Enhancing of security on critical accident locations using telematics support

Zdenek Dvorak, Zoran Cekerevac, Miroslav Kelemen and Radovan Sousek
University of Zilina, Slovakia, Zdenek.Dvorak@fsi,uniza.sk, University Union, Serbia, Zoran_Cekeravac@hotmail.com, Armed Forces Academy, Slovakia, Miroslav.Kelemen@aos.sk, University of Pardubice, Czech Republic, Radovan.Sousek@upce.cz

Abstract:
This article focuses on decreasing of transport accident frequency on critical accident locations. Main part of article describes risk assessment in case of road transport. The attention is paid on transport infrastructure, transport means as well as system, which is dedicated to road transport management.

Key words: security enhancing, critical accident locations, risk evaluation

1 Introduction

In central and eastern European countries is the highest ratio of people who tragically die or are injured compared to others EU countries. EU "White paper" defined task to decrease mortality in transport by 50% for these countries in period 2000 to 2010. This task involves all inhabitants. The process of enhancing security in transport is complex and includes complete transport system, which is – transport infrastructure, transport means, methods of transport traffic management, legal environment as well as inhabitant as traffic participant. According to results of analysis, most people die and are injured in road transport - therefore the content of the article will be oriented only on road transport. For successful fulfilment of mentioned tasks it is essential to apply certain measures in all mentioned areas. The article presents analysed tasks, which are based on analysis of state of transport infrastructure. Further presented tasks are based on analysis of transport means and methods of transport traffic management. The measures, which are inferred from state of legal environment and inhabitants' behaviour (who are traffic participants) are also very important.

2 Analysis of present security state on critical accident locations

In recent years authors and their workstations were cooperating on many projects, which were oriented on security issues. The issues we were working were on all levels, from global, regional as well as issues of local security – security of individual objects. This analytical activity was based on risk evaluation methodology – look at table n.1.

Table n. 1 Transport risks evaluation methodology

Risk evaluation	1. Circumstances – relation to environment	Investigate particular object in relation to surrounding environment- to look at transport system from different angles.
	2. Threat identification and defining of assets	To choose particular location in transport infrastructure- for instance tunnel, to identify all theoretically possible threats = p and to set values to all assets = d.
	3. Risk analysis	Create risk map – qualitative and quantitative methods. To decrease unacceptable risks. To eliminate risks, which remaining risk is unacceptable.
	4. Risk valuation	Measures aimed to active risk policy.
		Prevention, risk transfer, reserves creation.
		To choose and apply proper methods.

Mentioned methodology was applied on transport system. The article works out with first and second point of transport risks evaluation methodology. The analysis is using terms from theory of transport systems, and focuses primarily on these issues:

1. **transport infrastructure** – junctions, roads, routes,
2. **transport means** – driving, driven,
3. **traffic management systems** – operational – intelligent IS, telematics applications,
4. **legal frame** – international conventions, laws, regulations, directives and technical standards,
5. **people** – employees and other participant of transport traffic (passengers, bystanders, people living close to road, etc.)

2.1 Analysis of transport infrastructure security

Road transport infrastructure consists of highways, road, local roads, junctions, road bridges, road tunnels and crossings with other transport means (most often it is railway crossing).
First task is to describe relation of system to surrounding environment. Particular transport object, for instance railway crossing can be seen as individual system with defined structure and functions. Crossing itself is in relation to surrounding transport network viewed as limiting element. These limitations have technical character underpass height and width, as well as time character – they are related to transit of trains. Technical characteristics of crossing depend on road and railway classification. In our countries, it is forbidden to build crossing of highway and railway on the same level. The

same pattern is used also in case of 1st class roads and international corridors. On the other hand, in case of new high-speed railways all crossings are built as elevated crossings. Frequencies of using of railway as well as frequency of using of road are two most crucial features for defining technical equipment of crossing.

