Research Article

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Rescue of persons in traffic accidents on roads

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Abstract: The article deals with traffic accident rates in the Czech Republic and activities of the basic component parts of the integrated rescue system in relation to traffic accident addressing. On the basis of statistical data from the period 2011 to 2018, the purpose of the main component parts of the integrated rescue system in providing aid to victims of traffic accidents is emphasized. A real traffic accident is used to describe the intervention procedure with an emphasis on disentangling individuals from wrecked motor vehicles and provision of pre-hospital emergency care. Assessment of traffic accidents and the methods of their addressing are summed up in proposals for the safe rescue of victims, provision of (first) aid, and elimination of intervention-related complications.

Keywords: accident, assistance, recovery, rescue, health service

1 Introduction

Traffic accidents on roads form an inseparable part of driving and the consequences for the people involved may vary. Traffic accidents can occur without detriment to health; however, they might possibly result in the death of road users. Traffic experts estimate that since the invention of the car more than 30 million people have died worldwide [1]. Czech road traffic safety is mainly affected by the drivers themselves, their conduct and the ways they drive their vehicles, and their observance of the relevant legislation on road traffic safety, the technical condition of the vehicles, type and quality of roads, etc. In the case of collisions that may result in a traffic accident (hereinafter referred to as "TA"), the first interveners usually are the mobile guards of the Transport Police of the Czech Republic, who in the context of their preventive activities supervise safety and fluency of road traffic. The venue of any TA (traffic accident) must be made safe for the road users, including the victims of the accident.

When a TA occurs, a field crew of the Traffic Inspectorate of the Police of the Czech Republic is sent to the location of the accident to resolve it. In the case of TA reporting and the need to rescue victims further, taskforce and means of the Integrated Rescue System are sent to the place of the accident, with an emphasis on the Fire Rescue Service of the Czech Republic and the Medical Rescue Service sent directly by the operation centres of the individual components or by the Operation and Information Centre of the respective regional the Integrated Rescue System. The fire rescue and medical rescue services are the basic components of the Integrated Rescue System with non-stop emergency operation.

The first measures that must be taken after a TA should be saving lives and maintaining the health of people. Therefore, the crucial element, which contributes to saving lives and maintaining the health of people during the TA, is the Integrated Rescue System. The main bodies of the Integrated Rescue System provide assistance to people involved in TA, which depends on many factors. These factors are dealt with in this article. Traffic accident investigation is an activity consisting of identification, revealing and documentation of offences or criminal offences committed by violation of a legislative regulation causing the TA, which occurs after rescuing people from crashed vehicles.

The authors have processed statistical data from the period of 2011 to 2018 concerning traffic accident rates in the Czech Republic to describe activities of the basic

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component parts of the integrated rescue system involved in traffic accident response. Another aim of the project has been to analyse emerging issues and propose measures for quality improvement in the area of interventions of the basic component parts of the integrated rescue system.

The issues of the article have not yet been tackled as a whole in domestic or foreign publications. Other publications have dealt with the individual subareas as follows: statistics of accident frequency, the causes of TA, the activities of the Integrated Rescue System bodies and health service interventions. For example, in the Czech Republic, the issues of TA have been discussed in ref. [2], the activities of the Integrated Rescue System bodies in connection with the protection of the population in ref. [3], and in the Slovak Republic in ref. [4]. In Norway and Italy, the issues of statistical data processing in relation to safety and TA have been tackled in refs [5,6]. The purpose of the present study is to use statistical data of 2011–2018 and risk identification results to emphasize the role of Integrated Rescue System and the necessity of mutual close cooperation between its units in addressing TA. The study also deals with potential complications to medical rescue services and the fire protection unit activities.

Ref. [7], for example, deals with the arrival of an emergency ambulance at the road accident site in India. Similar issues have also been tackled in England in ref. [8], which deals with the activities of the Fire Rescue Service, the Police and giving first aid in accidents. In view of the fact that the issues of rescuing people in TA on roads are very topical and serious, many authors in different parts of the world pay great attention to this area. The authors of this article have selected only some authors and their publications to support their research in the given field.

2 Methods

The study used an empirical method (scientific observation method) and logical methods (analysis and synthesis). The scientific observation method was applied to the observation of activities of selected Integrated Rescue System teams addressing TA (traffic accidents) with an emphasis on the place of the accident and the particular activities of medical rescue service and fire brigade in the course of the intervention. The analytical method was used for an itemisation of the investigated issue with regard to the accident, the place and roles of the individual Integrated Rescue System units in TA intervention and TA intervention statistics. The synthetic method was used for the evaluation of cooperation of Integrated Rescue System units in TA intervention. A generalisation method was used in Section 4 – Discussion for identification of complications that can affect Integrated Rescue System intervention activities.

One of the most serious social aspects that impacts the lives and health of people is traffic safety. TAs can be serious events, involving the deaths of people or animals, fires, damage to roadways as well as cargo. According to the World Health Organization [9], 1.25 million people die in the TA all around the world every year, while 20–50 million get injured. In the European Union, there were approximately 25,100 victims of the TA in 2018 and about 135,000 persons were seriously injured (55,000 persons died in TAs in 2001) [10,11]. Out of the total number of victims worldwide, 49% are cyclists, motorcyclists and pedestrians. The Czech Republic is no exception to this statistic. Over the past five years, the number of people killed in TAs averaged about 584 per year. The number of people who died or were seriously or slightly injured in TAs is shown in Table 1 together with the estimated damages.

