Land transport safety and security – threats, vulnerability and after-effects

Bezpieczeństwo transportu lądowego – zagrożenia i ich następstwa

**Streszczenie:** Artykuł dotyczy zagrożeń bezpieczeństwa w transporcie lądowym oraz ich następstw, podkreślając rolę badań naukowych w tej dziedzinie. Praca zawiera również informacje na temat nowego europejskiego projektu badawczego, którego wynik dostarczy w przyszłości wiele informacji na temat bezpieczeństwa w transporcie lądowym.

**Słowa kluczowe:** bezpieczeństwo transportu ziemi i bezpieczeństwo, zagrożenia, europejskie podejście badawcze

**Key words:** land transport safety and security, threats, European research approaches

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INTRODUCTION

Safety and security are currently the most frequently used terms all over the world. Security issues influence our everyday life directly or indirectly. We are facing several threats, the ones which are well known and which are currently seriously covered by protecting measures, but also those which are newly arising from current economic, social and geopolitical situation. Security experts have to deal with new challenges in all public sectors.

Transport system is a backbone of an economic and social existence of our society. Therefore, it is one of the most important sectors concerning population all over the world, whose prosperity depends on the proper, effective functioning of all the sectors of the transport system and traffic infrastructure. For that reason, a requirement calling for their safety and security is essential and vital.

THREATS AND THEIR ORIGIN

We are witnessing globalisation of the world, but does that also mean global safety? The answer is “NO”. This directly refers to the traffic as well as to a pace in which it has recently increased itself and keeps increasing. The traffic infrastructure is developing in a slower pace but the demands imposed on it keep increasing.

On the other hand, the traffic system faces safety threats. Except for the well-known threats, which often acquire new forms, there are also many new ones, which have only been implied so far or are even unknown.

Providing we perceive the traffic as a structured system with three basic components, those being a traffic route, a transport vehicle and traffic participants (both active and passive), we can say that the safety threats might fall on some of them or all of them at the same time. Consequences then relate to local and global safety with negative impacts on health and people’s lives (both traffic participants and those uninvolved in the traffic system) and damages on properties (transport road, infrastructure, and transport vehicles), which often bears no direct relation to the traffic.

Traffic safety is a phenomenon with certain regularities, yet at the same time it is influenced by various casual phenomena. The traffic and its safety
system keep evolving. Transport vehicles support this fact the most and in the most apparent way.

A relation between the transport road and transport vehicles has been the subject of many extensive research in several countries of the world for many years. Terms such as “intelligent road” or “intelligent highway” are likely to become reality in not-so-distant future. These trends may be referred to as “an intelligent traffic system”. Although the above mentioned facts refer to the road transport, this term may also relate to all the other kinds of transport.

This may suggest that the vulnerability of traffic systems is due to a technical enhancement of their components decreasing. This is however partially true. In order to understand the issue in a better and more complex way, it is necessary to know all the threats the traffic system faces. Generally, safety threats jeopardizing the traffic may be classified into three groups, based on their origin:

1. “objective” (without human participation, occurring independently of human action): a) Technical breakdowns; technological imperfections and accidents (on transport roads, in transport vehicles), b) Natural catastrophes (seismic; volcanic; climatic);

2. “subjective” in transport (caused by traffic participants – active or passive or by other human actions): a) Subconscious – unconscious actions (e.g. those influenced by health or other acute problems), b) Conscious actions – intentional or unintentional (e.g. impassiveness, negligence of duties, unpredictable actions under the influence of alcohol, arrogance, aggressiveness, ...);

3. “external” attacks on the traffic system: a) Individual and/or organised crime (e.g. theft of goods and transport vehicles transported, including violence towards personnel, ...), b) Terrorism – individual and/or organised (e.g. attacks applying the “CBRNE” threats, which stands for “chemical, biological, radioactive, nuclear, explosive”, or cybernetic).

RISKS AND CONSEQUENCES

Supposing these threats become real, they result in emergency situations (ES), often in crisis situations with undesired consequences. It is thus crucial
not only to identify them, but also to analyse them and know the vulnerability – the weak points of the traffic system – in details. The probability that the threat “turns” into the emergency situation varies and needs to be analysed. The consequences of the emergency situations may be and are serious in various manners. All of these emergency situation aspects in transport must be researched rigorously and must become the object of a risk assessment. A risk represents a function of the probability (the occurrence of the ES) and a severity of consequences. There are various effective risk assessment methods.

Each emergency event requires a detailed analysis, within the scope in which the causes of their occurrence, course, consequences and measures and suggestions are researched. The very first aim of the measures is to recover the system and its full-valued functionality. Another aim of the measures to be implemented is to eliminate the risk. As the risk is expressed by means of two parameters, measures and recommendations may and should focus on the two following areas:

The area focusing on decreasing the probability of the ES occurrence (prevention). The area focusing on decreasing the severity of consequences supposing the ES has already occurred.

