategy in the Russian Federation for 2018-2024 was approved. The strategy was developed in order to determine priorities in the field of road safety, directions and ways to achieve them, as well as to form ideas among participants in legal relations in the field of road safety regarding the prospects and guidelines of the state of road safety in the Russian Federation for the medium term (The road safety strategy in the Russian Federation for 2018-2024).

The main causes of accidents are violation of the rules of the road, both by drivers and pedestrians, technical malfunction of vehicles, as well as an increase in the volume of passenger and freight traffic. In addition, the organization of the work of traffic lights significantly affects traffic safety. Since the development of the transport network is associated with motorization, it can be argued that the introduction of an intelligent transport system on the roads is an important prerequisite for improving traffic safety (Komarov, 2012).

The city of Yakutsk is the capital of the Republic of Sakha (Yakutia), it is the largest city located in the permafrost zone. The area is 3600 square meters, and the population of about 300 thousand people, which is approximately equal to 30 percent of the inhabitants of the RS (Y). Yakutsk is located somewhat north of the parallel of 62 degrees north latitude, as a result of which there are long periods of “white nights” in summer, and in winter, daylight hours last only 3-4 hours (Geoportal of the Republic of Sakha).

Street-road network (hereinafter - UDS) - a set of city streets, highways, roads, driveways, including the main roadway, sidewalks, lawns, outdoor lighting and other amenities, as well as road surfaces of engineering structures (bridges, overpasses).

The city’s UDS is part of urban communication routes, providing the necessary freight and passenger links between the individual functional areas of the city and within individual zones and other urban areas (Pugachev, 2004).

The main elements of the road network are expressways, main streets and roads, local roads and streets. Based on the list of motor roads of local importance (Appendix No. 1 to the order of the District Administration of the city of Yakutsk dated November 19, 2015 No. 1987r), the total length of the streets of the city of Yakutsk was calculated, which amounted to 200877.5 meters with an area of 1295830.5 square meters. There are 214 streets in all, of which 81 are paved with sand and gravel; 15 streets coated with asphalt / sand and gravel; 79 streets coated with asphalt; 1 street coated with asphalt concrete / mountain sand; 11 unpaved streets (Appendix No. 1, 2015). The street-road network of the city of Yakutsk consists of:

- Main streets, and public centers with other main streets, city and external roads: Dzerzhinskogo, Lenina, Petera Alekseeva, Kalvitsa, Kiroav and others;
- Main streets and freight traffic roads, which are used to transport construction and industrial goods that are carried out outside the residential zone between the industrial and communal-warehouse areas of the city, these are mainly the streets of the Soviet Army, Chernyshevskogo, Avtodorozhnaya, highway 50 years of October, etc.;
- Streets and roads of local importance, providing transport and pedestrian communication of residential neighborhoods;
- Sections of streets and roads through which there is a pedestrian connection with the places of employment, with

places of rest, stopping points, public transport.

The effectiveness and nature of urban traffic depends on the transport layout of the city. The city of Yakutsk has a rectangular layout. With this scheme, the delivery of goods from the sender to the recipient within the city limits is extended by about 30% compared with the shortest direction through the air line. Existing disadvantages of such a layout are eliminated by the use of a rectangular-diagonal layout (Solovyov, 2014).

One of the many significant reasons for the high accident rate in the city is the existing disproportion between the development of the street road system and the growth of the vehicle fleet, which leads to worsening traffic conditions, congestion, increased delays and increased harmful emissions into the atmosphere, environmental degradation, and social discomfort. The quality of the road surface remains unsatisfactory; traffic conditions in urban areas are constantly deteriorating. The street-road network in many places of the city is already at the limit of capacity and is in danger of jamming and the creation of emergencies when passing cars and pedestrians.

Intelligent transport system (hereinafter - ITS) is a management system that integrates modern information and telematic technologies and is designed to automatically search for and implement the most effective scenarios for managing the region's transport and road complex, a specific vehicle or group of vehicles in order to ensure a given population mobility maximizing the performance of the road network, improving the safety and efficiency of transport otsessa, comfort for drivers and transport users (GOST R 56829-2015; ISO / TC 204 / 15638-1, 2011).

