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DEVELOPING NOVEL REGISTRATION OF ROAD TRAFFIC ACCIDENTS

Jamshid Sodikov , Quvonchbek Musulmonov , Dilshod Imamaliyev *

Department of "Construction and Maintenance of Automotive Roads", Tashkent State Transport University, Tashkent, Uzbekistan

*E-mail of corresponding author: dilimshod@gmail.com

Resume

The paper reviews the road traffic accident registration form and discusses existing practices carried out in Uzbekistan. The popularity of mobile phones/tablets and internet technologies in daily use and their increasing power in terms of speed and memory could assist efficiency and accuracy in the road traffic accident data collection. The authors review up-to-date mobile/internet technologies for the road accident data registration and propose a novel approach that covers various data sources including police data, hospital data, road department data, insurance company data, transport company data and social media data. The proposed approach integrates all the data into a single system (database), which can be used for public audit and research purposes.

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1 Introduction

The likelihood of the road traffic accidents (RTA) is random because road traffic accidents happen due to several factors or a combination of factors that characterize its randomness. It is customary to consider the driver-vehicle-road system as the main factor influencing the occurrence of an accident. The lion's share of accidents of these factors lies with the driver, about 80 %. The road traffic accidents are one of the most important social problems at present. With improvement of the welfare and growth in the level of motorization, the growth rate of accidents on the roads increases every day.

According to the latest data from the World Health Organization (WHO, 2018) [1], 1.35 million people die every year around the world, in other words, almost 3,700 people die every day on the world's roads and about 20-50 million people sustain various non-fatal injuries, more than half of all deaths and injuries happen to vulnerable road users such as pedestrians, cyclists and motorcyclists and their passengers. Young people are particularly vulnerable on the world's roads and the road traffic injuries are the leading cause of death for children and young people aged 5-29. Young men under the age of 25 are more likely to be involved in the road

traffic crashes than women, with 73 of all the road traffic deaths occurring in young men of this age. Developing countries have higher rates of road traffic injuries, with 93 % of deaths occurring in the low- and middle-income countries. In addition to the human suffering, caused by road traffic injuries, they also carry a heavy economic burden on victims and their families, both due to the cost of treating the injured and the loss of productivity of those killed or disabled. More broadly, the road traffic injuries have a major impact on the national economy, costing countries 3% of their annual gross domestic product, both due to the cost of treating the injured and due to the loss of productivity of the killed or disabled.

According to the concept of ensuring road safety in the Republic of Uzbekistan for 2018 - 2022, statistical indicators show that annually on the territory of the Republic of Uzbekistan there are on average about 9-10 thousand road accidents, including more than 2000 of the - human victims (Directive 377, 2018) [2].

2 Literature review

Accounting for the road traffic accidents plays an important role, since based on the data it is possible to identify the road sections with the highest number of

Table 1 Road accident data collection state of the art

No.	Research paper/report	Authors	Findings
1	Design and development of a prototype mobile geographic information system for real-time collection and storage of traffic accident data (thesis), 2016 [10]	Peter Markus	Researcher reviewed existing STRADA crash database used in Sweden, highlighted shortcomings. Based on that author proposed the smartphone-based crash data collection and layout web application for visualization and data analysis.
2	Critical Review of the International Crash Databases and Proposals for Improvement of the Italian National Database, 2012 [11]	Alfonso Montella, David Andreassen, Andrew P. Tarko, Shane Turner, Filomena Mauriello, Lella Liana Imbriani, Mario A. Romeroc, Rohit Singh	Authors critically reviewed the crash data base in developed countries and point out weaknesses of existing Italian crash database. They stressed out the following key points: consistency in crash data collection by police officers, national crash database should include all the relevant information and recommended improvements of the highway police practice.
3	Development and evaluation of a web-based software for crash data collection, processing and analysis, 2017 [12]	Alfonso Montella, Salvatore Chiaradonna, Giorgio Criscuolo, Salvatore De Martino	Researchers overview state of the art road accident data collection around the world and pinpoint main issues and prospects for improvement. They mentioned key aspects of software framework, structure of database, features of the system. Authors proposed ReGIS web-based software platform-independent, for the crash data collection, processing and analysis, which can be used as mobile and desktop application.

road traffic accidents (RTA), that is, their concentration. The probable cause of the origin can be also determined; the accident itself is a probable phenomenon, therefore, the causes of origin are indirectly probabilistic. It is generally known that the occurrence of an accident is due to the three classic factors driver-car-road, some researchers also suggest taking into account the environment.

