Abstract: To properly define countermeasures to improve traffic safety it is necessary to determine the specific causes and circumstances of accidents. In this sense, the current practice, developed a series of tools for the analysis of accidents that can accurately point to the problem. In-depth analysis of accidents or as they are called independent assessment of traffic accidents is one of the modern tools in traffic safety analysis. Worldwide, this method is recognized as one of the key methods for analysis of traffic accidents and accidents with the most severe consequences. However, the practice is not entirely agreed about procedures which are going to carried out in such an analysis, and is not fully complied participants in the in-depth analysis. This paper aims to show the current global best practice in terms of in-depth analysis and, according to the obligation to conduct such analyses as defined in the Law on Road Traffic Safety in Article 156, but also to show the possibilities for the implementation in the Republic of Serbia.

Keywords: traffic safety, traffic accidents, in-depth analysis, worldwide experience, implementation

1. INTRODUCTION

Analysis of traffic accidents are of great importance because the analysis of traffic accidents are relevant for conclusions that create the ability to manage traffic safety. Depending on which level of analysis is necessary, it can implement various types of analysis of traffic accidents. The scientific and professional practice known as analysis of accidents can be divided into two groups: phenomenological and etiological analysis [3]. Phenomenological analysis of traffic accidents are tasked to determine the global problems of traffic safety and are usually implemented using the so-called aggregate data on traffic accidents. By applying the appropriate statistical analyses, the most common descriptive statistics leads to the conclusion where and what time is the most common event of a traffic accident, leads to the distribution of participants in traffic accidents, the distribution of the consequences of accidents, etc..

On the other hand, so-called etiological analysis opens ”black box” [3] and allows to determine the causes of traffic accidents. With knowledge of the causes of road accidents it can
be defined the appropriate set of measures to improve the traffic safety situation. Within the etiological analysis of traffic accidents is usually recognized by the expertise of traffic accidents in-depth analysis of accidents, and an independent assessment of traffic accidents.

In this paper we will present the in-depth analysis of traffic accidents, as well as a modern tool for improving traffic safety situation, the best international practice and the possibilities of its implementation in the Republic of Serbia.

2. BACKGROUND

It has been mentioned that the phenomenological analysis of accidents has the ability to determine “What?” happened in traffic accidents, but it is important to note that the phenomenological analysis are normally carried out on a sample of any traffic accident seen as a phenomenon. Therefore, in addition to these types of analyses need to be implemented and analyses that have the ability and the goal is to determine as precisely as possible cause of every traffic accident, respectively, and that recognize so-called in-depth analysis of road accidents. In Serbia, currently there is no tool that relates to in-depth analysis of traffic accidents, but perhaps the most similar to in-depth analysis of traffic accidents are called the expertise of traffic accidents.

Each traffic-technical expert has the task of the Court to determine the causes of accidents and therefore expertise of traffic accidents can be considered currently most similar tool with in-depth analysis. On the other hand, in-depth analysis of road accidents is a world recognized contemporary tool for improving road safety. Primarily developed in the world as a tool that has the task of determining whether a road or road infrastructure caused or contributed to road accident and consequences of those road accidents. In-depth analysis of accidents has been recognized as so called reactive tool for improving road safety, and as a rule carried out in those places where it has already occurred traffic accidents (Figure 1).

![Fig. 1. Place of in-depth analysis in the life cycle of the road](image)

The aim of etiologically analysis is therefore to determine WHY? occurred specific traffic accident and that is the way it contributed to or was the underlying cause. All this is carried out
because the one simple fact: any traffic accidents that occurred was a big disaster for the individual but also for society as a whole and to the society. Because of previously mentioned the nation that have a lower number of accidents and casualties can be considered successful in every respect, not only in terms of traffic safety.

In-depth analysis of traffic accidents are tasked to carry out an objective analysis of each traffic accident the most serious consequences and that their results provide increased awareness and commitment. This refers to the increasing awareness of how individuals, as road users, and the appropriate subjects (stakeholders) that contribute to or create proper and safe traffic conditions. In-depth analysis have also the indirect impact on improving standards in road safety such as traffic and road design standards, transport modes, and standards for creation of safe traffic conditions.

Finally, although the in-depth analysis of traffic accidents are considered reactive analysis, because analysis conducted after the occurrence of road accidents with the most severe consequence, the results of these analyses certainly allow preventive action, especially in terms of prevention of future similar events.