In other words, this is a system of modeling and regulation of traffic flows, aimed at improving road safety, based on advanced developments, providing consumers with information and qualitatively increasing the level of interaction of traffic participants. The best foreign practices and experience in using ITS show that it can be harmoniously integrated into a single city management system operating on the basis of the "smart city" (Bakici, et. al., 2013).

As a result of using the above systems, we get the so-called "smart roads". They include:

- Adaptive traffic lights;
- Connected information boards;
- Means of automatic recording of traffic violations;
- Traffic detectors;
- Electronic means of non-stop fare payment;
- Automated lighting control systems;
- Other connected objects (for example, automatic road weather stations, road controllers, etc.);
- GPS / GLONASS systems (On conceptual approaches to the formation and development of Intelligent Transport Systems in Russia; The journal "Technologies and means of communication, 2016).

Consider three global directions for the development of ITS:

- Introduction of new types of fuel and engines;
- Optimizing the functioning of multimodal logistics networks using more economical modes of transport;
- Increasing the efficiency of using transport infrastructure due to the development of information services.

The Smart Traffic Light system is designed to improve intersection performance by dynamically controlling traffic signals. The system consists of controllers, cameras and remote motion sensors, which in real time assess the traffic intersections and transmit this information to a central management server.

According to the readings of the sensors, the central server instructs the traffic light controllers to turn on the red / green light so as to minimize the time spent by cars at intersections.

With a high load of one of the directions, the green light is extended for it (The journal "Technologies and means of communication, 2016). The system makes a forecast for 15-30 minutes in advance, which allows you to work out a traffic management plan in advance. In the event of an emergency - such as an accident - the plan is automatically adjusted to take it into account.

Depending on the types of sensors, the system can take into account the priority of public transport, emergency services and "special escorts" over other participants in the movement. In the event of a malfunction, the traffic lights switch to offline mode, and the intersections begin to be adjusted in the traditional way. It

allows you to avoid transport collapse in case of emergency.

Note that, despite the obvious advantages, smart traffic lights will not be able to completely solve the problem of traffic jams. The Smart Traffic Light system can only maximize intersection performance. At the same time, the city authorities will still have to expand roads and build complex transport interchanges. According to analysts, one city strip on average is capable of servicing no more than 1800 cars per hour. And this is provided that the vehicles do not stop at intersections and do not encounter obstacles such as a narrowing of the road, poor quality of the roadway, etc. Since the number of vehicles in our country is steadily growing, it is obvious that even with the maximum traffic capacity of intersections, traffic jams in large cities will grow if you only deal with the implementation of Smart Traffic Light systems and do not solve other traffic problems.

Materials and methods

Analysis of the existing traffic light control system in the city of Yakutsk

Yakutsk is a typical regional center of the Russian Federation with a low population.

Currently, traffic lights in the city have simple traffic lights.

Modernization and integration of traffic lights on the main roads of the city will allow:

- Significantly reduce daily congestion by smoothing traffic flows;
- Reduce pollution (stopping driving is inefficient and pollutes the environment);
- Give preference to buses approaching interchanges;
- Provide a much more effective response to traffic accidents;
- Enable flow control.

Simultaneously with the modernization of traffic lights, it is advisable to install monitoring equipment, which will allow collecting detailed large data on the number and types of vehicles, traffic intensity and load on the road network. Each set of traffic lights will have communication equipment that can be used to transmit (anonymous) vehicle data, either from ANPR cameras or Bluetooth detectors, and from video surveillance channels (if necessary).

On the territory of the urban district "city of Yakutsk" 145 traffic lights of which 100 intersections (table 1).