Table 1: The number of fatalities and injuries in TAs, and estimated material damage between 2011 and 2018

	Year							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
	Number of							
Number of TAs	75,137	81,404	84,393	85,859	93,067	98,864	103,821	104,764
Casualties in TAs	707	681	583	629	660	545	502	565
Seriously injured in TAs	3.092	2.986	2.782	2.762	2.540	2.580	2.339	2.465
Slightly injured in TAs	22.519	22.590	22.577	23.655	24.426	24.501	24.760	25.215
Estimated material damages (in M CZK)	4628.1	4875.4	4938.1	4933.2	5439.0	5804.2	6316.3	6547.9

Data source: Adjusted according to ref. [11].

Table 1 shows the continuously increasing number of TAs in the Czech Republic, while the opposite trend would be expected and welcomed too. The Czech Republic, in compliance with the European Union policy, adopted its national strategy of road traffic safety for the period 2011–2020, with the aim to reduce the number of fatalities and severe injuries resulting from TAs to the mean level in the European Union (i.e. by about 60% of fatalities and 40% of severe injuries, counted 30 days after the accident). The predictions of the Ministry of Transport suggest that, in 2018, 287 fatalities and 1,304 severe injuries should have resulted from TAs in the Czech Republic. However, as follows from Table 1, this prediction has unfortunately exceeded and the Czech Republic lagged behind the European mean in the area of fatal consequences of TAs by nearly 27%. The balance of 2018, i.e. the number of fatalities resulting from traffic accidents on the roads in the Czech Republic per 1 million inhabitants was virtually identical to the European mean achieved already in 2010 (62 fatalities per 1 million inhabitants).

In the European Union, in 2018, 49 persons per 1 million inhabitants died in the course or as a consequence of traffic accidents. In 2018, the Czech Republic with its 62 fatalities per 1 million inhabitants only ranked 21st within the EU. The EU countries with the lowest figures in the area of road traffic accident rates include Sweden, the United Kingdom, Denmark, Ireland and the Netherlands. The most dangerous road traffic accidents were reported in Rumania, Bulgaria and Croatia.

The basic parameters monitored in the area of road traffic safety in the Czech Republic in 2011–2018 include the development trends of road accidents, and the numbers of fatalities in the period 2011–2018 (Figures 1 and 2).

As follows from Figure 1, the assessed parameter shows an increasing trend, whose gradient can be very exactly expressed by a linear regressive curve with a high-reliability value, unfortunately confirming a continuous increase of the number of TAs in the period of interest.

As revealed in Figure 2, the trend in fatalities following from traffic accidents expressed by a regression function shows a high level of reliability and in fact confirms a continuous decrease across the monitored period, with just a few exceptions in the years 2015 and 2018. A lower probability was found in the trend of decreasing numbers of TAs with consequences including severe injuries.

To specify the relevance of the selected groups of safety-related data from road transport, their mutual relationships must be assessed. The individual correlations together with the expected development trends in each category will allow for more accurate predictions of real fulfillment of the term tasks in the area of road traffic safety [12].

The correlation factors resulting from an assessment of the individual value sets included in Tables 1 and 2 are shown in Table 3.

The values of the correlation coefficients can be deemed proving that the numbers of fatalities and severe injuries are closely linked to the development (increase/decrease) of the number of traffic accidents. A similar conclusion was arrived at by the authors in ref. [13].

When rescuing persons, the bodies of the Integrated Rescue System provide, through their technical and material resources, urgent professional, medical, technical and other necessary assistance to people in distress based on

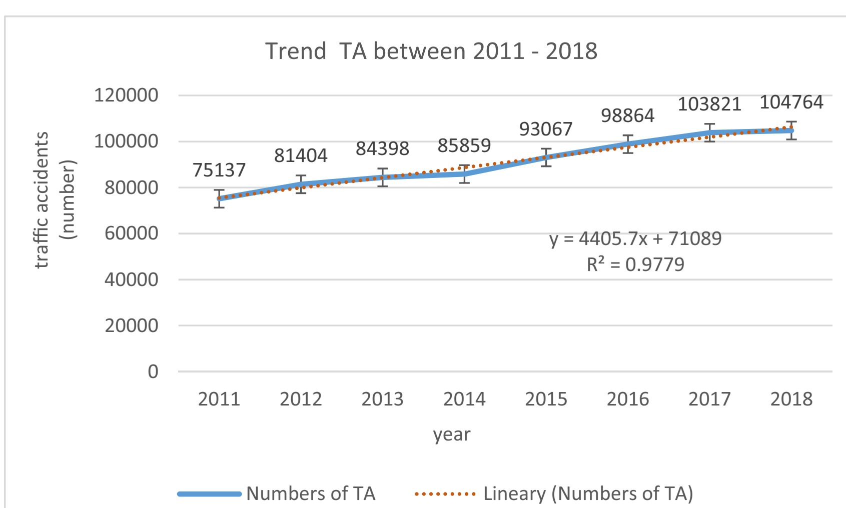

Figure 1: The TA number trend in 2011–2018.