**Examples of emergency situation in transport system**

For the purposes of illustration, some characteristic or typical emergency events shall be mentioned, which “evolved” from the above mentioned threats. Threats originating in technical breakdowns and/or technological imperfections are rare, yet not non-existent. Unfortunately, the threat like that also occurred in Slovakia. During the construction of a highway bridge which was under construction, there was a failure in a technological device. A supporting scaffold while an in-situ cast bridge was being concreted. This happened in November 2012 (figure 1). A “crisis situation” with fatal consequences and major economic damage occurred. The case is still being investigated, though partial information suggests inaccuracies in the process of designing the technological supporting scaffolding.
The traffic infrastructure is often threatened by natural catastrophes. One of the biggest took place in 1995 in Kobe, Japan, during an earthquake, leaving the city almost totally destroyed. Seismicity is a natural phenomenon which does not pose a major threat to our area. The probability of occurrence – the occurrence of an emergency event due to this threat is much lower than in some other parts of the world. The severity of consequences, however, may be exceptionally high. Although this is mainly related to the stricken area, from the perspective of traffic, it has supraregional impacts, as for a long time, the “supraregional and global” part of the traffic system is interrupted. Volcanic threats in Slovakia as well as in central Europe are rather improbable, too. Their impacts are of supraregional or even global character, as the volcanic dust threatens air transport in a very large area, for instance. Another natural catastrophe, that being floods, is not that rare in Slovakia. It threatens the land transport and the probability of its occurrence and occurrence of an emergency situation is rather high. Also, the seriousness of consequences is high and therefore floods represent a large and serious risk for the traffic system.

Except for ground communications and railway tracks being flooded, thus made dysfunctional, it may also result into damages in civil engineering objects, mainly bridges, the repair of which is demanding in terms of time and
finances. In case of the so-called flood flow, bridge bases get underwashed, as it portrayed in the picture, which exemplifies a breakdown of a bridge over the Ondava River (Figure 2). Subsequently, the bridge, as well as the road leading through it, is put out of order for several months.

In the world, some cases regarding breakdowns (destruction) of bridges due to wind have occurred. In 1940, in the USA, shortly after it had been put in use, the Tacoma suspended bridge collapsed [Leonhardt 1982]. As the wind speed was 19 m/sec, the bridge started to oscillate, and then it achieved the resonance and collapsed (a picture made by an accidental witness at that time in Figure 3).

![Figure 2. A bridge damaged as a result of a flood.](image)

As this happened under the circumstances of a relatively low wind speed, the case became an object of extensive research which resulted in the bases of the so-called wind engineering. There were clarified many phenomena related to the impacts of wind on engineering constructions which had been unknown. Mainly due to that, currently, the impact of “normal” and frequently occurring wind does not pose any real threat any more. However, what remains an actual threat are other phenomena related to high-speed
wind, such as typhoon, tornado or hurricane. As a result of global climatic changes, these threats are becoming real even in the Central Europe.

The second group of threats (those of subjective character) refers mainly to such emergency events as traffic accidents. According to the World Health Organization, road traffic injuries caused an estimated 1.24 million deaths worldwide in the year 2010 and millions of others get injured or even permanently handicapped [World Health http://www.who.int]. Fortunately the most severe effects of road accidents are decreasing as it is shown in figure 4 (the situation in European Union is presented for the period from the years from 1991 up to 2014 [Road safety http://ec.europa.eu]). While the curves expressing number of accidents and the number of injured are nearly parallel during whole period, the third curve representing fatalities decreases much faster. The reason of this effect consists in the effective technical protective measures mainly in vehicles – as mentioned above.
The most serious traffic accidents are those which happen in tunnels, whereas the greatest threat is posed by fire. As the traffic intensity increases, bigger and bigger portions of it shall be situated in tunnels. In the European Union, there are more than 50 road tunnels longer than 1 km. A fire (either accidental or intentional) poses a highly probable threat. The temperature reaches 1200°C within 5-6 minutes and within 20 minutes, it reaches 1300°C. Such temperatures might then remain unchanged for several hours, as it shown by the RWS fire curve valid in cases of fires in tunnels. In 1999 during the one of the biggest fires in the Mont Blanc tunnel 39 people died. The “cooling” of the tunnel took 15 days – and it was only after that, that inspecting and diagnostic works could have been done. Primary damages represent engineering reconstruction works. After the fire of 1999, 380 million euros were invested to completely rebuild the tunnel, making it a world reference in terms of safety [Autoroutes et Tunnel http://www.atmb.com]. Secondary damages – demanded expenses (such as those on diversion routes during more than three years the tunnel was closed) were almost three times as high as the primary ones.