Table 1 - The list of intersections with traffic lights in the city of Yakutsk

№	Crossroads	№	Crossroads
1	Dzerzhinskogo - Poyarkova	51	Lermontova - Kurashova
2	Dzerzhinskogo - Chiryaeva	52	Lermontova – Oktyabrskaya
3	Kirova - Poyarkova	53	Lermontova - Petear Alekseeva
4	Kulakovskogo - Yaroslavskogo	54	Lermontova - Petrovskogo
5	Lenina - Ammosova	55	Lermontova - Sverdlova
6	Lenina - Kalandarishvili	56	Lermontova - Khalturina
7	Lenina - Kirova	57	Oyunskogo - Kalandarishvili
8	Lenina - Korolenko	58	Oktyabrskaya – Gorkogo
9	Lenina - Kulakovskogo	59	Petera Alekseeva - Pirogova
10	Lenina - Kurashova	60	Petera Alekseeva - Rydzinskogo
11	Lenina - Oktyabrskaya	61	Petera Alekseeva - Lomonosova
12	Lenina - Petrovskogo	62	Stadukhina - Machan
13	Oktyabrskaya - Oyunskogo	63	F. Popova - B. Marlinskogo
14	Ordzhonikidze - Kirova	64	F. Popova - Gubina
15	Ordzhonikidze - Korolenko	65	Khabarova - Bogatyreva
16	Ordzhonikidze - Kurashova	66	Khabarova - Victory Square
17	Ordzhonikidze - Oktyabrskaya	67	Khabarova - Lenina
18	Ordzhonikidze - Petera Alekseeav	68	Khabarova - Chiryaeva
19	Ordzhonikidze - Petrovskogo	69	Khabarova - Yaroslavskogo
20	Petrovskogo - Oyunskogo	70	Tchaikovskogo - Kalandarishvili
21	Poyarkova - Korolenko	71	Tchaikovskogo - Petrovsky

22	Poyarkova - Kurashova	72	Chernyshevskogo - Arzhakova
23	Poyarkova - Petera Alekseeva	73	Chernyshevskogo - Kulakovskogo
24	Poyarkova - Pushkina	74	Avtodorozhnaya - check into the territory of the DSK
25	Yaroslavskogo - Ammosova	75	Avtodorozhnaya - Prometheus
26	Yaroslavskogo - Kirova	76	Avtodorozhnaya - Utkina
27	Yaroslavskogo - Kurashova	77	Avtodorozhnaya - Sevastopolskaya
28	Yaroslavskogo - Oktyabrskaya	78	Vilyui tract - STSI
29	50 years of the Soviet Army - Babushkina	79	Vilyui tract - Three pines
30	50 years of the Soviet Army - R. Sorge	80	Dezhneva - Chkalova
31	Bogdana Chizhika – F. Popova	81	Dezhneva - Timiryazeva
32	Bogatyreva - Gubina	82	Dzerzhinskogo - Nekrasova
33	Gorkogo - Korolenko	83	Dzerzhinskogo - Stroiteley
34	Gorkogo - Pushkina	84	Zhornitskogo - Stroiteley
35	Dzerzhinskogo - Kalvitsa	85	Ilmenskaya - Bilibina
36	Dzerzhinskogo - Lermontova	86	Keshi Alekseeva – J. Potapova
37	Zhornitskogo - K. Zetkin	87	Krasilnikova - Sergelyakhskoe highway
38	Ilmenskaya - Tchaikovskogo	88	Kurnatovskogo - Zhornitskogo
39	Kalandarishvili - Belinskogo	89	Kurnatovskogo - Sevastopolskaya
40	Kalvitsa - B. Marlinskogo	90	Lenina - Dezhneva
41	Kalvitsa - B. Chizhika	91	Lermontova - Keshi Alekseeva
42	Kalvitsa - Khalturina	92	Lermontova - Shevchenko
43	Kirova - Gorkogo	93	Mozhaiskogo - Bykovskogo
44	Kulakovskogo - Belinskogo	94	Mozhaiskogo - house 15
45	Kulakovskogo - Dezhneva	95	Ob'yezdnaya - Ochichenko
46	Kurashova - Gorkogo	96	Oyunskogo - Avtodorozhnaya
47	Lermontova - Vilyui tract	97	Khalturina – Stroiteley
48	Lermontova - Kalandarishvili	98	Chernyshevsky – Avtodorozhnaya
49	Lermontova - Kirova	99	Chernyshevsky - Gastello
50	Lermontova - Korolenko	100	Chernyshevsky - Dezhneva

In the city of Yakutsk, there are two modes of operation of traffic lights at intersections:

1. New mode. In 2019, a new cycle of intersection regulation was introduced for pedestrian safety at the intersections of Dezhneva-Timiryazeva streets (table
2. Two more intersections operating in this mode are located at the following addresses: Ilmenskaya - Bilibina, Babushkina - 50 years of the Soviet Army.