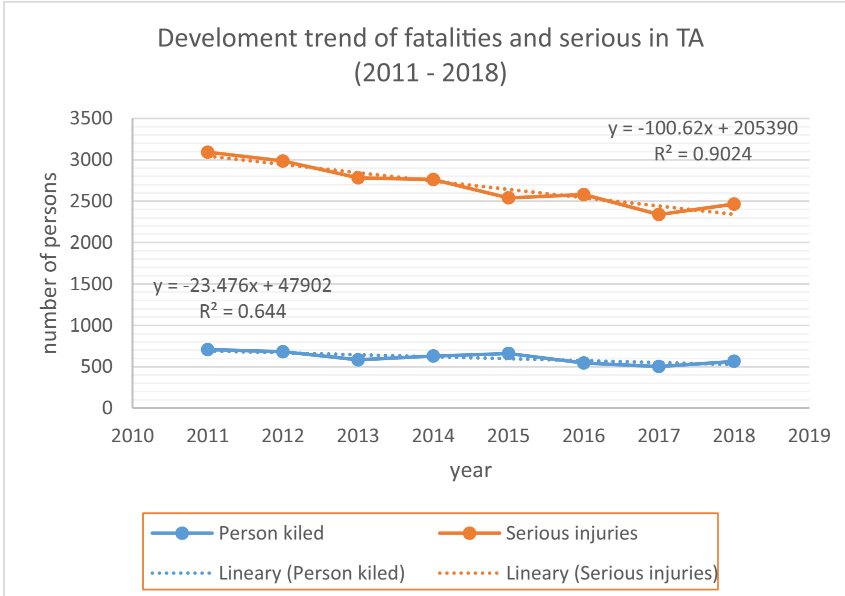

Figure 2: The trend in the number of fatalities and severe injuries as a result of TAs in the period 2011–2018.

instructions from the operation and information centres of the Integrated Rescue System (operation centre of the regional Fire Rescue Service and the medical operation centre).

A traffic accident is an event that occurs on roads, for instance, a car crash or a collision, which happens or initiates on the road and involves a death or injury to people, or damage to property in direct connection with the operation of a moving vehicle [14].

Every TA can be characterized by the behavior or negligence of a road user that caused an accident and an incident that manifests itself as a specific type of TA (e.g. collision, fall, etc.) [15].

Every TA affects road passability where it happened in one way or another and also the scope of workforce and means used by the intervening Integrated Rescue System units. Road passability will depend on the traffic accident seriousness (the number of fatalities and injured persons, animals, leaks of hazardous substances from the vehicle, or its load deck, etc.) For example, the higher the number of fatalities or severe injuries the longer the traffic congestion and the longer and more demanding the Integrated Rescue System intervention.

To minimise the impact of TAs on human life, health and property and environment damage cooperation is needed with the individual component parts of the integrated rescue system with the following tasks:

- secure the area of the TA and its surroundings, and provide traffic control with emphasis on ensuring the safety of other road users,
- give first aid to injured persons,
- implement preventive measures to avoid fire to the vehicle or its cargo (e.g. disconnecting batteries, searching for possible sources of ignition, firefighting if necessary, etc.),
- rescue the injured people and those in danger from the crashed vehicles (the vehicle has to be stabilized prior to any rescue operation),
- prevent leakage of dangerous substances and substances hazardous to the environment in the event of damaged shipping containers or vehicles,
- provide necessary humanitarian aid to the affected persons (especially in winter or in bad weather).

TA interventions involved professional fire corps of the Czech Republic (Table 3), referred to as the TA venues. As of 31 December, the territory of the Czech

Table 2: Correlation coefficients of selected data sets

Assessed data sets		Correlation coefficient
Number of accidents	Number of fatalities	−0.8315599
	Number of severe injuries	−0.9568820
Number of fatalities	Number of severe injuries	0.8191004

Table 3: Number of events and accidents with fire protection unit intervention in the years 2011–2018

	Year							
	2011	2012	2013	2014	2015	2016	2017	2018
	Number							
Total number of events	101.101	103.985	112.281	100.776	111.984	105.490	100.776	104.764
Traffic accidents	17.061	18.910	19.023	19.219	21.330	21.521	19.219	22.265
Percentage	16.87	18.18	16.94	19.07	19.04	20.4	19.07	21.25

Data source: Adjusted according to ref. [16].

Republic was served by 243 fire corps units. A unit of this type arrives at the TA venue in 5 min from notification. In addition to professional fire corps, TA interventions further involve voluntary fire-fighters type II, 236 in number in the Czech Republic as of 31 December (Figure 3).

Ground mobile facilities of the medical rescue services are sent to the TA venue from the nearest emergency centre or rescue service centre. As of 31 December 2018, there were together 588 of them in the Czech Republic. The number of their interventions is shown in Table 4.

A correlation analysis has shown that the correlation coefficient between the numbers of professional and voluntary fire corps equals 0.647101.

The processed statistical data (on TAs) were used for the analysis of the causes and consequences of TAs. The results of the analysis revealed that the main cause for the motor vehicle driver caused TAs with fatal consequences (nearly 50%) was non-observance of speed limits. Further causes included non-observance of the give-way signs, driving under the effect of alcohol/narcotics, etc. To reduce the high number of TAs, implementation of more radical measures and instruments for their application and definition of responsibilities for them are required. The number of interventions of fire corps and medical rescue service point to their justification. These interventions require, inter alia, a high level of professionalism and state-of-the-art intervention, medical and transport equipment. On the basis of TA, the What-If method was used to identify risks for the interveners. The results are shown in Table 5.