It is widely known that in the world each year about 1.3 million people are killed in traffic accidents [10], while in the EU this number is around 40,000, while in Serbia in the last few years, every year in road accidents between 600 and 700 people died. It is also necessary to note that the factor Road caused by itself or in conjunction with other factors of traffic safety in approximately 30% of traffic accidents (Figure 2).

In Serbia, the situation was quite different than it is in the world in developed countries. In Serbia, the Road cause accidents with fatalities in less than 0.1% of accidents (Figure 3).

Not necessarily a lot of analysis and thinking reach to a conclusion that such a small percentage of the real situation is not appropriate, because if the developed countries, such as Sweden, the Netherlands, United Kingdom, Germany, France and others have Road as a cause of accidents in about 30% of cases, it has to be concluded that in Serbia the cause of accidents is incorrectly determined for sure in about 30% of traffic accidents.

Keeping above in mind, it is of great importance to the implementation of in-depth analysis of road accidents, because only relevant, specific and independent analyses may be aware of the real causes of traffic accidents, which, on the other hand, opens up the possibility for the prevention of accidents.
It should be noted that in-depth analysis of accidents not related to the Court proceedings, which are conducted on various grounds, or in connection with damages in Court cases. On the other hand, the Road Traffic Safety Law in 2009 is predicted by this tool as a necessary tool for the analysis of traffic safety times, in Article 156, paragraph 7 states:

‘‘In the case of traffic accidents with fatalities, the public road shall be based on an independent assessment, within a month, determine the cause, or contribute of a public road for consequences of accidents and take measures to improve road safety.’’[11].

Also in the same Law stipulates that the detailed requirements attributable to the Minister in charge of transport, that the relevant Regulations, but to date the regulation was not adopted.

3. IN-DEPTH ANALYSIS OF ROAD ACCIDENTS

When we talk about in-depth analysis of traffic accidents, one first needs to define ‘‘What is the place of in-depth analysis of the levels of analysis of traffic accidents?’’. Clearly is shown below in Table 1.

<table>
<thead>
<tr>
<th>level</th>
<th>explanation</th>
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<tbody>
<tr>
<td>Statistical data collection</td>
<td>collecting data on traffic accidents, which are mainly used to monitor trends and identify priorities</td>
</tr>
<tr>
<td>intermediate level</td>
<td>intermediate level located between the statistical data collection and in-depth analysis of accidents</td>
</tr>
<tr>
<td>in-depth analysis</td>
<td>detailed multidisciplinary analysis of a large number of parameters associated with each accident and are used to prevent recurrence of events of severe accidents by detecting causality and proposing corrective measures</td>
</tr>
<tr>
<td>special investigation of accidents</td>
<td>multidisciplinary approach to the analysis of traffic accidents who chide methodology of case studies in order to prevent a similar event of serious accidents, the discovery of causality and proposing corrective measures.</td>
</tr>
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</table>
In the above table, except of in-depth analysis can be used, it may also be noticed what in-depth analysis are and what they are for. Therefore, it can be seen that the trend in the world to conduct in-depth analysis of multi-disciplinary, to use a large number of parameters accident to discover the causes of traffic accidents and at the end to get it all used with the aim of preventing the occurrence of accidents with the highest consequences.

In-depth analysis of road accidents is a multidisciplinary analysis of traffic accident analysis, using a variety of areas: transportation, engineering, medicine, civil engineering, construction, etc. Special feature of in-depth analysis of traffic accidents are their independence, which is achieved by in-depth analysis of traffic accidents as a rule implemented by a person or teams, which are independent of the road management, but also from organizations that might be in any way involved in a specific road and specific location of the accident. On the other hand, it is important to note that independence must be: functional, financial and legislative. Functional independence means that there is no connection between the team and the individuals who carry out in-depth analyses, financial means that there must be a separate fund or the budget foreseen for the implementation of in-depth analysis and normative independence means that the relevant laws and regulations has to be defined which means implementation procedures, qualifications of experts who conducted the analysis, and all other necessary elements affecting the quality and independently conducting in-depth analysis.

In-depth analysis of traffic accidents, in addition to depth, it is essentially a really thorough and detailed analysis of traffic accidents. Detail is reflected in the analysis of a large number of parameters, which influence the occurrence of traffic accidents. As a rule, the number of parameters ranging in the hundreds of parameters relating to: the place of accident, vehicle speed, damage, injuries, weather conditions, environmental conditions, traffic signs, etc.