For a correct assessment of the road safety, an electronic accident database should be available. Additionally to create an electronic database of road accidents, an electronic road accident registration system should be introduced. At present, accidents in Uzbekistan are recorded in paper format but stored in an electronic database. The disadvantage of this approach is that when converting from a paper to an electronic version, there is a high probability of subjective factors that affect the quality and reliability of the data entered. There is also a time lag when one needs to get the latest reports in real-time. One of the main disadvantages of this method of accounting for accidents is that it is impossible to accurately determine the location of an accident since when filling out a registration card, the location is tied to the closest object, for example, a school, store, building etc.

Consequently, the relevance of the electronic registration development of the road accidents is increasing, with existing technologies, such as tablets, smartphones and other devices that are connected to the Internet, which have built-in GPS modules that allow to effectively solve the problems of electronic registration of road accidents. It is also important how much data is required to collect the crash data. Since the more data is required to collect, the more time and money is required to collect. Sodikov, 2018 [3] provides

a table of the existing road traffic accident registration card. It consists of 12 forms of filling out by an employee of an internal affairs body (traffic police officer) such as 1. General information, 2. Location (village, town), 3. Location of an accident on the road, 4. Road condition, 5. Violation of traffic rules by pedestrians, 6. Driver information, 7. Vehicle information, 8. The ownership of the vehicle, 9. Victim information, 10. Additional information, 11. Description and diagram of the accident, 12. Measures taken.

Since the existing accident registration requires the collection of a lot of data, therefore, the time spent on filling it out increases. Software for photo recognition (computer vision), machine learning (big data processing and forecasting) and others are already available and widely used. Therefore, to improve the productivity and accuracy of data collection, it is necessary to timely introduce new information technologies. In this direction, scientific prerequisites have been proposed by a number of researchers [4-9]. In addition, the researchers listed in Table 1 worked on this issue and offered their recommendations on the approach to registering road accidents. Currently, the traffic safety authorities keep records of accidents according to the corresponding forms, in a handwritten form. Traffic accident data collection requires a lot of time, sometimes for a district or city scale a few days and for a country level a week and sometimes more. Electronic registration of the road accidents with the use of geoinformation technologies has been proposed, [10-12]. A tablet computer running android or IOS is proposed for the data collection. The proposed electronic card for the traffic accidents has several advantages and will save the employee's time. First of all, after arriving at the scene of the accident, the employee takes a photo with the geolocation function,

Table 2 Main sources of data on road accidents

Source	Data type	Remarks
State Traffic Safety Administration of the Ministry of Internal Affairs of the Republic of Uzbekistan.	1. General information, 2. Location (village, town), 3. Location of an accident on the road, 4. Road condition, 5. Violation of traffic rules by pedestrians, 6. Driver information, 7. Vehicle information, 8. The ownership of a vehicle, 9. Victim information, 10. Additional information, 11. Description and diagram of the accident, 12. Measures taken.	Access to the road traffic accident database is internal and limited. There are assumptions about the underreporting of road accidents. There is a database, but there is no subsystem for identifying causes and effects. No electronic exchange with other state organizations.
Road organizations	According to MKN 15-2007 „Rules for the registration and analysis of road accidents on highways“, attention is mainly paid to the assessment of road conditions	Access is limited, there is no electronic database. No electronic exchange with other state organizations.
Vehicle fleets and transport companies	Road traffic accidents registered by transport organizations whose vehicles were involved in an accident.	Access is limited, there is no electronic database. No electronic exchange with other state organizations.
Ministry of Health	Number of road traffic accidents, number of fatalities, number of non-fatal injuries, age and gender of victims, driver's condition, age, occupation registered.	The base is not systematized, there are various discrepancies, incomplete data. Access is limited. No electronic exchange with other state organizations.
Insurance companies	Fatal and non-fatal injuries, damage to vehicles, cost of claims	There is no electronic database. Access is limited, no electronic exchange with other state organizations.
Social media	Mainly photography, from where one can determine the time of the incident and the types of vehicles	Access is not limited, but there is no systematic collection of data