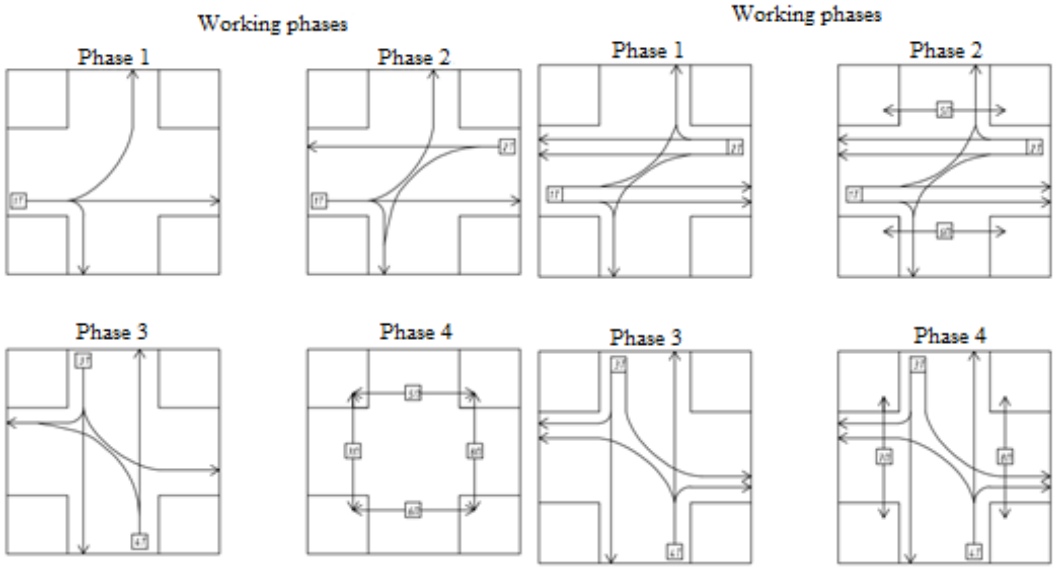
Table 2 - a new cycle of regulation of the intersection

Tact	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Time, s	0	8	10	50	53	55	56	57	74	77	80	81	96	99	101
Duration, s	8	2	40	3	2	1	1	17	3	3	1	15	3	2	2
Phase	Ph1	»	Ph2	»	»	»	»	Ph3	»	»	»	Ph4	»	»	»
1T			G	GB	Y	Y	R	R	R	R	R	R	R	R	RY
2T	R	RY	G	GB	Y	Y	R	R	R	R	R	R	R	R	R
3T	R	R	R	R	R	RY	RY	G	GB	Y	R	R	R	R	R
4T	R	R	R	R	R	RY	RY	G	GB	Y	R	R	R	R	R
5П	R	R	R	R	R	R	R	R	R	R	R	G	GB	R	R
6П	R	R	R	R	R	R	R	R	R	R	R	G	GB	R	R
7П	R	R	R	R	R	R	R	R	R	R	R	G	GB	R	R
8П	R	R	R	R	R	R	R	R	R	R	R	G	GB	R	R

1. The existing regime. The vast majority of intersections are regulated in the existing regime, for example, the intersection of Oyunskogo - Oktyabrskaya streets.