The results of the used risk analysis method called What-If? are included in the proposals for activities of Integrated Rescue System in connection with TA with

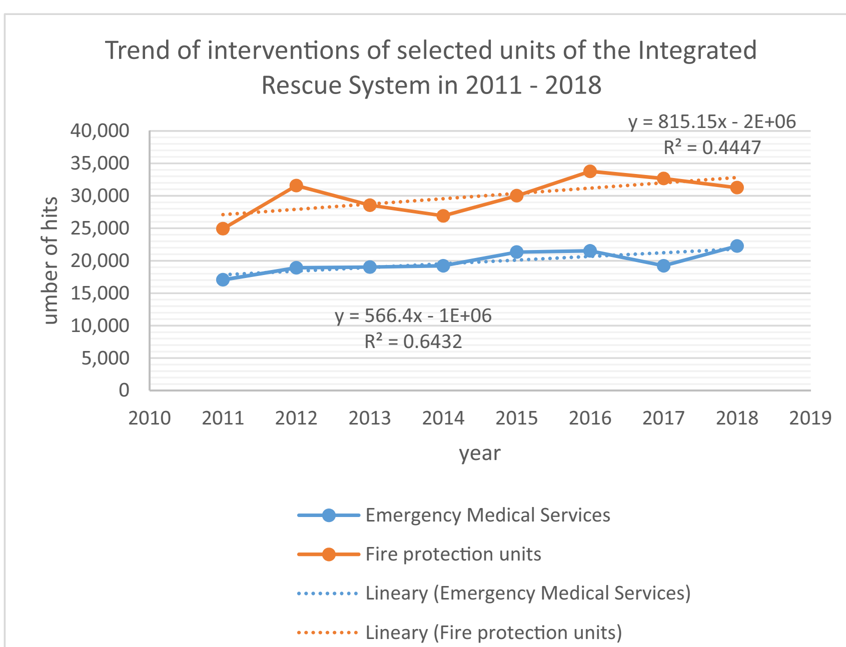

Figure 3: Integrated rescue system intervention development trend.

Table 4: The number of interventions of the Emergency Medical Services, interventions during the TA, number of bases of emergency services and numbers of emergency teams between 2011 and 2018

	Year							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
	Number							
Total no. of interventions	851.289	889.533	945.348	1012.678	1067.704	1073.034	1094.808	1133.549
– of which during the TA	24.921	31.577	28.554	26.903	30.005	33.763	32.661	31.253
Percentage	2.93	3.55	3.02	2.66	2.81	3.15	3.04	2.76
No. of bases	281	286	293	295	299	306	307	310
No. of teams	514	530	546	554	566	579	584	588

Data source: Adjusted according to ref. [17].

an emphasis on rescue of persons and assurance of safety and protection of Integrated Rescue System crew members in the course of the intervention.

3 Results

TA solutions can be divided into several stages. The first stage is the stage in which the uninjured TA participants will participate, and after the arrival of the police, the security stage. The aim of this stage is to minimize the occurrence of further vehicle collisions, and thus a possible increase in the number of dead, injured and damage to vehicles and other property. The second stage is the rescue stage, where the participating TA tries to provide the injured persons with first (lay) help. Part of this stage is also the activity of the fire protection unit, whose members carry out the rescue of people from crashed vehicles and their subsequent evacuation to a safe distance from the accident site after the survey. After the evacuation of the injured persons, the rescuers from the ambulances of the emergency medical service perform the sorting of the injured persons (dead, serious and light injuries, no injuries) and subsequently the pre-hospital emergency care. If necessary, they take the injured persons to designated medical facilities. The third stage is the investigative stage, which is carried out by the Police of the Czech Republic with the aim of finding out the causes and culprits of TA. Based on this, a report should be prepared on the accident and determine the cause of the accident and draw conclusions. In many cases, TA can cause serious injury to its participants. The result is then criminal proceedings against the perpetrator TA. The course of a criminal case can be divided into several phases. Immediately after the TA with injury to a third party, there is a screening phase in which the police investigate the preliminary accident, provide an explanation for the individual TA participants and determine the health consequences of the injured TA. If it is established that a criminal offense has been committed, then the driver of the vehicle is charged with the criminal offense of personal injury or serious negligence (or death due to negligence). The allegations begin the investigation phase. The criminal proceedings end with the police being able to study the criminal file, and subsequently, the public prosecutor decides on the indictment of the perpetrator of the accident or the conditional cessation of criminal prosecution. After the indictment has been filed, a judicial phase occurs, which usually ends with the issuance of a conviction or acquittal for the driver, or a criminal order is issued for summary proceedings. In the last stage of the TA solution, the road is brought into a pre-accident state, in which, in addition to fire protection units, the administrators of individual roads and their executive components also participate.

According to the seriousness of the TA, the Integrated Rescue System participates in the fulfillment of tasks, which are defined in ref. [18] as the coordinated course of action of the Integrated Rescue System during the preparation for extraordinary events and performing the rescue and salvage operations. The coordination is managed by an incident commander who is a member of fire protection units. It follows that the Integrated Rescue System is not an institution as such but it is a summary of rules for cooperation among its constituents.

Deployment of taskforce and Integrated Rescue System means in TA addressing is mainly affected by the road category [19] and traffic density, varying for different roads, from the densest traffic on the motorways and the least dense on tertiary roads. The number and seriousness of TA on these roads are affected by their condition and negotiable skills and, further, whether there are crossroads, railway crossings, close ground, etc. Further impact on the intervention is exercised by the type and number of

