Methodological foundations for the application of video analytics and incident management technologies in real-time detection and control systems for road incidents

Olga Dolinina[0000-0001-5256-3161]1, Andrey Motorzhin[0000-0002-9652-5965]2,
Vitaly Poltoratzky [0000-0003-2849-6442]3, A. Kandaurov[0000-0001-9292-7492]3,
A. Shatunov[0000-0003-1487-7973]3, A. Kartashev [0000-0001-5276-9418]3

[1] Yuri Gagarin State Technical University of Saratov, Saratov, Russia,
[2] Company “Satellite SoftLabs”, Saratov, Russia
[3] Company “AMT-GROUP” (Company Group “TransNetIQ”), Moscow, Russia
Odolinina09@gmail.com

Abstract. The article describes the official methodology adopted in Russia for the calculations of the risks of the traffic accidents. The statistics of the traffic accidents is considered. It is shown that the key reason of the accidents is traffic violation by the drivers and that’s why it is necessary to implement the system of the “smart traffic” for the on-line control of the traffic on the base of the video detection and transport analytics which detects the drivers’ state, state of the road-bed, traffic violation and accidents. This paper describes methods and solutions of the “smart traffic” currently used in Russia and suggested the way of control of the traffic accidents.

Keywords: Traffic Accidents, Smart Traffic, Video Detection, Control of Incidents, Efficiency of the Traffic Control.

1 Introduction

The importance of transport in the life of modern society can hardly be overestimated: the role of the transport system of any state is similar to the circulatory system of the body -- every failure in its functioning is fraught with social and economic losses. The price of any incident is human life and material and financial costs.

The most important mode of transport is automobile. In Russia, the length of public roads was about 1.6 million km, the share of road transport in the total passenger turnover was 22.1%, and freight turnover was 4.6%. At the same time, motor transport is the most emergency: the number of road traffic accidents (RTAs) in road transport in 2018 amounted to 168.1 thousand (58.3% of the total number of accidents in all modes of transport), the number of deaths in these incidents - 18.2 thousand people. (11.8%). The distribution of accidents by type is shown in the table 1. Three quarters of all accidents (77%) occurred in cities and towns, with the share of dead and injured being 47.8% and 74%, respectively. Information about the types of accidents in 2018 [1] is give in the Table 1.

Table 1. Types and percentage of road traffic accidents in 2018

Type of accident	Quantity	Percentage
Collision of vehicles	51022	42,70%
Vehicle rollover	9714	8,10%
Hitting a standing vehicle	3438	2,90%
Passenger fall	4687	3,90%
Pedestrian collision	32488	27,20%
Hitting a barrier	8201	6,90%
Hitting a cyclist	4584	3,80%
Hitting an animal	322	0,30%
Cartage accident	17	0,01%
Other type of accident	4902	4,10%

The number of deaths in road accidents in Russia per one million people in 2018 amounted to 124 people. For comparison, in the European Union, the countries with the lowest mortality on the roads in 2018 were Great Britain (28 deaths per million), Denmark (30), Ireland (31) and Sweden (32). The highest mortality rates were found in Romania (96), Bulgaria (88), Latvia (78) and Croatia (77).

According to the traffic police data, in 2019 in Russia the total number of accidents amounted to 164.4 thousand, 16981 people died and 210877 people were injured.

Despite a slight decrease in the total number of accidents, the significant increase (by 11.7%) in the number of accidents involving public road transport engaged in bus transportation, and for all indicators (see Table 2) [2,3], is alarming.

Table 2. Traffic accidents and injuries in them, with the participation of public road transport by mode of transport in 2019

Indicator	Russian Federation				
	Accidents	Died		Injured	
	Total number	Total	Passengers	Total	Passengers
Accident involving public road transport bus	**6926 +11,7%**	**359 +0,3%**	**62 -26,2%**	**10307 +11,1%**	**7461 +11,4%**
--including--					
regular transportation with passengers disembarking at designated stopping points	**6725 +10,5%**	**329 +7,2%**	**53 +17,8%**	**9656 +8,5%**	**7000 +9,0%**
regular transportation in urban traffic with passengers disembarking in any place not prohibited by traffic rules	**5618 +9,5%**	**155 +34,8%**	**12 +9,1%**	**7512 +5,6%**	**5501 +5,7%**
transportation in urban traffic on orders	**41 +36,7%**	**4 +300%**	0	**74 +23,3%**	**44 +51,7%**

regular transport in the suburban	**693 +13,2%**	**67 -16,3%**	**16 +23,1%**	**1261 +13,9%**	**829 +12,3%**
commuter transportation on orders	**37 +54,2%**	**5 -64,3%**	**0 -100%**	**128 +36,2%**	**73 +25,9%**
regular transportation in intercity (international) traffic	**420 +21,7%**	**106 -5,4%**	**24 +14,3%**	**935 +31,3%**	**652 +39,9%**
transportation in intercity (international) traffic	**117 +129,4%**	**20 -62,3%**	**9 -73,5%**	**443 +2,1%**	**341 +9,9%**

The main reason for the accident is a violation of traffic rules by drivers -- 89.2%. In total, due to traffic violations by drivers of vehicles last year, 146,688 traffic accidents occurred. In the period from January to October 2019 alone, 5598 accidents involving buses occurred in Russia, which is 12% more than in the same period in 2018. Unfortunately, the situation with road accidents with buses has not fundamentally changed for almost four years. In 2019, 5,535 accidents were caused by bus drivers. As a result of such accidents, 246 people were killed, 8795 were injured.