Table 3 - the controller of the intersection Oyunskogo – Oktyabrskaya

Exit	Direction	Signal light	Exit	Direction	Signal light
1y	1 transport	Red	17y		
2y	1 transport	Yellow	18y	6 walking	Green
3y	1 transport	Green	19y	7 walking	Red
4y	2 transport	Red	20y		
5y	2 transport	Yellow	21y	7 walking	Green
6y	2 transport	Green	22y	8 walking	Red
7y	3 transport	Red	23y		
8y	3 transport	Yellow	24y	8 walking	Green
9y	3 transport	Green	25y		
10y	4 transport	Red	26y		
11y	4 transport	Yellow	27y		
12y	4 transport	Green	28y		
13y	5 walking	Red	29y		
14y			30y		
15y	5 walking	Green	31y		
16y	6 walking	Red	32y		



a) b)

Figure 1 - Phases of work of traffic lights according to the new cycle (a) and according to GOST (b)

On the territory of the city of Yakutsk from 2015 to 2018, 1906 traffic accidents occurred, 2,415 people were injured in them, 2,319 were injured and 96 people died (Analytical materials of the Public Council of the party project "Safe Roads").

In order to identify the most dangerous sections in the city of Yakutsk, an analysis of road traffic accidents for 2018 was carried out. The accident data was provided by the Traffic Police Directorate for Republic of Sakha (Yakutia).

In 2018, 492 accidents occurred on the territory of the city of Yakutsk, 621 people were injured (603 were injured and 18 died) (Indicators of the state of road safety). 177 accidents occurred at intersections, of which 114 at 56 intersections with traffic lights. Having analyzed these intersections, the most dangerous 33 intersections were identified, which are listed in Table 4 (accident codes: 0 - collision with an animal; 1 - collision; 2 - rollover; 3 - collision with a pedestrian; 4 - collision with a cyclist; 5 - passenger fall; 6 - another type of accident). This table shows the areas in which more than two accidents occurred.

Table 4 - emergency-dangerous intersections of the city of Yakutsk

№	Name of crossroads	Types of accident	The number of victims in 2018, people	
			Died	Injured
1	Oyunskogo – Avtodorozhnaya	4/3/1	0	5
2	Krasil'nikova – Sergelyakhskoye shosse	4/3/1	0	3
3	Lermontova – Petrovskogo	4/1	0	3
4	F. Popova – B. Marlinskogo	3	0	2
5	B. Chizhika – F. Popova	3	0	2
6	Kal'vitsa – B. Marlinskogo	3	0	2
7	Dzerzhinskogo – Chiryayeva	3	0	2
8	Khalturina – Stroiteley	3/1	0	2
9	Kirova – Poyarkova	3/1	0	4
10	Chernyshevskogo – Arzhakova	3/1	0	3
11	Kulakovskogo – Belinskogo	3	0	3
12	Kal'vitsa – Khalturina	3/1	0	7
13	Oktyabr'skaya – Gor'kogo	3/1	0	5
14	Kal'vitsa – B. Chizhika	3/1	0	2
15	Kirova – Gor'kogo	3/1	1	6
16	Oktyabr'skaya – Oyunskogo	3/1	0	2
17	Lenina – Kurashova	3/1	0	3
18	Petrovskogo – Oyunskogo	3/1	0	4
19	Dzerzhinskogo – Lermontova	3/1	0	6
20	50 l. Sovetskoy Armii – Babushkina	3/2/1	0	3
21	Dzerzhinskogo – Poyarkova	3/1	0	3
22	Lermontova – Korolenko	3/1	0	3
23	Lermontova – Kalandarishvili	3/1	0	3
24	Poyarkova – Petra Alekseyeva	3/1	1	2
25	Dzerzhinskogo – Kal'vitsa	5/1	0	6
26	Khabarova – Chiryayeva	5/1	0	2
27	Lermontova – Petra Alekseyeva	1	0	2
28	Lenina – Ammosava	1	0	7
29	Khabarova – Lenina	1	0	2
30	Ordzhonikidze – Kurashova	1	0	2
31	Lermontova – Oktyabr'skaya	1	0	2
32	F. Popova – Gubina	1	0	2
33	Bogatyreva – Gubina	1	0	3

A sociological survey of residents of Yakutsk on the congestion of city intersections was also conducted, in which 122 people took part (table 5). Of these, 66.7% have a driver's license, more than 69.7% travel by car, 71.7% of those surveyed have driving experience of more than 3 years, and most of them are not satisfied with the organization of work of traffic lights. Intersection with the highest reference frequency (more than 5 times) is included in the final table 5.