Table 5: Risk identification by What-if method

What If?	What happens?	Preventive measures
Incorrect dislocation of the extraordinary event place given to the fire brigade, operation centre of the regional Fire Rescue Service	Extended arrival time of Integrated Rescue System vehicles – non-provision of pre-medical first aid to the injured victims	Proper inquiry by the emergency line operator in conversation with the TA reporter
Traffic accident of the intervention vehicles of the Integrated Rescue System on the way to the place of TA	Sending at least one fire vehicle and one medical rescue service vehicle to the place of the accident to help the crashed vehicle, and sending other rescue vehicles to the place of the original TA	Periodic training of rescue vehicle drivers with an emphasis on safe driving
Inconsistent investigation of the place of TA by the intervention head	Incorrect input information for the intervention heads. Incorrect identification of the number of injuries and participants in the TA	Profound and continuous investigation of the TA area
Failure to secure the place of TA	Unauthorised access to the TA area, leak of sensitive information and photos	Prevention of unauthorised access to the place of TA
Failure to perform fire protection measures with the crashed vehicles	Risk of fire of the crashed vehicles, with subsequent further injuries or death of the captured victims	Disconnection of all batteries of the crashed vehicles
Exhaustion of the interveners	Pre-medical first aid to the interveners	Mobilisation of a sufficient number of interveners and their periodic alternations
Hazardous substance leak from the crashed vehicle after TA (operation fluids of crashed vehicles or transported materials)	Threat for intervening Integrated Rescue System units, victims of TA and the environment	Timely use of respirators and other protective equipment by TA interveners. Use of means to prevent hazardous substance leaks
Use of incorrect protective equipment	Intoxication of the interveners with subsequent fire	Timely use of respirators and protective equipment by TA interveners
A TA victim is infected (HIV, TBC, jaundice, ebola, etc.)	Risk of infection of the interveners	Use of personal protective equipment (goggles, gloves for technical intervention, latex gloves)
Treatment of more injured persons	Transfer of infectious diseases between the injured	Use of more layers of latex gloves already before arrival at the TA place and taking them off one by one after treatment of each victim
TA victims are aggressive, under the effect of alcohol or narcotics	Verbal and physical attack of the interveners. Prevention of further rescue work	Immediate intervention of the Police of the Czech Republic on the place of TA
Risks of use of technical means for intervention in the place of TA		
Delayed airbag shot in the crashed vehicle in the course of the rescue works	Additional injuries of the rescued and the rescuers	For non-activated airbags: application of airbag catcher, battery disconnection and ignition key removal
Windshield cutting as part of rescue works	Inhalation of microscopic particles of the windshield	Respirator use by rescued and rescuers
Rescuing of entangled victims from crashed cars	Risk of injury of the entangled victims by the removed bodywork parts during bodywork cutting and tearing off	Use of appropriate technical means for the protection of the entangled victims
Sharp edges on the vehicle bodywork	Additional injuries of the rescued and the rescuers by sharp edges	Immediate covering of sharp edges with a set of protective sleeves
General risks for rescuers during TA intervention		
Other drivers passing by do not pay proper attention to driving	Another TA, crash into the intervention vehicles and the Integrated Rescue System crew	Complete traffic stop during rescue works

Source: In-house.

the crashed vehicles, as, for example, in the case of a crash of public transport the number of victims may be much higher than in the case of a traffic accident of two passenger cars. For that reason, the former case requires a higher number of deployed staff and means of Integrated Rescue System.

Dealing with a more serious TA involves [20] basic bodies and other Integrated Rescue System bodies (on request – breakdown, emergency, specialized and other services).

The basic components of an Integrated Rescue System for a TA solution must be the following:

- fire protection units falling within the fire protection of the whole region (during all incidents they try to maintain the maximum amount of evidence to assist any Police investigations); their tasks are to eliminate and reduce risks, to provide pre-medical first aid, to provide psychological and post-traumatic intervention care, to provide assistance to the Emergency Medical Services in accordance with their requirements and to provide coordinated rescue of persons, logistics support at the place of intervention (lighting, heliport – determination of the helipad in the size of ca. 50 m × 100 m, a logistic base unit) and to regulate traffic in the absence of the Police of the Czech Republic;
- providers of the Emergency Medical Services whose tasks are to maintain contact between the chief doctor and incident commander, to assess the affected persons and provide them with professional pre-hospital emergency care, to monitor the conditions of the rescued people and to perform necessary medical treatment, to coordinate the rescue procedure according to the type and nature of injuries and to transport the injured to a medical facility;
- Police of the Czech Republic whose tasks are to investigate accidents and to secure evidence, to regulate, divert and control traffic and manage closures related to the intervention, to secure the accident site against unauthorized access and property theft, to maintain public order and to provide physical protection of the Integrated Rescue System crew, etc.

Possible deployment of the Integrated Rescue System technology at TA is depicted in Figure 4 [19]. In order to secure the safe movement of intervening persons and to enable easy access to technology, a sufficient distance must be maintained between the parked intervention vehicles of the Integrated Rescue System. It is recommended for the front wheels of a safety unit vehicle of the fire protection units to be directed in such a way as to prevent the vehicle from being pushed towards the Emergency Medical Services.

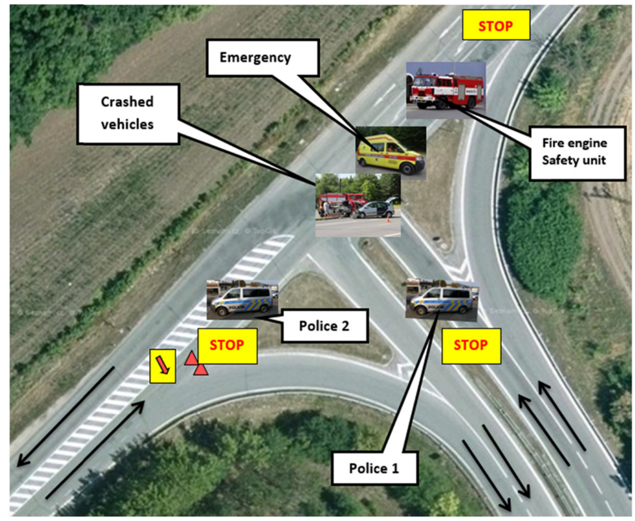

Figure 4: Possible arrangement of the Integrated Rescue System vehicles during the traffic accident.

A set of tasks and measures, that have to be dealt with during each TA can be collectively called the rescuing of people affected by the TA. The first aid given by witnesses of the TA and consequent pre-hospital emergency care play an important role.