which will allow visualizing the given accident in an electronic map (QGIS, ArcGIS, or Google Fusion). After that, one can use the electronic driver's license database to determine the characteristics of the driver/vehicle or to recognize the photo. The built-in scheme library can be used for drawing the road accident diagram.

Vision Zero, adopted in 1995, represented a fundamentally new way of looking at road safety problems and their solutions. Vision Zero is a multinational road safety project that aims to create a road system without fatal or serious traffic-related injuries. It started in Sweden and was approved by their parliament in October 1997. The core principle of the vision is that “Life and health can never be exchanged for other benefits in society” rather than the more traditional cost-benefit comparison, in which life and health are valued in monetary terms and then this value is used to decide how much money to spend on the road network to reduce risk. Vision Zero means that ultimately no one will be killed or seriously injured in the transport system, [13]. Currently, the zero-mortality concept has been introduced in countries such as Canada, the Netherlands, the United Kingdom, the United States, Norway and other countries.

The Zero Death Concept views the road transport system as a whole, whose components - roads, vehicles and pedestrians - work together to ensure safety. This holistic approach is fundamentally new in the field of the road safety. The concept of zero deaths implies a new perspective on responsibility. The primary responsibility for safety rests with the creators of the road transport system - road services, vehicle manufacturers, carriers, politicians, government officials, legislators and the

police. The concept of zero mortality consists of many components, each of which contributes to improving road safety: these are ethical principles, human qualities, responsibility and scientific data.

3 Methods

Accidents are recorded by several government agencies. Those are the State Traffic Safety Inspectorate of the Republic of Uzbekistan, the Ministry of Health, Road services. However, there is a problem of data exchange between government organizations. Table 2 lists the main sources of crash data. As can be seen from Table 2, despite the fact that there are various sources of collection and recording of road accidents, there are several problems such as the incompleteness of data, lack of a single electronic database, lack of electronic data exchange between government departments and causes underreporting of road accidents.

Regardless of the data source on road accidents, there are certain problems associated with recording and collecting data. The most complete base, in terms of storing and processing data, can be considered the electronic database of the State Traffic Safety Inspectorate of the Ministry of Internal Affairs, which currently more or less meets modern requirements.

However, the main drawback is the paper-based crash accounting method, which prevents accurate and timely crash registration. Therefore, a methodology for electronic data collection using modern tablet computers should be developed. A unified electronic system for collecting, storing and analyzing data on road accidents

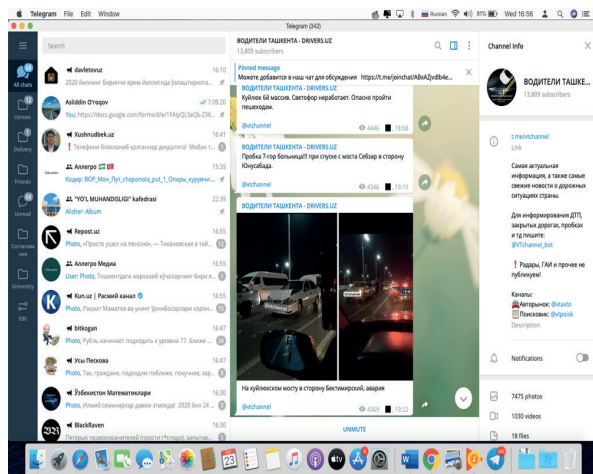


Figure 3 Photo report of the accident (source: page of the group “Drivers of Tashkent” of the social platform “Telegram”, [3])