The main causes of accidents due to violation of the rules by drivers are:

- failure to comply with the order of intersections – 20%;
- wrong choice of distance between vehicles – 10%;
- violation of the rules of passage of pedestrian crossings – 9.2%;
- departure into oncoming traffic lane – 8.4%;
- speed mismatch to specific traffic conditions – 5.8%;
- violation of the requirements of traffic signals – 2.7%;
- excess of the established speed of movement – 2.3%;
- violation of the rules for overtaking – 1.3%.

Such a significant number of accidents caused by drivers, driving under the influence of alcohol or drugs (only from April 1 to May 11, 2020 revealed 35.5 thousand motorists who got behind the wheel while intoxicated), the aggressive behavior on the roads necessitates the improvement of mechanisms control the behavior of drivers on the road. In Russia, the concept of hazardous driving has been introduced into the Rules of the Road, which is the repeated commission of one or more subsequent actions, if these actions entailed the creation by the driver of a road traffic situation where his movement and (or) the movement of other road users in the same direction and at the same speed poses a threat of death or injury to people, damage to vehicles, structures, goods or other material damage. Outside Russia there is also the “3D reason” -- drunk, drugged and dangerous, what means driving under the influence of drugs or drugs and dangerous driving, while the most significant fines are imposed for dangerous driving.

It should be noted that in addition to a direct violation of traffic rules by drivers, the causes of traffic accidents are also:

– the physical impossibility of preventing drivers of traffic accidents caused by other vehicles and pedestrians;

– physical fatigue of drivers associated with non-compliance with the regime of work and rest;

– accidents with drivers (heart attacks, acute attacks of chronic diseases, etc.);

– distraction of drivers (acts of unlawful interference, accidents in the passenger compartment, etc.).

The second concomitant cause of an accident is a violation of the requirements for the operational condition of roads and railway crossings. Unsatisfactory road conditions were recorded in 48,259 traffic accidents. In such accidents, 4317 people died and 61637 people were injured. The main types of unsatisfactory road conditions include the absence, poor distinguishability of the horizontal marking of the carriageway (51%), lack of winter maintenance (13.7%), lack of road signs (21.9%) and pedestrian fences in the required places (9.8%), improper use, poor visibility of road signs (9.4%) [4].

In third place among the causes of the accident is a violation of the rules of the road by pedestrians. The share of such accidents is 10.56%.

The share of accidents due to the operation of technically faulty vehicles is also significant. Accidents in which technical malfunctions of vehicles were recorded, or conditions under which their operation is prohibited, amounted to 4.14% of the total.

In general, traffic accidents cause Russia and its society not only social and demographic, but also significant material and economic damage. One third of those killed in road accidents are people of the most active working age (26–40 years), and about 20% of the victims become disabled.

The country's annual economic losses from road accidents amount to about 2 percent of the gross domestic product and are comparable in absolute terms with the gross regional product of such constituent entities of the Russian Federation as the Krasnodar Territory or the Republic of Tatarstan.

A similar picture exists in many countries of the world — average road accident costs at the country level are about 3% of GDP [5].

2 Approach to Assessing the Economic Losses from the Road Accidents

It should be noted that now in Russia there is no single approved methodology for assessing economic losses from road accidents. In 2001 -- 2005, in domestic practice, a methodology was used to assess the calculation of the standards of socio-economic damage from road accidents. According to this technique, the magnitude of socio-economic damage resulting from a traffic accident includes several components: damage resulting from deaths and injuries; damage resulting from damage to vehicles; damage resulting from damage to the cargo; damage resulting from road damage. However, the approach prescribed in this document has a number of significant drawbacks (the standards used in international practice and the availability of statistical data are not taken into account) and is outdated.

Modern domestic and foreign methodological approaches to assessing the economic losses from the road accidents are described in sufficient detail in the articles “Study of foreign methods and domestic practices for determining the economic damage caused by death as a result of an accident” [6], “Approaches and methods for assessing socio-economic damage from road traffic accidents” and others. In different countries, these approaches are different, or rather different combinations of these approaches. But the main are two approaches. The first is the assessment of damage from the point of view of the theory of human capital, when the monetary assessment of the benefits that society will bear from preserving human life and health with a certain set of socio-economic characteristics is taken as the basis. The second approach is the assessment of damage in terms of the willingness of the population to pay for improving the quality of life and public safety [8].