First aid is defined as immediate assistance given to an injured or sick person prior to treatment by a health care professional [21]. In addition, first aid can be defined as simple and effective methods and measures used for immediate help during a sudden impairment to health or threat to life, which can be provided anywhere and by anybody. The objective of first aid is to help the afflicted avoid complications and reduce the consequences of injury or trauma. Therefore, first aid has to be quick, efficient and without undue delay [22].

According to the World Health Organization, about 4,000 people die in TAs in Europe because first aid and pre-hospital emergency care are given too late.

Pre-hospital emergency care is professional medical care for the affected persons at the accident site, or during their transfer to a medical facility where they are provided with further professional treatment [21]. Tasks connected with the pre-hospital emergency care and rescue of people during TAs fall within the responsibilities of the Emergency Medical Services.

The emergency teams can perform their activities within the so-called Rendez-Vous system if the medical operation centre or ancillary operation centre sends one or more emergency teams of the urgent medical assistance and one or more teams of the ambulance services to the accident site where they all meet. Depending on the situation, the emergency teams carry out their activities at the accident site either independently or in association with other teams [21].

Vehicles used by the Emergency Medical Services for the pre-hospital emergency care must meet all requirements for the safe operation of motor vehicles on roads; see e.g. ref. [6]. They must also meet all technical and material equipment requirements and requirements related to identification and colors in accordance with ref. [23]. The mandatory equipment of the Emergency Medical Services vehicles must include a wheeled stretcher equipped with a restraint system for children and adults; vacuum mattress, equipment for moving a seated patient (provided this feature is not available in the wheeled stretcher), medical transport sheet; devices for immobilization of the cervical spine and the overall immobilization, spine splint vest, etc.

4 Discussion

The question is how to reduce the number of interventions by the fire protection units and the medical rescue service in the cases of traffic accidents and with it the number of fatalities and injuries. As already stated above, the main problem is the number of TAs. Reduction of this number should bring about the reduced number of interventions by the Police of the Czech Republic, fire and medical rescue units and groups for the purpose of addressing TAs. The most important measures to increase road traffic safety must include, in addition to continuous improvement of road and vehicle quality, improvement in prevention. Prevention must be paid maximum attention. The most important preventive measures for the reduction in the TA number may be, for example, measures preventing inadequate speed of driving and speed limit exceeding by instruments such as campaigns for speed limit observance, with an emphasis on driving in urban areas and keeping the safe distance between vehicles or use of informative speed meters. Further measures include application of the wide range of measures for traffic calming and slow-down, especially in urban areas, increased number of speed meters, improvement of crossroads visibility, improvement of legal awareness of drivers, improvement of instruction on how to behave after a traffic accident and how to provide first aid, etc.

The purpose of the fire protection unit's departure to the place of TA must be the departure of the unit from the place of its deployment or from the place where it is at the given time with the specified forces and resources to the specified place. After the alarm is sounded, he must leave his place of departure no later than 2 min for a unit composed exclusively of professional firefighters, and within 10 min for a type II fire protection unit. These exits must be carried out within the territorial scope of the fire protection unit. The transfer speed is 45–60 km h^{-1} depending on local conditions.

The availability of the Emergency Medical Services is given by a plan of coverage of the region by the Emergency Medical Services bases. According to ref. [24], the time of arrival to the accident site for the Emergency Medical Services vehicles should be 20 min from the moment of receiving the instruction of the medical operation centre or the ancillary operation centre. The actual response times are influenced by a number of unexpected factors (e.g. availability of the Emergency Medical Services vehicles, the distance of the vehicle from the accident site, traffic density, weather conditions, or other more serious life-threatening conditions of persons elsewhere, etc.). Regardless of the specified response time, the vehicle of the Emergency Medical Services arrives at the accident site as quickly as possible (2–50 min) [25].

It is also important to emphasize that the total intervention time of the Emergency Medical Services vehicle can be 60 min and more, and depending on the time of accepting an emergency call by the operation and information center and sending the emergency team (about 1–3 min), arrival time (20 min according to ref. [24]), the time to provide pre-hospital emergency care (about 20 min) and the final time transfer of the injured person to the relevant healthcare facility (about 20 min).

Upon receiving information on intervention, the crew members of the Emergency Medical Services vehicle leave for the accident site where they have to perform the following:

- assess the situation,
- establish cooperation with the incident commander (usually a member of the fire protection units),
- assess the risks for the crew and other persons,
- assess the need for additional medical personnel and resources,
- count the injured persons, assess their conditions and sort them if appropriate,
- provide the pre-hospital emergency care (on the spot, during transport and handing the injured person over to a health care facility),
- transport the injured to the relevant health care facility,
- handover the injured person to the target inpatient care provider,
- document ongoing activities.

The target inpatient care provider is obliged to accept the patient if the provider confirms the possibility of acceptance to the medical operation centre or the ancillary operation centre. In addition, the target inpatient care provider is obliged to accept the patient upon the request of the medical operation centre or the ancillary operation centre whenever the patient is in immediate danger of life. The target inpatient care provider must confirm accepting the patient in writing to the leader of the emergency team [25].

The provision of timely pre-hospital emergency care during the TA requires rescuing people from crashed vehicles, which should be carried out by units of the fire brigade in cooperation with the Emergency Medical Services. As a result of their injuries in the TA, the persons to be rescued can be trapped in vehicles or wrecks, or they can be hemmed in as a result of vehicles' deformation. It is possible to use various special technical means specified in ref. [26] for their rescue. The procedures and methods for the rescue operations are selected in such a way as to allow treating the most serious injuries first. Also, the most accessible areas are given primary attention and only then does the rescue team deals with the worse accessible places. The incident commander determines the procedures and methods for the rescue operations. The methods of rescue and determination of priorities must be in accordance with the instructions of health professionals based on the injuries (spinal trauma, respiratory arrest, bleeding).