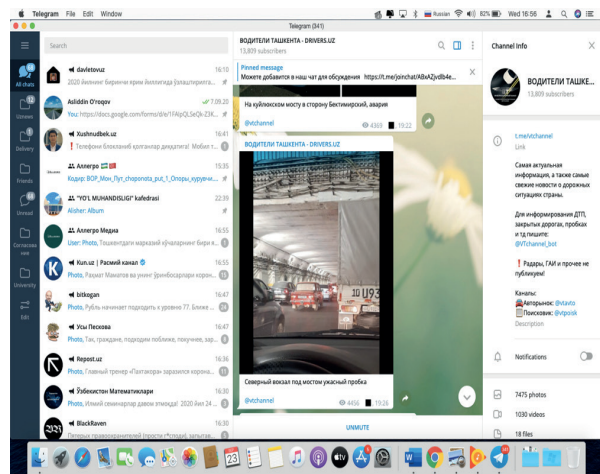


Figure 4 Traffic jam photo report (source: page of the group “Drivers of Tashkent” of the social platform “Telegram”, [3])

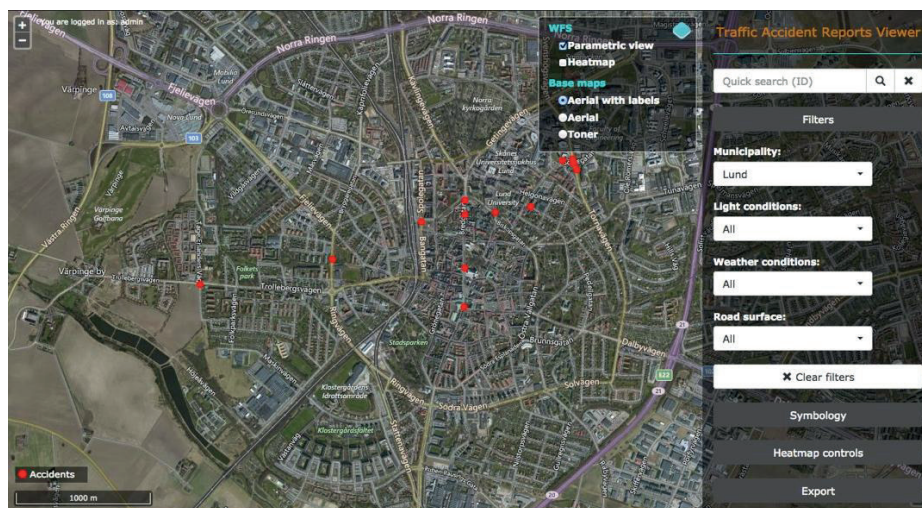


Figure 5 An example of visualization of the location of an accident, [10]

cited definition of a fatal road traffic accident is “any person who is killed immediately or died within 30 days in a road traffic accident (Preliminary report, 2003) [14]. However, there are different periods to determine the days after which a person can be considered killed due to an accident. For example, the European Union, Greece, Portugal and Spain use 24 hours, France uses 6 days, Italy uses 7 days and other countries use 30 days (Mackay, 2006) [15].

Insurance companies keep records of accidents in terms of fatal and non-fatal injuries, vehicle damage and the costs of claims. In addition, there is no electronic registration nor the data exchange for further analysis of the consequences of road accidents.

The development of information technology, as well as the penetration into the daily life of social networks, makes it possible to register the events taking place in real-time. Existing telegram channels/communities such as “Drivers of Tashkent”, “Behind the Wheel” and others allow keeping records directly during the

accident or immediately after the accident. The pages of the publication of posts about road accidents on the social network “Telegram” in the group “Drivers of Tashkent” are shown in Figures 3, 4. Therefore, in this direction, attention should be paid to creation of a traffic accident registration boot, which would allow collecting preliminary information about incidents.

Sweden is a leader in the road safety with the lowest death rate of 3 per 100,000 inhabitants. The number of road traffic fatalities per 100,000 inhabitants in Sweden fell by 52% between 2000 and 2018. In 2018, there were 3.2 deaths per 100,000 inhabitants, up from 6.7 in 2000. For comparison, the European Union average is 4.9 deaths per 100,000 inhabitants in 2018 (Road Safety Annual Report, 2019) [16].