In the general case, damage caused as a result of an accident can be considered as a combination of direct costs directly related to the accident, indirect costs and intangible losses. The first includes expenses on medical care, rehabilitation of victims, administrative, police, legal expenses, etc., the second – the costs borne by society from the reduction in the number of economically active population as a result of death, as well as full or partial disability, to the third – losses of an emotional nature: pain, sadness, grief, loss of quality of life, etc. Direct and indirect costs can be calculated in monetary terms using existing methods. Less obvious and more time consuming to calculate intangible losses [9]. Most of the existing methods are based on models of the theory of human capital and the willingness of the population to pay for risk reduction. To some extent, when calculating the economic losses from road accidents, the methodology for calculating the economic losses from mortality, morbidity and disability can be used [7] and a unified methodology for determining the amount of expenses for restoration in respect of a damaged vehicle [4]. Another option is the Methodology for assessing economic damage from death, disability and injuries as a result of an accident, the main approaches of which are shown in Figure 1.

TOTAL LOSSES = DIRECT LOSSES + LOST PROFITS

	Direct Losses	Lost profits
Fatal Outcomes	total number of deaths as a result of an accident (compensatory payments for loss of a breadwinner + expenses for ritual services in the average in the region	number of fatalities as a result of road accident x the number of man-years lost to life expectancy in the region x average income in the region per person
Disability	(total number of people with disabilities as a result of an accident) x (average expenses for medical services depending on the group of disability + disability benefits) x (the number of person-years by group of persons with disabilities to the average life expectancy in the region)	(the number of man-years lost by group of persons with disabilities to the average life expectancy in the region) x (number of persons with disabilities) x (disability weight coefficient for different groups of disabled people) x average income in the region per person
Injuries	(total number of injured as a result of an accident) x (average medical expenses depending on the category of injuries)	(average recovery period for injuries of varying severity) x (the number of persons injured by this type) x (average income per person in the region)

Fig. 1. Calculation procedure considering the gender and age structure of dead and injured

In the analytical review "Socio-economic consequences of road traffic accidents in the Russian Federation” a simplified methodology for the valuation of damage caused by deaths and injuries in traffic accidents is presented, the initial information for calculations of which is the damage standard for 2006 (calculated according to P-03112100-0502-00), as well as the size of the traffic accidents (TA) and the number of people employed in the economy.

In various documents, scientific papers and the media, the economic damage from road accidents is estimated from 2% to 5% of our country's TA and the wide variation in estimates is precisely explained by the existence of a large number of diverse approaches, methods and recommendations. Russia's gross domestic product for 2019 amounted to 110.046 trillion rubles, and therefore, even if 2% of GDP is adopted as the normative value, the economic damage from road accidents in Russia is more than 2.2 trillion rubles [10], a huge number, which indicates that this remains one of the acute socio-economic and demographic problems in Russia, requiring the intensification of the efforts of the state, business community and citizens. It should be noted that the state authorities of the Russian Federation and its constituent entities are taking measures to improve the organization and safety of road traffic by introducing modern digital and navigation technologies in the operation of road transport and improving control and supervision activities based on their use.

Under these conditions, the participating countries of the Third World Ministerial Conference on Road Safety in February 2020 in the Stockholm Declaration committed themselves to encouraging and stimulating the development, application and implementation of existing and future technologies and other innovations to expand the coverage and improve all aspects of road safety movements from accident prevention to emergency response and the provision of medical care in case of injuries.

3 Smart Traffic as the Solution of the Problem

In particular, the most important steps in improvement of the traffic management making it the smart one are:

- equipping vehicles with satellite navigation equipment, emergency call systems, tachographs with video surveillance systems;
- creation and commissioning of the GAIS “ERA-GLONASS”, regional navigation and information systems, the “Platon” charging system;
- deployment of video recording systems for traffic violations and weight and weight control;
- implementation of components of intelligent transport systems and hardware systems “Safe City”, etc.

Of course, there is a certain effect from the implementation of each of these systems, but today it is time to achieve a synergistic effect from the integrated use of advanced technologies in order to prevent accidents or minimize its negative consequences for the life and health of citizens, the state of transport complex facilities (if the incident is happened).

One of the possible ways to achieve such a synergistic effect is the transition from automated systems for recording traffic incidents to automated systems for detecting and managing traffic incidents in real time, based on the use of video detection technologies and transport analytics.

Such systems using cameras can automatically recognize events in the passenger compartment of the vehicle (deviations in driver behavior, riots among passengers, things left behind), on the road network (large crowds and riots on the street, a person lying down) and highways (accident, vehicle fire, traffic jam/congestion, a pedestrian knocked down, the appearance of obstacles or ground failures on the road, for example, a fallen tree or pole).