Since the main objective of in-depth analysis is the prevention of accidents and prevention of identical or similar accident, it is necessary in the chain of events that preceded the accident, which occurred during a traffic accident and that occurred after a car accident, to determine where the failure occurred. These failures are usually looking at the elements of the factors Man-Vehicle-Road-Environment, and after determining the cause of a traffic accident followed by proposing appropriate corrective measures and define ways to prevent the occurrence of new accidents.

The process of implementing in-depth analysis of accident involves analysis of previously collected data and information related to specific road accident. For this purpose we can use different sources of information, from crash data obtained from official statistics and all the information collected in the field or at the site of a traffic accident. After detailed analysis of all available and collected data, we come to the final conclusion, and it is implemented as ‘assembly puzzle’, because it is necessary to analyse each part to be mutually agreed and together make a whole. Practically, the analysis of all data should be just to get a picture of a traffic accident chain of events and to answer the question, what happened before, during and after a traffic accident?

4. STATE-OF-THE-ART – SHORT REVIEW

In the last fifteen years in developed countries led to the development of in-depth analysis of accidents. It should be noted that several important strategic international projects, such as SAFETYNET and DACOTA [1, 2, 4, 5, 6, 7, 8, 9] in some of its parts were treated exactly an independent investigation of accidents and in-depth analysis of accidents. Specially treated the way to collect the analysis of accidents with the highest consequences.
Experience in conducting of in-depth analysis in developed countries (Sweden, Norway, Great Britain, France and the Netherlands) will be presented in the following parts of this paper.

In Sweden, the in-depth analysis of traffic accidents conducted since 1997 and Sweden is considered one of the countries who first introduced in-depth analysis of accidents in their practice. In Sweden, there are specially designated independent teams who are responsible for conducting in-depth analysis. Their task administered to the field, or at the place of accident, collect the appropriate amount of information and to conduct a proper analysis. In Sweden there are three levels of analysis of the accident: the first, which is carried out in places where it occurs more than five people killed in a traffic accident, the second, which analyses the facts and aggregate data on traffic accidents, so-called phenomenological approach, and the third, which involves in-depth analysis of all accidents with the highest consequences.

When conducting in-depth analysis, in Sweden are coming to a final conclusion by analysing the various documents and reports as follows: Report of a specialist team for in-depth analysis, Police reports, Information from the records of drivers’ licenses, vehicle and other records, autopsy reports, reports on other activities conducted, etc. As a final result of a comprehensive in-depth analyses receives a report which includes a detailed analysis of traffic accidents along the proposed possible Road or Road environment corrections. Particularly interesting detail of in-depth analysis of traffic accidents in Sweden is publishing the results to the general public and the submission of reports to the Road management and to the Leading the road safety agency (in this case the Swedish National Road Administration). In addition, the obtained results are made available for further analysis, and the results of in-depth analysis are summarized and create periodic reports, which are also publicly published.

Example of output of in-depth deep analysis in Sweden is shown in Figure 4. It can be seen that the main output of the analysis was observed unprotected part of the road by the right edge of the pavement causing the vehicle accident slipped from the roadway and crashed into a tree (‘Before’ the Figure 4), and that the proposal, which was later implemented in the field was an extension of protective fencing and construction beginning protective fencing in a safe way (‘After’ in Figure 4).

![Fig. 4. An example of final output from in-depth analysis in Sweden](image)
The second, also a Scandinavian country, which is among the first to introduce in-depth analysis of accidents in their practices is Norway. Norway conducted the first pilot study in terms of in-depth analysis in 1999 and 2000 and immediately achieved more than satisfactory results. After that, as Norway observed a very large potential of in-depth analysis specialization in terms of specialization of teams for performing in-depth analysis was conducted. Teams are specialized in various types of accidents, particularly for the traffic accident which involved a motorcycles, for traffic accident which involved pedestrians, for traffic accidents in which are involved vehicles only and the accident with one vehicle, especially a particular incident with more vehicles, accidents with commercial vehicles, etc. In order to facilitate the harmonized implementation of in-depth analysis of traffic accidents in the entire territory of Norway in 2004 has been prepared Instruction manual for conducting in-depth analysis of traffic accidents, and since January 2005 has been fully established system of in-depth analysis of accidents.