Studies carried out by Markus, 2016 [10] and Sjöo and Ungerback, 2007 [17] in Sweden have shown that the use of outdated crash data collection methods revealed the following disadvantages: reporting delays, reports with insufficient information such as attribute

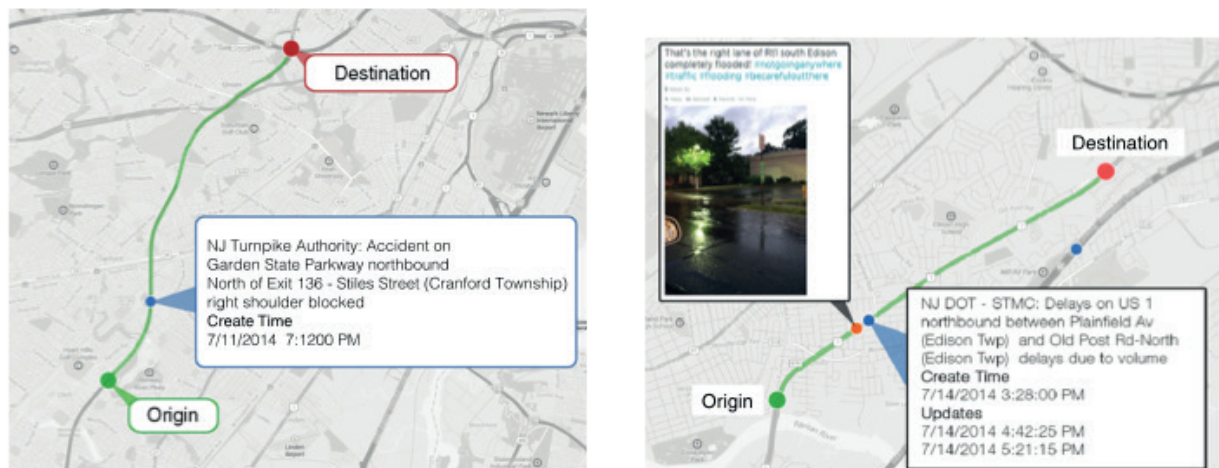


Figure 6 An example of visualization of accidents and road problems in the state of New Jersey, [18]

data and inaccurate location. According to researchers [3, 9 and 10] using a GPS device could increase the accuracy of the location of an accident. Figure 5 provides an example of visualization of an accident, as well as the area, lighting, weather conditions, type of coverage. This application is based on an open-source software that allows to develop additional functions for statistical analyzes and construction of various thematic maps, such as the concentration of road accidents, zones of hazardous areas (heatmaps) and others.

A review of the literature shows that, even the country with the lowest number of the road accidents per 100,000 people, is at the stage of developing electronic accounting and analysis of road accidents.

Several researchers have attempted to collect data using internet technology. For example, the state of New Jersey used the social network Twitter to collect data on traffic conditions and accidents. The popularity of alternative data collection procedures among researchers in various fields has increased, especially with the development of mobile and wireless devices over the past two decades. Authors of [18] highlighted an improved data collection method, which was presented for analyzing traffic conditions and traffic accidents. An integrated database system using the open online data sources for real-time traffic information. At the same time, the main goal of the study is to collect and use data for sections of the transport network where the physical sensor infrastructure is limited at best. Figure 6 shows an example how in the real-time it is possible to get data from the social networks and visualize. Although the data that is collected in this way does not allow obtaining detailed data on road accidents, it plays a huge role in the timely response of the police and ambulance.

The sections of the road where an accident occurred can be determined in the real-time. A photo of the scene can be also obtained if the user posted it on his Twitter account.

When switching from paper technology, or a semi-

computerized road accident accounting system, to a complete electronic accounting system using mobile devices (smartphones, tablets), it can increase accuracy, timeliness, describe the incident in more detail using audio, video, photos, sketches and geolocation. It shows that outdated methods of collecting data on road accidents do not provide data promptly, at times it can reach up to 50 days from the time of registration of the road accidents at the scene of the accident until the storage to a central database for further processing and development of measures to prevent the occurrence of road accidents. Accordingly, this entails not only incompleteness of the database but underreporting of road accidents, as well.