The use of additional sources of information (sensors of various physical nature and panic buttons in the vehicle interior and transport infrastructure objects, data from the ERA-GLONASS and 112 systems, etc.) can significantly expand both the range of detected incidents and the range of typical algorithms their automated mining. Currently, damage reduction from the consequences of incidents in the road transport complex is achieved, mainly, by the following set of organizational and technical measures:

- driver control;
- road condition monitoring;
- identification of violations of traffic rules and the identification of accidents.

So, the main methods for controlling the driver are: pre-trip and post-trip medical examinations, traffic control by the traffic police, traffic controllers. In addition, a unified system of electronic digital waybills is introduced in the Russian Federation, which allows controlling the rules for the transport of passengers and goods. Information environment is created where, in the automatic mode, visual information on the driver's condition before and during the vehicle's movement can be recorded also in real time [11,12].

As the main technical means of driver control, CCTV cameras are used, including those with video analytics functions. Unfortunately, they do not have quick response mechanisms from dispatching, operational services and emergency response services.

The main methods for monitoring the condition of the roadway are: visual inspection, automated monitoring by mobile complexes, video surveillance, data collection from road users. As the main technical means, automated mobile complexes for monitoring the condition of the roadbed and road infrastructure facilities [13], specialized social networks (https://dorogi-onf.ru), video surveillance equipment on the roads (http://www.cud59.ru). The condition of roads is also studied using unmanned aerial vehicles [14,15].

The most promising from the point of view of the rapid detection of incidents on the roads and in transport are the methods and means of photo and video recording of traffic violations and the detection of road incidents.

The main methods are: reports of road accident participants, eyewitnesses, police officers; automated incident detection, including ERA GLONASS; video monitoring.

Means – telephone and radio communications, social networks, special hardware and software systems for detecting incidents on the road network [16], means of surveillance video surveillance on the roads (http: //www.cud59.ru).

Unfortunately, about the presented methods and means, despite the fact that they individually solve the tasks assigned to them to ensure the effective and safe operation of transport and road infrastructure facilities, there is a major and serious drawback: they do not allow operational, in real time, identify the prerequisites for the occurrence of incidents and the incidents themselves and promptly organize their elimination.

In this regard, in scientific and technical articles and publications, articles and studies are increasingly appearing on methods and means of quickly detecting incidents on the roads through artificial intelligence technologies and video analytics. In addition, there are more and more projects, startups related to this topic.

According to Berg Insight research [17], the video telematics market is growing at a rate of 15.6% per year. So, in 2019 in the United States 1.6 million installed active video telematics systems, in Europe 1 million. According to forecasts, in 2024 the market in Europe and the USA will grow to $ 1.5 billion.

According to this study, one of the largest suppliers of such systems is Lytx [18]. The main tasks solved by their systems are driver identification, identification of dangerous driving and warning the driver in real time about dangerous driving behavior.

In addition to Lytx, a notable player in this market is the Trafficvision solution. The solution is based on video analysis of a video stream from video cameras and allows you to automatically detect:

- oncoming traffic;
- slow motion (slower than a given speed for a certain time);
- a stopped car or mechanical obstruction on the road;
- pedestrian on the road;
- traffic jam if traffic jam has reached a certain fraction of the visible length of the road.

The solution of the Citylog company (www.citilog.com) offers the solution of the following tasks:

- automatic detection of incidents;
- collection of traffic information;
- intersection management (adaptive control based on data from video cameras).

MediaVMS solution integrates several technologies of intelligent transport systems:

- video analytics;
- automatic detection of incidents;
- license plate recognition;
- traffic data;
- smart traffic as control of intersections, smart traffic lighting.

Valerann (www.valerann.com/solutions) is a startup that creates an artificial intelligence-based traffic control system. It is based on special sensors built into the roadbed and collecting traffic information, using data mining and artificial intelligence, transmitting information wirelessly. The system collects, analyzes traffic data, predicts dangerous traffic situations.

Brisksynergis (brisksynergies.com) based on an analysis of the interaction between traffic participants, analyzes the organization of traffic, identifies incidents that did not happen by a lucky chance, in order to make changes to the organization of traffic:

- real-time incident prediction, collision risk assessment;
- analysis of road safety / road infrastructure;
- analysis of user behavior on the road.

System I2V (www.i2vsys.com) based on the existing road video cameras networks and video analytics provides information about the incidents:

- Automatic fire detection;
- Advanced Motion Detection;
- Perimeter Tripwire;
- Abandoned Object Detection;
- Determination of the disappearance of an item;
- Zone Intrusion Detection;
- Boundary Loitering Detection;
- Intelligent People Counting;
- Crowd Counting and Detection;
- Object Classification;
- Attribute Search;
- Vehicle Speed Detection;
- Stopped Vehicle Detection;
- Wrong Way Detection;
- No Helmet Detection;
- Automatic Traffic Counting and Classification;
- Vehicle counting and classification system for integration with toll systems on toll roads, for online monitoring and offline analysis.