In Norway, in the analysis of accidents, started from a simple algorithm which implies that it is necessary to determine what happened in the accident, but the police investigation of traffic accidents is mostly carried out on more than determining who is to blame?, while the in-depth analysis of traffic accidents conducted with the aim of preventing new accidents.

Teams that implement in-depth analysis of traffic accidents in Norway have further specialized teams to collect data, and teams that perform processing. Teams that collect data conduct the following steps in-depth analysis of accidents: on-ground collecting data, filling out the appropriate questionnaire, send preliminary information to the relevant agency within 24 hours, describing the facts and send a preliminary report to the relevant agency. Teams that perform data analysis implement appropriate specialized analyses, and among them the most important is to point out the following: it is a descriptive statistics and analysis towards the accident, the vehicle, according to the road; then conducted analyses of causing traffic accidents, especially to carry out analysis of the causes of traffic accidents, and especially the analysis of the causes of the consequences of road traffic accidents. The causes of accidents are divided into about 70 factors, which are related to road users, road and road environment and vehicle. The team that carried out the analysis of data write the preliminary report, conduct in-depth analyses, prepares a final report with recommendations and proposed measures, and send a final report to the relevant agency and finally, prepares periodic annual reports.

In the UK, data used for later in-depth analysis of accidents are collected by the traffic police. So far in the UK several studies of in-depth analysis of accidents were conducted and these studies have shown significant effects on the improvement of road safety. Data on road accidents collected by the traffic police are matched with data on injuries, for which they are responsible to collect by medical institutions. After collecting data specialist independent teams analysing the collected data and investigate the causality of any particular traffic accident, seeking the causes in the system human-vehicle-road.

Today, the United Kingdom is also a leader in in-depth analysis of accidents, as further as an active participant SAFETYNET and DACOTA project significant impact on the development of methodologies for data collection and methodology of in-depth analysis of accidents. Particularly significant detail in relation to Great Britain and in-depth analysis of traffic accidents is the development of a national database STATS19 and STATS20, which have a large number of variables and parameters, which are collected on the actual site investigations of accidents. These figures greatly facilitate further in-depth analysis of accidents, especially in the part already pre-collected data on the so-called possible influential (contributory) factors on the occurrence of accidents.
France also is one of the leading countries in the European Union, which conducts in-depth analysis of accidents. In-depth analysis of accidents carried out by independent, multidisciplinary teams.

Data collection oversees the responsible ministry, in this case the Ministry of Transport of France. At the beginning of the implementation of in-depth analysis in France studies were carried out primarily with the research purpose, and after the first results achieved in-depth analysis of traffic accidents were renewed in France.

And finally, in the Netherlands, the national body for road safety established the agency for conducting independent investigations of accidents. Also an independent multidisciplinary team conduct in-depth analysis of traffic accidents in Norway and has the task of determining the causes of accidents, and the consequences, and particular conduct analysis to prevent future accidents and the consequences by the proposal of appropriate measures. Practically, the proposal of appropriate measures is designed with the aim of preventing future accidents, a national body for Traffic Safety oversees the agency's operations and implementing the recommendations and proposed measures through appropriate competent operators, road companies and the like.

5. THE POSSIBILITY OF IN-DEPTH STUDIES IMPLEMENTATIONS IN THE REPUBLIC OF SERBIA

Serbia has the opportunity to join the most developed countries of the European Union, which are in-depth analysis of road accidents already introduced into their practice. For that Serbia has great potential and a good starting point. The Road Traffic Safety Law has recognized and defined in-depth analyses as an obligation for the Road management organisation. On the other hand, the institutional capacity in the Republic of Serbia are quite high, ranging from being established National Council for Traffic Safety, that there is a responsible ministry, it was founded and operates The Road Traffic Safety Agency, that clearly defines the duties and responsibilities of the Road management organisation at both the national and local level, and so on. All this represents a good starting point to start the implementation and application of in-depth analysis in the Republic of Serbia. Specifically, missing Regulation on the implementation of in-depth analysis, but has so far been possible to conduct in-depth analyses and without the mentioned Regulation, of course, according to best worldwide practice.