Using ref. [27], one can say that timely and safe rescue of persons from crashed vehicles can be affected by many different complications. The most important include the scope and way of damage to the crashed vehicle, its position and stability with regard to the number of the rescued victims and seriousness of their injuries(see Table 4). In some cases, also unfavourable weather conditions may affect a quick and safe rescue of persons in the crashed vehicle (rain, snow or frost) complicating the situation to the intervening fire brigade.

To provide sufficient space for access to the victims stuck in the crashed and usually deformed cars and subsequent securing of their basic vital functions, various technical means are used by the intervening fire brigade. These can be divided into the following four main classes. Prioritised means of rescue include hydraulic disentangling tools such as hydraulic shears, spacers or cutters. These are combined with appropriate manual or motor drive units providing sufficient pressure for the operation of the former. To increase the efficiency of the rescue of persons entangled by the weight of objects in the car, there are various pneumatic lifting bags. Manual disentangling equipment is a necessary complement to the hydraulic tools, and the most important ones include manual glass cutter, glass crusher, etc. Their names suggest that they are mainly used for preparatory works such as window breaking, cutting off the glued front windshields, creation of suitable holes for hydraulic shears and spacers, etc. The fourth group includes other auxiliary tools, for example, to secure vehicle stability and create sufficient space for handling the entangled victims. These include, for example, wedges, stabilisation supports and sides, electrical saw, etc. This group also includes a transport board used to prevent unwanted moves of the rescued injured victim.

The use of these tools and equipment requires knowledge of their functions and risks associated with their use. The hydraulic and pneumatic rescue equipment can only be used by a trained member of the fire protection unit, who has been familiarized with its operation together with occupational safety. All persons who are close to the rescue operations (including the people being rescued) must be informed about the action being carried out. It should be kept in mind that the damaged and deformed parts of the vehicle can move uncontrollably or spring up into any direction during the rescue operation. Therefore, the people being rescued must be appropriately covered, e.g. by protective shields or tarpaulin covers by members of the fire protection units.

During the performance of the rescue work, it is necessary to take account of the following:

- providing stabilization of the vehicle after the TA and taking fire protection measures,
- providing access in order to provide help to people with respect to their injuries,
- averting potential risks and danger caused, for instance, by active and passive safety features of the vehicle, side effects of rescue works, etc.,
- communication with people to be rescued and their possible cooperation during rescuing,
- creating a space for safe access to the injured persons, their release and rescue out of the wreck and their transport to a safe zone and handing over to the Emergency Medical Services.

The immobilization and transport equipment for the provision of emergency care used by the fire protection units, for instance, includes the following: manual rescue tool; rescue and evacuation stretcher; Kramer splint; neck collar; spine board; and spine splint vest.

Addressing a TA can bring about a large number of different complications making it more difficult for the individual component parts of the integrated rescue system to resolve the TA and rescue the victim entangles in the crashed vehicles. These complications can be caused by people involved in the TA, the environment of the TA, the weather, other vehicles, etc. As for complications caused by people, they also include the high number of persons killed by the traffic accident, who need to be disentangled from the crashed vehicles, with a potentially negative effect on the psyche of the fire-fighters and the rescuers. Further difficulties result from communication with the TA victims (foreigners, handicapped and injured individuals), including their inappropriate behaviours caused by shock, alcohol, narcotic use, increased aggressiveness, lethargy or panic. Environment-related complications include inaccessibility of the TA venue, non-negotiable terrain, poorly parked cars in housing estates and in narrow streets, development of traffic congestions, crashed vehicles on/off the road, etc. Inaccessibility may be further multiplied by unfavourable weather, such as heavy rain, snowfall, strong wind, frost, etc. Non-negotiable terrain and extreme weather conditions may also affect the safety of the fire-fighters and rescue service teams. The rescue activities may further be threatened by vehicles passing by, or inappropriate behaviour of "audiences" of the TA having nothing in common with the TA. Further complications may result from aggressive animals or hazardous substances leaking from the crashed vehicles to their surroundings. Vehicle-related complications are related to the fact that the vehicles involved in the TA may be of different types, ages, constructions (including unknown or untypical constructions or safety elements), technical conditions and with different levels of difficulties related to the disconnection of batteries in the crashed vehicles (batteries under seats in an inaccessible place, more than one battery in the car, etc). Yet, further complications may also be represented by the considerable psychic and physical burden exerted on the fire-fighters and rescuers and their potential accidents and injuries, as listed:

- Improve Information accuracy relating to the site and extent of the TA – within the initial information, the participants or witnesses of the accident provide the Operational and Information Centre (telephone number 112) with the correct and accurate information. Later, the intervening bodies of the Integrated Rescue System will receive the information via the relevant Operational and Information Centre. This is mainly the information on the site and extent of the TA, the number of the injured and the types of injuries or, if need be, the information on the cargo carried with the emphasis on dangerous goods. Here, it is necessary to specify, among other things, whether in the case of the accident there has been no leakage of dangerous substances in relation to the protection of the population and the environment; the leakage can also occur in the case of damaged vehicles without any cargo.
- To provide the route passability for the designated transport means of the Integrated Rescue System bodies from their specific location or from the base to the site of the intervention by selecting the fastest (or shortest) route; the problem may be, e.g. repairing the road that requires a detour and may be longer and more demanding.