Terrorist attacks on traffic system represent the newest and an exceptionally serious threat. The traffic system, as well as the ground transport
being a part of it have been and still are an easy and thus a “favourite” target of attacks. Those may focus on transport rods, transport vehicles, engineering construction objects or information and communication traffic systems. These attacks are realized by different terrorist groups, or by individual terrorists – individuals. Besides such attacks, the land transport is an area of interest for economic crime as well.

Within the range of the solution of CARONTE, a European research project (“Creating an Agenda for Research ON Transportation sEcurity”) [Caronte, a European, http://www.caronte-project.eu], attacks on traffic systems during the period of years between 2000 and 2013 were researched. More than 400 attacks, most of which were terrorist attacks, were processed. Attacks took place on all continents, in more than 32 countries. 1921 people died as a result of them and 6962 people got injured. The severity of consequences was expressed by means of stages ranging from the most serious ones (an exceptionally large number of people who died there and many people got seriously injured, exceptionally large economic damages and dysfunctional traffic system) – the S7 stage to the least serious ones – S1 (no people died there, nor there was any damage to health, temporary damage to the system, negligible economic damages). There were also attempts for attacks which were unsuccessful or inhibited at the end of the day and they were classified into the stage covering potential consequences (which might be serious). Mainly in Europe, there have been many unsuccessful/inhibited attacks as well as attacks which were finished, yet there were no victims (no death or injuries) – with not very severe consequences (S1 and S2).

The first aim consisted in the analysis of previous attacks on land transport with the help of some catalogue form, which comprises a specific list of attacks with the available information. Consequently, this catalogue was analysed and evaluated, mainly in the terms of severity of effects and security measures taken after the attacks. It should help to improve the transport security system in the future.

Generally, each emergency event was analysed regarding the following four aspects:

- causes (the situation before attack),

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− course of the attack,
− consequences and
− security measures taken after the attack.

Each of these four aspects is quite difficult, and it usually consists of more sub-parameters which could be subdivided into further groups. That is, why we have to perceive the analysis of previous attacks multi-parametrically.

For example, causes of the terrorist attacks, which have roots in certain conditions and in a specific socio-economic situation before the attack, could be divided at least into two groups. Both of them have common basis – extremism and fanaticism. It could emerge from the national, ethnic or religious intolerance. This is only one point of view, but we have to also take into account certain economic conditions and the status of different negatively aggrieved groups of population in the society.

Consequences will appear in the form of human casualties as a damage to lives and health of the participants of transport, and/ or in the form of economic losses. Economic losses can be further divided into two groups. Primary losses consist of immediate material damages to the vehicles on the road and on the objects of the transport infrastructure. Secondary losses are for example economic damages which happen due to traffic restriction, or due to short or long-term using of the detour routes during the road and other related traffic infrastructure reconstruction after the attack. Other losses can arise in the area of logistic ensuring in the transportation of goods (delay or cancelation of delivery). The project team did not consider negative environmental impacts.

Security measures taken after the attack can be divided into the two groups. The first group has an operative character; it has to be accepted immediately, for example, due to the mitigation of the primary consequences. The second group of security measures result from the recommendations adopted as a conclusion of the emergency events investigation.

These security measures should be adopted in the future in the form of prevention focused on two areas: reduce (or completely eliminate) threats, that is, to reduce the risk of emergency event occurrence; reduce the range of the consequences.
Figure 5. A diagrams of the frequency of attacks on traffic systems depending upon the severity of their consequences – in the world (on the left) and in Europe (on the right).

**CONCLUSION**

Traffic security risk eventually causing traffic accidents is generally accepted risk by the whole human society. The majority of population takes part in the transport system ever day - knowingly and wilfully. But consequences of the road accidents in the EU are very serious: more than 70 people die every day. On top of that, on every death on Europe's roads there are 4 permanently disabling injuries estimated such as a damage to the brain or spinal cord, 8 serious injuries and 50 minor injuries [Road safety, http://ec.europa.eu]. This fact is considered a part of a daily life, a matter of course. Everybody, the staff and/or passengers willingly enter the road transport system accepting the well-known risk.

On the other hand, the society in general does not accept violence, brutality – terror nor in the transport system, even if the consequences are much less serious (much less fatalities, injured). The development and application of effective measures against terrorist attacks in the land transport or against terrorism in general is the main challenge nowadays. Whatever is targeted by the terror, it directly or indirectly affects the transport in very negative way. The transport is a very complex system with many variable parameters. Therefor the scientific research has unsubstitutable position in the future safe and secure transport system preservation.
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