Let’s consider the "classic" response scheme for various incidents in the transport (road) system of a typical city agglomeration.

In the event of an incident more often participants or witnesses of it exist (including video surveillance equipment) who, using available means (phone call, SMS, mobile application, service radio, the operation of specialized detectors, etc.), report the incident to a certain abstract center (this can be a dispatch center in the event of an incident on board of a passenger vehicle or another incident witnessed by a bus driver, it can be a traffic safety center or a call reception dispatch center of System-112 if an accident/traffic accident occurred on a street urban agglomeration road network with the participation of road or rail transport, it can be a control point in the event of cracks/failures/flooding on the infrastructure of artificial road structures (bridges, overpasses, tunnels), etc.).

The center staff receives an incident report, verifies its reliability, first classifies it and must perform a certain series of actions according to the scenario (regulation rules) of the typical proceeding for the fixed incident. Moreover, depending on the severity of the incident itself, as well as possible consequences, in order to minimize them, the center employee should organize (if necessary) high-quality and operational interaction with other services. Not only the size of the resulting material damage, but also human lives often depends on the correct and timely actions of the center's personnel.

In the course of analytical studies in the period 2018-2020, a number of existing systems for managing (responding) incidents in the transport complex in the regions of the Russian Federation were analyzed. One of the result of the study was detection of the following systems flaws:

- low speed and reliability of incident detection (in some cases, eyewitnesses / participants cannot reach the relevant services due to insufficient call center capacity and "busy telephone syndrome");
- most of the functions of notification and coordination of services in resolving incidents are performed manually, by telephone;
- "watching and seeing is not the same thing" -- the majority of video cameras located on the street-road network of the city agglomeration operate in archive mode without any analytical processing in the operator rooms (in this case, incident data is mainly claimed by incident participants only for their requests when providing information to the group of traffic accident analysis or to the court);
- the relatively low level of wages of dispatch center personnel causes staff turnover in key responsible positions, while an employee with insufficient qualifications (little experience) may act reflexively at the time of a serious incident, violating established regulations and instructions.

Despite the undoubted advantages and effects of existing and promising methods and means of identifying incidents on the road network and transport, their main drawback, which does not fully ensure road safety, is the fragmentation, lack of comprehensive technology and systems for detecting road incidents and their premises and management coordinated development and mitigation with the possibility of big data analytics and predictive analytics.

In this regard, in order to increase the efficiency and reliability of identifying incidents on the street-road network of urban agglomerations and managing them, it is proposed to consider the possibility of using methods and means for automatically detecting incidents based on video recording technologies, video analytics and machine learning (based on the mathematical apparatus of neural networks) to ensure automatic incident detection in the form of a distributed video analytics platform (video surveillance and incident detection). At the same time, in order to increase the efficiency of the procedure of direct testing and coordination of participants, it is advisable to ensure the integration of the video analytics platform with the incident management system. Thus, the implementation of a real-time applied incident management system is proposed.

It should be noted that the main problem of the most existing video analytics systems is the high frequency of false positives, which quickly reduces the economic effect of the technology. The problem is gradually being solved by improving video analysis algorithms, automatic testing on special test benches and ranking events by importance. Another problem is the significant cost of the system integration and implementation of video analytics. The role of this factor is reduced due to the emergence of open standards such as ONVIF (Open Network Video Interface Forum), simplification of calibration procedures and video analytics settings.

The main functional steps for responding to an incident subject to the implementation of a full-cycle incident management system are (see Figure 2):

1. detection (fixing) of the incident;
2. classification, loading of a video fragment (if possible);
3. determination of the most optimal scenario (regulation) of development / elimination of consequences.