Table 5 - The busiest intersections of the city of Yakutsk

№	Name of crossroads	Interviewed	Number of accidents
1	Dzerzhinskogo - Lermontova	17	4
2	Lermontova - Petrovskogo	17	3
3	Lermontova - Kurashova	13	1
4	Lermontova - Petera Alekseeva	12	2
5	Poyarkova - Petera Alekseeva	12	3
6	Petrovskogo - Oyunskogo	9	3
7	Oyunskogo - Kalandarishvili	8	0
8	Dzerzhinskogo - Kalvitsa	8	5
9	Lermontova - Kirova	6	1
10	Petera Alekseeva - Pirogova	6	1
11	Oyunskogo - Avtodorozhnaya	5	4
12	Kalvitsa - B. Chizhika	5	2

An analysis of accident statistics was carried out and classification was carried out by type (from 2014 to 2018) and by reason (from 2015 to 2018).

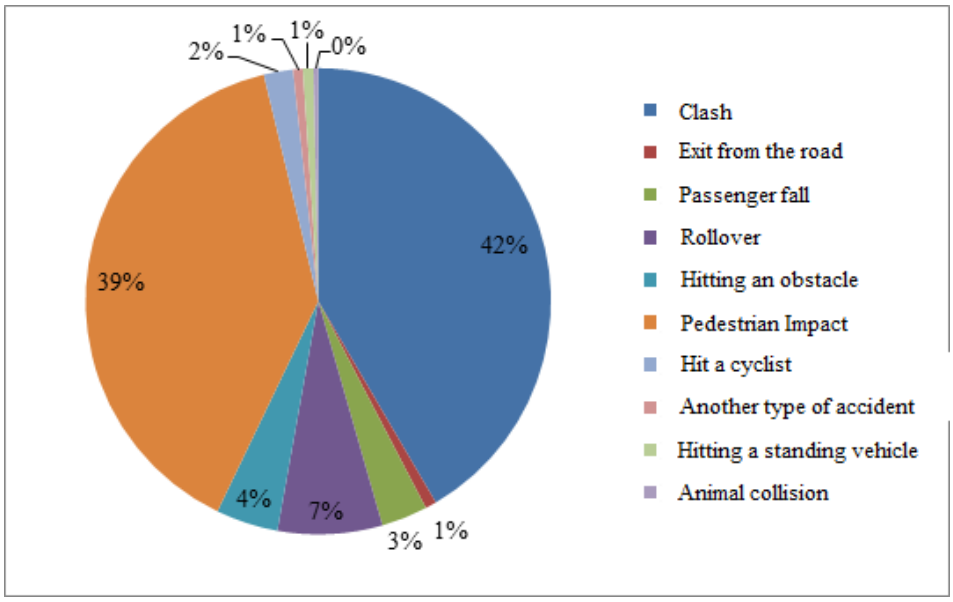


Figure 2 - The average number of accidents by type for 2014-2018

During the period under review, collisions most often occur, this type of accident is - 42% of the total number of accidents. The second type of traffic accident is pedestrian collision and makes up - 39%, the next is rollover - 7% and collision with obstacles - 4%, other types occupy less than 3%.