To create the conditions for the safe and rapid intervention of the Integrated Rescue System bodies at the TA site lies in the following:

- The Police of the Czech Republic will immediately provide the TA site for the safe intervention of the Fire Rescue Service and the possibility to give pre-hospital emergency care through the rapid emergency medical service. The policemen will have to protect the other road users through the appropriate deployment of their means of transport and technical means. The personal assistance of policemen also lies in regulating traffic along relevant routes.
- The Fire Rescue Service members will have to perform a survey of the accident site and its immediate vicinity to check crashed vehicles and pull people out from the crashed vehicles quickly and safely and hand them over to emergency rescue workers. They will also have to extinguish the fire and, if need be, prevent the leakage of dangerous substances in relation to the protection of human health and the environment. They will eliminate the consequences of the TA on the road and in its immediate vicinity. The Fire Rescue Service unit does this only when there is an imminent threat to the health and the lives of people, animals or the environment, or when there is a risk of fire, explosion or the leakage of dangerous substances. Further, the units may, on the basis of a contractual relationship with the owner or the road transport manager or a person who caused the accident, participate in the liquidation work connected mainly with the cleaning of the contaminated routes.
- The Rapid Emergency Medical Service provides pre-hospital emergency care not only to the injured but also to the participants otherwise affected in a traffic accident. It works in close co-operation with firefighters in order to preserve the essential life functions of the injured and to ensure the subsequent transport to designated health care facilities.

As the analysis of all possible problems associated with the rescue of people in road TA is beyond the scope of this article, this contribution focused only on particular issues, which directly affect the quality of rescue operations.

5 Conclusion

Traffic accidents represent a serious society-wide negative phenomenon, occurring every day. In addition to disrupting road traffic continuity and material damage, TAs also cause health consequences, fatalities and family tragedies. In the Czech Republic, the term road traffic accident covers all incidents reported to the police and investigated by the police as such. Unless specified otherwise, the numbers of fatalities of traffic accidents correspond to the status within 30 days after and after 24 h from the accident.

The United Nations Organisation estimates that about 1.25 million people die as a consequence of a traffic accident all over the world in 1 year and another 20–50 million are injured. [28] Traffic accidents on the roads of the European Union in 2018 caused the death of about 25,100 persons and another about 135 thousand victims suffered severe injuries. In some European Union countries, there were about 30 TA fatalities per 1 million inhabitants last year. On the other hand, there are countries where this number amounted to between 76 and 96 in the same period. In comparison to the above mean, the Czech Republic appeared to lag behind the last year´s European mean number of TA fatalities by nearly 27% with a year-on-year increase in the number of fatalities by 14%.

The aim of the European Union is to reduce the number of road traffic accident fatalities on European roads by one-half. This objective is also followed by the Czech Republic with its long-term goal in the area of road traffic to reduce the number of TAs and thus to minimise the numbers of fatalities and severe injuries. In compliance with the policy of the European Union, the Czech Republic has also prepared and published the National Strategy of Road Traffic Safety for the period 2011–2020. The main objective of the National Strategy is the reduction of fatalities and severe injuries in TA. Although in the years 2016 and 2017, the consequences of TAs in the Czech Republic decreased in number, in 2018, the number of fatalities and severe and light injuries in road traffic accidents increased again. The published number of fatalities and severe injuries in the Czech Republic suggests that their numbers will not be halved in the Czech Republic, and the objectives of the European Union and the Czech Republic in the area of road traffic safety will not be fulfilled.

The growing number of TAs and the consequences also result in the increasing numbers of interventions by the basic component parts of the Integrated Rescue System.

The rescue of victims of road TAs is one of the most demanding tasks of fire-fighters and medical rescue service teams. Addressing each TA can be divided into multiple stages. With regard to victim rescue and minimisation of negative effects of TAs on their lives and health, the most relevant stages are the safety and rescue stages of the intervention. The activities of the basic component parts of the Integrated Rescue System must be performed in time by appropriate technological means and with a highly professional approach. Using statistical data on interventions of selected component parts of the Integrated Rescue System in the years 2011–2018, the article specifies their particular roles. Timely intervention requires as quickly as possible set off for the venue of the accident; in the case of some of the component parts of the integrated rescue system, in 2 min from the announcement of the need for intervention by the local operation centre. An important role is also performed by the time of arrival of the integrated rescue system components to the place of the intervention for timely provision of pre-hospital first aid. Even though the time to arrive on the venue of TA should be as short as possible, its length cannot be specified accurately as it is affected by a number of factors, including the type and the condition of the road, traffic density, passability of roads, behaviour of drivers and other persons on the road, including cyclists, etc. Another requirement for the TA victim rescue is the corresponding technological equipment of the rescue vehicles for disentangling victims from the crashed vehicles and subsequent use of life-saving equipment and quick and safe transport of the injured to the nearest hospital. The rescuers must be professionally trained for use of this technology.

The safe and timely intervention of the integrated rescue system units may be affected by various risks and complications that can increase the difficulty of the rescue action. In addition, in extreme cases, they can even cause injury or death to the integrated rescue system team members. To prevent or minimise these problems, the potential risks and complications on the way to/from the intervention and in the course of it must be analysed. The purpose of any TA rescue activity is to eliminate any imminent danger to the lives and health of persons. Danger elimination must however be understood as a set of various activities dependent on a number of different factors. One of them may be professional qualifications of the rescue team members; the What-if method has been used to propose the relevant measures and recommendations for improvement of intervention quality on the side of the basic component parts of the integrated rescue system intervening in the case of a TA for the purpose of potential risk reduction. This article also includes proposals for improved solutions to TAs applied by the basic component parts of the integrated rescue system.

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