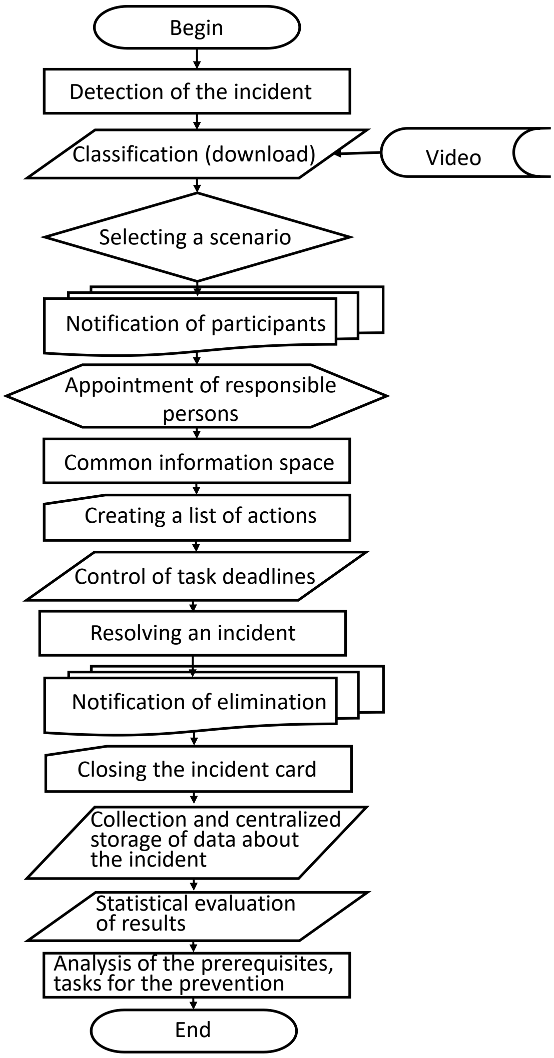

Fig. 2. Algorithm of the main functional steps for responding to an incident subject to the implementation of a full-cycle incident management system

4. notification of officials and responsible persons proceeding the documents of the road incidents (if necessary);
5. the appointment of responsible persons (central coordinator, delegation of responsibility to hierarchically superior units (if necessary);
6. organization of a common information space for data collection and coordination of actions (formation of an incident card and a dynamic conference communication group (if necessary);
7. the formation of a list of actions / tasks for each proceeding area;
8. control of the deadlines for completing tasks by each participant, the formation of recommendations (if necessary);
9. the elimination of an incident according to its type under the regulations;
10. notice of rectification;
11. closing the incident card;
12. collection and centralized storage of incident data (photo, video, audio materials from the scene of the incident, aggregation of various reports on the actual actions of the participants);
13. statistical evaluation / analysis of the results of mining (assessment of personnel efficiency);
14. analysis of the prerequisites, the formation of tasks for prevention.

A number of similar pilot projects are currently being implemented in the Russian Federation, with the successful implementation of real-time detection and control systems of the road incidents. An example is TransNetIQ's solutions, which have proven their success in a number of regions (Perm Territory, Kursk, Ryazan regions) based on using real-time passenger transport cameras (via the mechanisms of a hybrid video analytics system based on neural network processing). TransNetIQ system allows:

- on-line detection of the traffic incidents based on the vide-cameras data;
- monitoring the physical state and driving style of drivers;
- video surveillance inside passenger vehicles to provide data to authorized bodies (with the ability to search for the necessary video clips by time and georeferencing events/incidents);
- integration with ERA-GLONASS and System-112 systems;
- integration with specialized social networks for additional detection of potential incidents (events);
- decision support based on the objective data (video and photo materials from the scene of the incident, including online, an objective picture of the effectiveness of the actions of all participants involved in the development of the incident);
- an expanded adaptive system of recommendations for personnel actions in accordance with the approved regulations;
- the possibility of retraining neural network sensors during the operation of the system based on feedback from employees of the dispatch center.
- systems for detecting and managing traffic incidents, while ensuring real-time availability.

Fig. 3. An example of an accident detector on board of the passenger bus

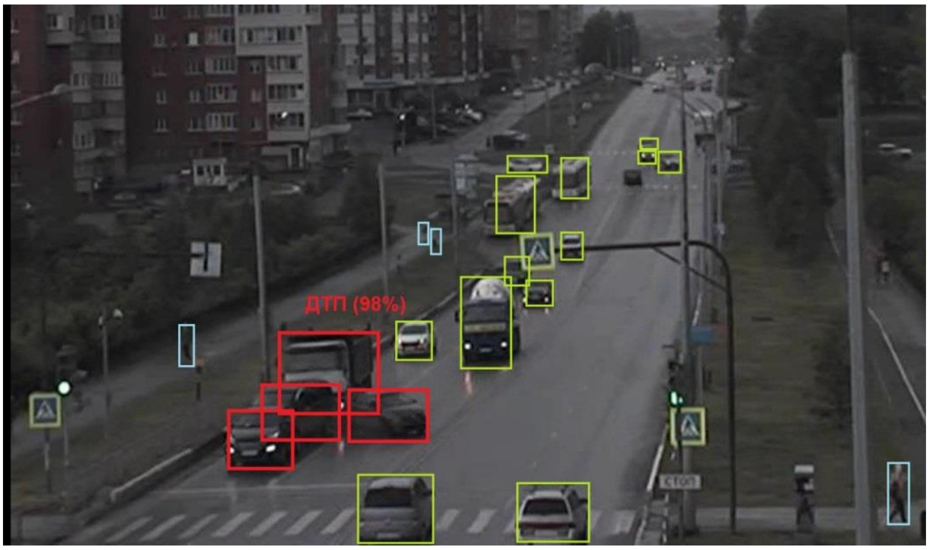

Fig. 4. An example of an accident detector by a traffic control video camera

The effectiveness of such systems was tested during experimental testing, including through urban exercises. The comparison was carried out on two cohorts of road incidents on ground urban passenger transport. As a result of pilot implementations of the full-cycle incident management systems, the following effect is noted:

- reduced response time and incident handling (up to 40%);
- increasing the efficiency of informing management about incidents and the progress of their development (up to 40%);
- improving the quality of incident handling (up to 20%);
- reduction of time for incident handling by dispatching personnel of organizations involved in liquidation of consequences of incidents (up to 30%).