Underreporting of road accidents is relevant even in developed countries. In all the countries, there is a problem of underreporting road accidents with victims. In the Scandinavian countries, where the accounting system is at a high level, an average of about 50 % of road traffic accidents with injuries are recorded. In the UK, only 60 % of accidents are recorded, in which drivers or passengers of vehicles were injured, in Australia - about 70 %, in New Zealand and Spain – 67 %. In Russia, there is also an underestimation of road accidents with victims and is about 10-20 % according to [19].

Mortality due to road accidents is a special object of statistical research and is characterized by specific features that are directly related to its accounting.

- Firstly, the number of deaths includes both persons who died at the scene of a road traffic accident and those who died from its consequences within 30 next days.
- Second, the road traffic deaths are estimated based on a large number of structural characteristics. The death toll will be distributed according to standard demographic characteristics (gender, age) as well as non-standard, original characteristics. The latter include the distribution of the number of fatalities in the road accidents due to the causes of road accidents (for example, road accidents and

victims due to the unsatisfactory condition of streets and roads etc.); distribution of the number of deaths in road accidents by subjects of road traffic accidents (for example, road accidents and victims of traffic violations by pedestrians, road accidents and victims of traffic violations by drivers of vehicles in condition etc.); distribution of the number of fatalities in road accidents by category of vehicle owners guilty of road accidents (for example, road accidents and victims of traffic violations by drivers of vehicles of legal entities etc.) etc.

- Thirdly, some special factors affect the intensity of mortality due to road accidents. Among them: time of the day and period of the year; roadway lighting; length and coverage of highways; traffic capacity of highways; traffic intensity and many others, [20]. In Kazakhstan, the software “Accident” was developed with the following functions:
 - ❑ search, entry, change and removal from the database of statistical data from road traffic accidents cards
- Search for the required card according to one or several specified criteria (date of the accident, vehicle state number, the name of the vehicle owner, victim etc.);
 - ❑ statistical analysis of road accidents (quantitative, qualitative and topographic);
 - ❑ filtration of data by one or several criteria (up to four), combined with the use of logical operators, which allows to select a certain range from the total volume of statistical information;
 - ❑ forming and printing out various forms of reporting, analysis results, individual accident cards;
 - ❑ the use of specialized dictionaries when entering information into the database, allowing to unambiguously identify the input object and reduce the size of the database.

A review of scientific literature shows that there is a need to develop an automated accounting system and real-time data transfer to a central electronic database, as well as electronic data exchange between departments, such as the state road safety service, road organizations, medical institutions, insurance organizations and other interested parties. organizations. The use of modern portable devices (smartphones, tablets), equipped with GPS modules, high-resolution photo/video cameras can solve the problem faced by road safety employees. Another task is to store this data in a single electronic database. In this direction, the State Traffic Safety Inspectorate of the Republic of Uzbekistan has already done a fairly large amount of work, but there are some disadvantages:

1. The electronic database has a local version;
2. Data is stored in outdated software that does not meet modern requirements;
3. Statistical analysis of crash data is very primitive;
4. There is no electronic exchange of data on road

accidents between government agencies

5. Due to the manual collection of data on road accidents (record card), there are gaps (missing data), late transmission and data entry, underestimation of victims, low data accuracy.
6. There is no precise geolocation of the accident location
7. There is no visualization of the location of the accident in the electronic map
8. Manual registration of an accident scheme
9. The accident database is not connected to the driver's license and vehicle database
10. Weather conditions are not taken into account when accounting and storage accidents