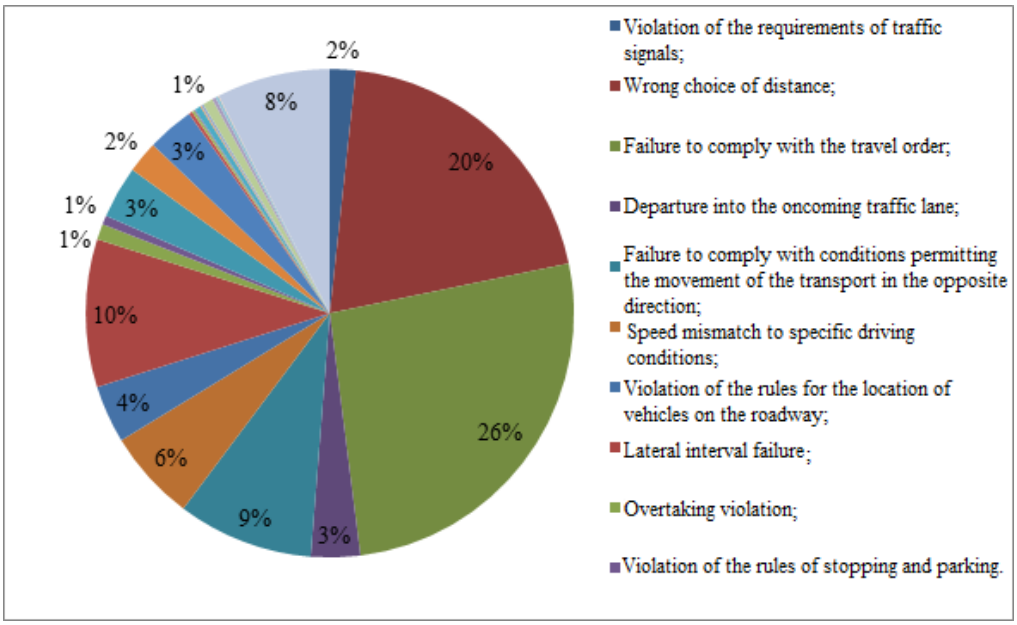


Figure 3 - Distribution of accidents for reasons on average for 2015-2018.

From Figure 3 it follows that the largest number of accidents occur due to non-compliance with the travel order and accounts for 26% of the total number of accidents in 2015-2018. For the reason, the wrong choice of distance is 20%, non-compliance with the lateral interval - 10%, non-compliance with the conditions permitting traffic in reverse - 9%, other traffic violations - 8%, speed mismatch with specific traffic conditions - 6%, other reasons occupy less than 5%.

Results and discussion

At the venue of the international Arctic forum "The Arctic - the Territory of Dialogue" held on April 9, 2019 in St. Petersburg, a tripartite agreement was signed on the implementation of a pilot project on smart city digitalization in Yakutsk "Smart City". Within the framework of this agreement, it is planned to introduce intelligent transport systems until 2022 (Materials of the international Arctic forum, 2019).

According to the results of a sociological survey, the busiest intersections were selected, in particular, the intersection of Dzerzhinskogo-Lermontova streets and the intersection of Lermontova-Petrovskogo streets. At these intersections in 2018, 4 and 3 accidents occurred, respectively.

Having analyzed the most dangerous sections (Table 4) and comparing the statistics of incidents with the data of a sociological study, we can conclude that the most emergency streets are Dzerzhinskogo and Lermontova. The introduction of an intelligent transport system at a separate intersection will not have a positive effect, but may lead to a deterioration in the traffic situation, since traffic regulation at one intersection must take into account the congestion at nearby intersections. Therefore, the introduction of intelligent transport systems must be carried out in parallel with the introduction of the Smart City system. For the successful implementation of ITS, it is recommended to start with the busiest and most dangerous intersections. Analysis of traffic accident statistics and public opinion of the city residents made it possible to compile a map of the coverage of the road network of Yakutsk with an intelligent transport system (Figure 4). The complex system is proposed to include 70 intersections, grouped by accident and congestion.