At the same time, such systems provide effective coordination of actions of transport organizations and emergency services in response to incidents.

In conclusion, it should be noted that the resolution of emergency situations is one of the basic tasks of any management process. In different countries, the same management tasks are being solved, but the methods for solving them differ. The article "Features of National Management" identifies the American, Japanese and Russian management models. The unconditional and recognized leader who has been exporting his management practices for over 100 years is the American management model. This model has the most developed conceptual apparatus, which is also used in other national management models. One of such universal concepts, the analogues of which are present in all control models, is the concept of “incident”.

In their historical circumstances, each of the above management models was formed on its dominant incident management scenario:

- the Japanese model was built on a scenario to prevent incidents, eliminate the causes before they start generating incidents;
- the American model was built on a scenario to quickly eliminate incidents until they turned into a crisis situation;
- the Russian model was built on a scenario to quickly eliminate crisis situations until they turned into a disaster.

Each of these models has its own advantages and disadvantages; inevitably, in each model, to one degree or another, there are also scenarios that are more characteristic of another control model.

Of course, regardless of the management model, the best way to deal with incidents is to prevent them, that is, to create conditions that exclude or at least minimize the likelihood of incidents. But in the case when the incident nevertheless becomes a reality, the effectiveness of measures taken to eliminate both the incident itself and its onset and/or potential consequences is crucial. In solving these problems in Russia, the best foreign incident management practices are increasingly being introduced.

It is also important that with a large flow of incidents, the response to some incidents must be postponed to a later time. That is, incidents must be ranked according to the scale of possible consequences, and, consequently, the urgency and scale of the reaction to them.

With regard to the management of road incidents, this means the special importance of the rapid detection and ranking of incidents according to the degree of (potential) damage to the health of the participants of the incidents, and their socio-economic consequences.

As experience shows, the time to bring emergency traffic information to the accident using traditional means (telephone) takes at least 5-10 minutes. Significantly reduces this time the commissioning of the ERA-GLONASS system, but the low percentage of equipping vehicles with emergency call devices, as well as their failure in certain conditions (for example, in case of minor accidents) determine the special role of video surveillance systems (video recordings) and video analysts in the process of managing incidents in automobile transport, especially taking into account the significantly increasing number of photo and video recording cameras annually (as of the end of 2019, there are 12.5 thousand pieces of stationary cameras only).

In the modern sense, the essence of incident management processes consists in the implementation of automated algorithms for collecting data about traffic incidents, detecting events based on this information, and creating and working out options (performing a sequence of measures) for optimal response to them.

The basis for the implementation of these algorithms is an integrated intellectual processing of data got from video surveillance systems, satellite navigation and other sources, as a result of which answers must be obtained not only to the questions “WHAT?” (what happened and under what conditions), "WHERE?" (in what place and in what environment), "WHEN?" (at what time and under what seasonal and diurnal features)? ”, as well as a strategy and tactics for responding to the incident [6,7]. At the same time, the answer to the eternal Russian question “WHAT TO DO?” must be formulated in one or more scenarios.

It should be noted a number of related factors that can reduce the cost of implementing video analytics and incident management systems. These include:

- a significant number of cameras installed on federal highways and the road network of settlements in order to control traffic. Requirements for installation locations and technical specifications are normatively established in national standards (GOST R 57144–2016 & GOST P 57145–2016). An affordable price and a short payback period contribute to a significant annual increase in the number of photo and video recording complexes (the price of a stationary complex of video and video recording violations varies between 2 million and 5 million rubles, the payback period is 3-5 months . In 2019, the number of fines for motorists increased to a record high - more than 142 million fines were issued to Russian drivers, and the total amount of fines exceeded the milestone of 100 billion rubles);
- equipping vehicles with satellite navigation equipment and emergency call devices in accordance with the technical regulations of the Customs Union “On the safety of wheeled vehicles”. The requirements for these on-board devices are also established in interstate and national standards;
- the presence in the regions of significant computing power that can be used (traffic management centers, regional navigation and information systems, etc.).

4 Conclusion

Thus, for the implementation of traffic incident management systems, only an increase (if necessary) in server capacities, the development of a scientific and methodological apparatus and special software are needed.