4 Results and discussions

The existing method of accounting for the road accidents does not meet modern requirements in terms of accuracy, reliability, making the right decisions, ignoring the available mobile and internet technologies. Consequently, the development of modern methods for accounting for the road accidents is relevant in Uzbekistan. As the results of the study show, data on road accidents are stored in various state and non-state departments such as the Ministry of Internal Affairs, road organizations, the Ministry of Health, transport companies, insurance organizations and at the same time they do not exchange data with each other. Many questions arise, what this data is stored for and what is the use of it, what measures are being taken to reduce the number of fatal and injury accidents. To solve the above tasks and problems, a computerized system should be developed for collecting, storing, transferring and analyzing. A theoretical basis for the collection, storage, analysis and recommendation should be created, which would form the basis of a unified automated electronic system for registering, analysis and recommending of road accidents and would provide access and exchange of data between various departments and organizations. To solve several problems mentioned earlier, a system of automated accounting of road accidents for Uzbekistan was proposed. It consists of several subsystems, such as an accident registration system at the traffic police department, at the Ministry of Health, at the road organization, at the insurance companies, an accident accounting system in transport organizations (Figure 7). The central database would be under the control of the State Traffic Safety Inspectorate of the Ministry of Internal Affairs of Uzbekistan, where all the data related to road accidents would be stored. Each subsystem would be independent but would provide the real-time data exchange. In the event of an accident, the traffic police officer registers the accident using a tablet and assigns an ID number, which would serve as a unified link with other departments and organizations. The materials of the accident are sent to the Department of Inquiry of the

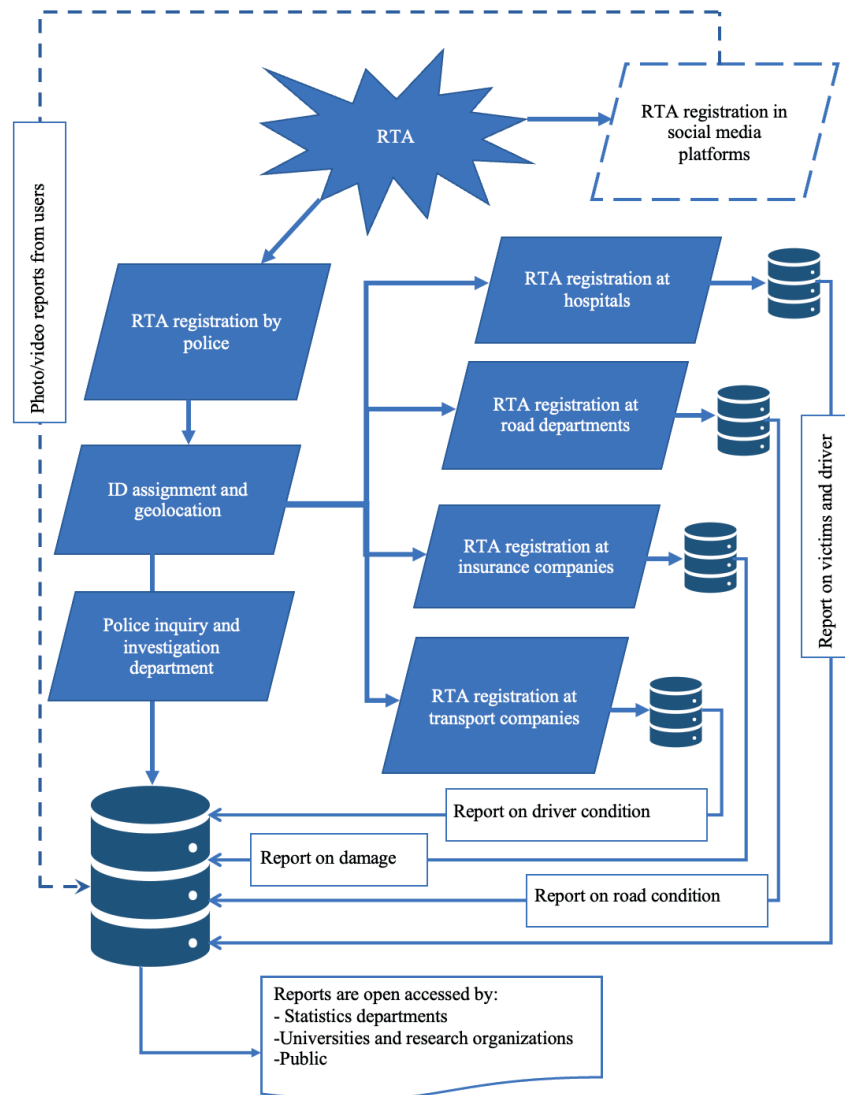


Figure 7 Proposed automated accident registration system in Uzbekistan

Road Traffic Safety Department to establish the possible cause and details of the accident and are transferred to court proceedings. If people are injured in an accident, then upon admission to the nearest hospital, the patient is registered with the same ID number that was used by the traffic police officer in automatic mode. After the patient is discharged from the hospital, the medical staff prepares a report on the condition and injuries. In addition, the subsystem takes into account data on the medical examination of drivers involved in an accident. The reports are sent to a central database for further analysis.