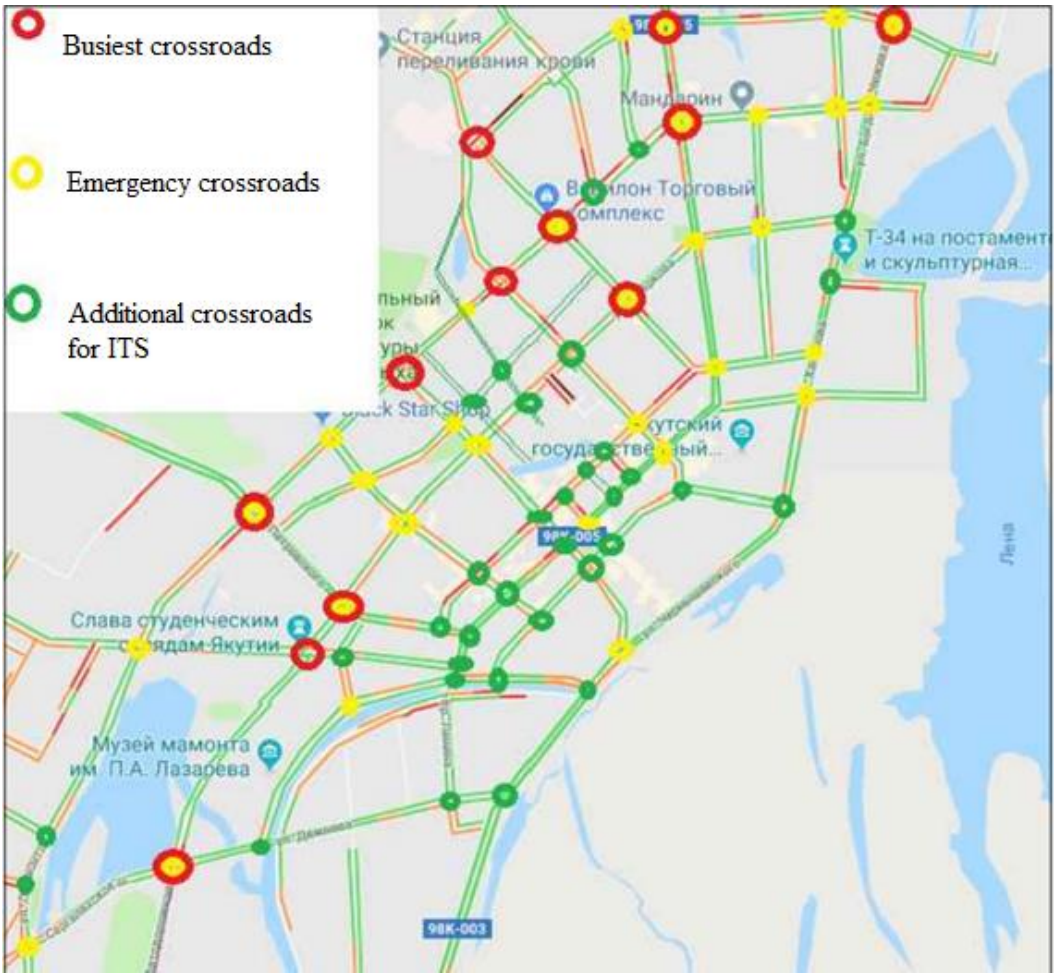


Figure 4 - Coverage of the road network of Yakutsk with an intelligent transport system

Conclusion

Given the current level of socio-economic development and the prospects for the development of Yakutsk, the following can be attributed to negative factors affecting not only safety and traffic management, but also sustainable social and economic development as a whole (Karakeyan, Nikulina, 2014):

- Insufficiency of urban transport infrastructure planned for other historical conditions;
- Low culture of road users;
- Low level of technical equipment of the traffic management system;
- The existing demographic situation and the movement of labor resources;
- Growing level of motorization.

Obviously, the modern technical equipment and the state of the organization of traffic do not allow ensuring the safety of traffic entities, and the growing level of motorization of the population and the existing labor migration traffic create an enormous load on the street-road network of the city agglomeration. The above factors generally do not stimulate accelerated social reproduction and are expressed in negative consequences such as an increase in travel time, an increase in the number of vehicle stops, an increase in the loss of time for legal entities and individuals, accelerated wear of the road surface, increased fuel consumption, and environmental degradation.

To reduce the impact of negative factors and achieve the goals of improving security and ensuring accelerated reproduction, the planned ITS should be comprehensive and integrate various elements into a single whole, in particular, traffic safety, automated traffic management, the state of the road infrastructure with the characteristics of road conditions, an

information user service interface. Intelligent transport system functions as a system based on big data management, that is, at the design stage it is necessary to solve such technical issues as developing an intelligent platform, interfacing various information systems, creating data centers, not to mention the design and construction of communication networks and resolving issues of technical connection.

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