The effects of the introduction of photo and video recording technologies, video analytics and satellite navigation in the systems for detecting and managing traffic incidents are:

- reducing the time to bring information about transport incidents to emergency operations services (due to the automatic detection and detection of events);
- reducing the number of employees involved in incident analysis today and reducing the influence of the "human factor" on the quality of video detection processes (due to the implementation of automatic processes);
- ensuring the rational use of forces and means of emergency operational services (by detecting, ranking incidents and using optimal response algorithms for them);
- reducing mortality in road accidents (by increasing the efficiency of the distribution of forces and emergency medical facilities and units of the Ministry of Emergencies of Russia when planning measures to prevent accidents and eliminate their consequences);
- reducing economic losses from traffic incidents (by preventing the occurrence and timely response to accidents and other incidents, as well as organizing automated information for road users).

Ultimately, the implementation of automated systems for managing of the traffic incidents will increase the safety of passengers and goods, the efficiency of transport work by carriers, the stability and quality of public transport services.

References

1. Identified the main causes of accidents in Russia. https://www.zr.ru/content/news/914726-nazvany-osnovnye-prichiny-avari/# (2020). Accessed 11 May 2020

2. The main causes of accidents on Russian roads in 2019. https://www.9111.ru/questions/777777777797951 (2019). Accessed 12 May 2019

3. Road Safety Strategy in the Russian Federation for 2018-2024 (approved by the Order of RF Government 08.01.2018 № 1-p)

4. Road traffic accident in the Russian Federation for 12 months of 2019. Information and analytical review. Moscow. FKU "NTs BDD MIA of Russia", 2020, 21 p.

5. Elvik, R., How Much Do Road Accidents Cost the National Economy? Accid Anal Prev. Nov;32(6) (2000):849-51. https://doi.org/10.1016/s0001-4575(00)00015-4

6. T.S. Karabchuk, A.A. Moiseeva, N.E. Sobolev, The study of foreign methods and domestic practices for determining the economic damage caused by death as a result of an accident. Economic Sociology, vol.16., No.5, November 2015, https://cyberleninka.ru/article/n/issledovanie-zarubezhnyh-metodik-i- otechestvennyhpraktikopredeleniya- ekonomicheskogo-uscherba- nanosimogo- gibelyu-v- rezultate-dtp. Accessed 13 May 2020.

7. Assessment of socio-economic damage from road accidents in Russia: methodological issues in the context of foreign studies, Higher School of Economics, Moscow, 2015, https://lcsr.hse.ru/data/2016/02/16/1139248711/GIBDD_17.12.2015.pdf. Accessed 13 May 2020.
8. N. A. Popov, Approaches and methods for assessing socio-economic damage from road traffic accidents. In: Strategic decisions and risk management, vol.10, No.3, 2019, http://www.fa.ru/org/dep/men/coik/SiteAssets/Pages/ publications/ 852-1889-1-SM.pdf. Accessed 2 Feb 2020.
9. E.S. Demakhina, N.S. Pogotovkina, E.A. Nikitin, V.A. Parkhomenko, Socio-economic consequences of road traffic accidents in the Russian Federation. Quality and Life, No.3, 2018, http://ql-journal.ru/ articles/ru/ 2018/3/ 3_2018_sait_61-64.pdf. Accessed 11 Dec 2019.
10. ROSSTAT presents the second GDP estimate for 2019, https://www.gks.ru/folder/313/document/81201. Accessed 16 Feb 2020.
11. F. Kessels, Traffic Flow Modelling. Introduction to Traffic Theory Through a Genealogy of Models (Springer, 2019).
12. S. Escalera, X. Baró, O. Pujol, J. Vitrià, P. Radeva, Traffic-Sign Recognition Systems (Springer, 2011).
13. Tselykh DS, Privalov, OO (2012) Devices for analysis and evaluation of road surface condition. In; Technical Sciences: theory and practice: Proc. of I International research conference (Chita, 2012), pp.74-78. Chita, Molodoy Ucheny, 2012, https://moluch.ru/conf/tech/archive/7/2149. Accessed 17 Apr 2020.
14. D.V. Filippov, K. Yu. Velikzhanina, Unmanned aerial vehicle studies the roads conditions, Portal 'Russian Drone', 27.12.2017, https://russiandrone.ru/publications/sostoyanieavtomobilnykh-dorog-izuchaet-bpla (2020). Accessed 11 Apr 2020.
15. Fines in the morning, money in the evening, https://www.kommersant.ru/doc/4011628?from=doc_vrez (2020). Accessed 11 May 2020.
16. Earnest P.I., Dhananjai C., Savyasachi G., Goutham K. Computer Vision-based Accident Detection in Traffic Surveillance, arXiv:1911.10037v1 [cs.CV], https://arxiv.org/pdf/1911.10037.pdf. Accessed 22 Nov 2019.
17. Berg Insight research, The Video Telematics Market 2020, http://www.berginsight.com/ReportPDF/TableOfContent/bi-videotelematics-toc.pdf (2020). Accessed 15 Apr 2020.
18. Lytx Video telematics systems, https://www.lytx.com/en-us/fleet-management/fleetsafety/telematics-system (2020). Accessed 6 May 2020.