The ID number and location are automatically sent to the road service that operates in this section of the road, to study the impact of road conditions on the occurrence of an accident. After studying and researching the transport and operational qualities of the road, a report is drawn up and sent to the central base to study the degree of influence of road conditions. Insurance companies take into account the damage in the event of an accident, they would also use the ID

number that was created by the traffic police officer. After technical expertise and damage assessment, the report is sent to a central database for analysis and assessment of all the damages. Transport companies, in turn, also use the ID number that was assigned to this accident. They assess the psychophysiological state of the driver, identify the likely cause of the accident. A report is drawn up and sent to a central database for further research.

Social networks play an important role in the registration of an accident since most users have mobile phone video recorders, which allow not only to record an accident after the occurrence but also before and during the occurrence of an accident. It serves as a quick response of traffic police officers. In addition, photo/video materials can be used in an investigation department of the traffic police. Collecting data using social networks is of a recommendatory and informative nature (dashed line in the flowchart in Figure 7).

The system of automated registration of road accidents works online and is stored in a cloud resource

to ensure the reliability and timely workflow between departments and organizations. The data in the central database is processed and analyzed. Based on this data, reports are compiled for other departments and provided to universities and research institutes for the further development of the road safety measures. Accident statistics are made available to the general public for outreach and training purposes.

5 Conclusions

Analysis of scientific and technical literature has shown that the methodology for the road accidents registration is outdated and does not meet modern requirements. Sweden, which has adopted the concept of zero deaths and has the lowest road traffic accident rate in the world, is developing a methodology for automated road traffic accidents using modern technology. Since 2016, authors began to create a pilot project for registering for accidents using tablets and fixing accidents in real-time. The created system for collecting, storing and processing road accident data allows to receive and analyze data on time. In Uzbekistan, large-scale transformations are being carried out to improve the road safety by introducing up-to-date technologies such as video recording of violations at the main city intersections, speed cameras recording, recording violations using tablets, data storage of road accidents in electronic form etc. Nevertheless, there are drawbacks to the road accident registration system. This is the use of outdated methods of registration for road accidents: manual/paper method of accounting for road accidents (filling out a road accident registration card). This method has several limitations, such as low data accuracy (location), data completeness (not

all the data is available at the scene of the incident), untimely data transmission (late, sometimes data loss), errors and inaccuracies when entering data from paper (traffic accidents cards) to a database, not a perfect and outdated database (data is stored in a local resource, not in cloud systems). To solve these problems and tasks, this paper proposes to improve the methodology of automated accounting of road accidents data, which solves the existing problems and fills in the gaps in the system. The proposed automated system consists of several subsystems, such as the central database at the Ministry of Internal Affairs of the State Traffic Safety Inspectorate (the main database of which all data is stored), the road service subsystem provides an assessment of the impact of road conditions on the likelihood of an accident, the ambulance subsystem (Ministry of Health) performs the function of recording the state of victims in accident and driver expertise, the insurance subsystem is used to record and assess damage in the event of an accident, the transport organization subsystem studies the psychophysiological state of vehicle drivers. Based on data from the central database, open road accident data are provided for various departments and educational institutions for outreach activities. A feature of the proposed system is the synchronized exchange and transfer of data between subsystems, which increases the accuracy and reliability of data at times in comparison with the existing methodology for collecting, recording, storing and analyzing road traffic accidents data. Each subsystem is associated with an incident ID number, which allows data to be synchronized between different subsystems. This allows, at different stages of the analysis, to determine exactly where, when, what consequences, damage, culprit, road conditions and much more.

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