Perspective, which developed countries aspired and that as soon as possible should join the Republic of Serbia is continued developing of CARE database, through its extension called CAREPLUS and through international consensus and harmonization of data collection on accidents by using CADaS protocol. Also, the experiences presented in SAFETYNET and DACOTA projects show the widespread use of in-depth analysis of traffic accidents. European Union directives, recommendations and resolutions, and all documents of the Decade of Action for Road Safety (Global Plan of Action for the decade of road safety, etc..) propose to collect data on traffic accidents for monitoring and creating opportunities for improving traffic safety, and Serbia can join to the developed countries if already at this point be thinking proactively and introduce modern procedures improve road safety in their practice.

Taking into account global best practices [1, 2, 4, 5, 6, 7, 8, 9] the most basic recommendations of this study for the introduction and implementation of in-depth analysis of traffic accidents are:

- In-depth analysis should be conducted in order to contribute to the improvement of road safety at all levels, international, national and local.
• Conducting in-depth analysis must be transparent, and that there is a possibility that the conclusions obtained by this analysis are published publicly.
• In-depth analysis must be independent, with some particular data about road accidents can be obtained by certain stakeholders, but it should be emphasized that there should be no influence of these stakeholders on the process of conducting in-depth analysis.
• There must be independence in the financing of in-depth analysis of accidents, through planning funds or budget.
• In-depth analysis, depending on the complexity of traffic accident, may conduct individual or team of experts, and on the other hand should be multidisciplinary. Key members of the team must have adequate knowledge and experience in traffic safety, and the analysis of traffic accidents, particularly the expertise of traffic accidents. Also, members of the team and individuals must have appropriate training in order to unify the process of implementing in-depth analysis, to ensure that all the in-depth analysis carried out by the same procedure.
• Team or individual who conducts in-depth analysis must be informed of the occurrence of traffic accidents with fatalities immediately upon receiving notice of an event of a traffic accident, to the earliest possible time after the accident came to the accident site and carried out the collection of necessary data.
• Data collected at the site of accident should apply not only to road but also to the human factor and the factor of the vehicle, as well as environmental factors.
• The best is to get to the accident site while still carrying out an investigation of a traffic accident, and no later than a few days after the accident, vehicle data should be collected at the scene of an accident or until done extraordinary technical inspection and discussion with the participants of the accident should be done as soon as possible after the accident, and is best if possible to the scene of an accident. Finally, the injury data should be collected by the medical staff.
• Member(s) of the team must possess the appropriate equipment to collect data on the accident scene.
• In-depth analysis of accidents should be conducted so that at the scene of an accident clarify all the present subjects, the police, via ambulance, of the participants in traffic and other possible subjects, which are being implemented this analysis for what purpose will be use the data collected.
• It would be necessary to prepare the Manual for conducting in-depth analysis of traffic accidents, which would have been harmonized with the best international practice, and with the regulatory requirements in Serbia.
• Publication of the reports must not be published identification information that might reveal the identities of the participants of accidents, and these data may only be used in the analysis.
• Reports conducted in-depth analyses, as well as periodic reports that would include more in-depth analysis should include recommendations and suggestions of preventive measures for the prevention of future accidents.
• Periodic reports, at least every sixth months, except for publication, should be sent to the competent Ministry for review and to the National Assembly for consideration.
• Periodic reports adopted should also be sent to the competent institutions of the European Union.
• Reports has to be public.
6. CONCLUSION

It is necessary to conclude in comprehensive way that it is necessary to conduct analysis of traffic accidents, especially those analysing accidents that can with high reliability to accurately determine the causes of accidents. For this purpose, nowadays it is possible to use the so-called in-depth analysis of traffic accidents, which fully meet all the requirements for accurately determining the cause of accidents.

Although this analyses have certain drawbacks, mainly in terms of lack of time necessary for the implementation of each analysis separately, the benefits obtained by this study are extremely high. Having previously stated, in-depth analysis of accidents such analyses must be independent and that should be carried out by a multidisciplinary team and held out of the accident with the most severe consequences.

Results of in-depth analysis should be one of the key results necessary for the definition of preventive measures, but also for planning and defining future policies and strategies of traffic safety, thus to significantly improve traffic safety, both at the local and national level.

Finally, in Serbia the necessary is promotion of in-depth analysis of traffic accidents, as well as the promotion of benefits that can be achieved by using in-depth analysis, because all countries, including Serbia should have developed and established a system of in-depth analysis of accidents. This can most effectively be achieved by determining stakeholder (leading agency, or some other body) that would be responsible both for implementation and for monitoring the implementation of in-depth analysis of traffic accidents in the Republic of Serbia.

7. REFERENCES