Figure n. 1 Vertical road sign on railway crossing
Source: www.ipravda.sk, 2.12.2009

In case of crossings with very low usage frequency, it is sufficient to use vertical road sings – see figure n. 1.
More frequently used crossings usually have warning lights signalisation. In certain specific cases, the security is enhanced by railway gates. In Slovak republic, there are 2200 crossings, where 20-30 people die every year. Other important factors, which can influence crossing security, are local natural and urban conditions. There are crossings, where the main factor for occurrence of extraordinary event is weather – fog, snowing, and heavy raining.
On the other hand, some of human impacts, like other constructions, vegetation, light conditions and so often lead to tragic accidents. Therefore in certain cases it is inevitable to rebuild such crossing into elevated crossing.
To analyse mentioned objects it is necessary to integrate them into suitable overview tables – look at table n.1. This process corresponds to point two in risk evaluation – we execute threat identification and thereafter we define possible impacts of extraordinary event.

Table n. 2– Probability of transport object threatening

Type of occurrence	Class	Frequency of occurrence in region	Time effect of threat
5 – Very high	A	Event appears very often (almost daily)	Continually
4 – High	B	Event appears occasionally (once in a month)	Often
3 – Medium	C	Event appears rarely(once in a year)	Rarely
2 - Low	D	Event appear abnormally (once in 20 years)	Abnormally
1 - Very low	E	Appearance of event is almost impossible (less than once in 100 years)	Almost impossible

Source: Balog et.al.

Table n. 3 – Impacts of extraordinary event in case of transport object

Type of impact	Category	Impact description
4 - Catastrophic	I	Great loses on lives and property, long-term shutdown of transport object, long-term and serious impact on surrounding environment.
3 – Critical	II	Certain loses on lives, serious injuries, great loses on property and damage on natural environment.
2 – Marginal	III	Injuries, low loses on property, partial damage on natural environment.
1 - Negligible	IV	Traffic limitation – traffic jams with no accidents or injuries.

Source: Balog et.al.

For risk calculation we have to define impact of extraordinary event - (crisis situation). Impact classification according to used methodology is shown in table n.2.
Application of previous characteristics on particular objects can be done in following way. As a model situation we choose road D3 in town Čadca. There is a segment, with length 2km, where are located different objects, which can fundamentally influence functioning of transport infrastructure. Figure n.2 shows particular road segment from air view.
First part of road segment, the road goes op on a slope, which had to be indurated, because of low soil stability. This part is followed by bridge and entrance to tunnel. After passing the tunnel we get to sharp left side curve, the road continues as scaffold bridge up to main crossroad in town Čadca.
After approximately 500 metres, there is railway crossing with warning lights signalisation. Due to the location and altitude of town Čadca, investigated road segment is influenced by freezing temperatures for approximately 100 days of a year. This fact in combination with fogs, heavy snowing or heavy raining defines this segment to be risky.

Figure n. 2 Air view on segment of model road D3
Source: www.mapy.sk 2.12.2009

2.2 Analysis of transport means security

Issues connected to transport means security is question of its technical security. Automobile producers and producers of other transport means pay lot at attention to technical security issues. People according to their financial situation prefer transport means, which offer higher security standards.

If we have a look on transport means as an individual subsystem, than it is possible to identify different factors from surrounding environment influencing such subsystem. It is primarily present state of transport infrastructure, weather, physical and psychical state of driver and crew, state of transported cargo and other factors. [3]

Due to defined methodology, second point is threat identification. If we want to investigate technical security it is necessary to have a look on internal and external factors. Internal factors are – state of major sets of transport mean – brakes, driving, motor, and body shell. While investigating external factors it is important to focus on state of infrastructure – its construction and operational features. If we find out, that, quality of road after winter is very bad, but number of transport means using that road is relatively low, than the probability of extraordinary event appearance is relatively low. If the road is in good conditions, but intensity of its usage is high, than the probability of extraordinary event occurrence is relatively lower. The worst variant is in case of road in bad technical conditions and high volume of transport – in such case the probability of extraordinary event occurrence grows rapidly.

Second point of mentioned methodology helps us to define possible consequences of extraordinary event. Transport mean is constructed and designed in order to minimize threats connected to transported persons and cargo. Special attention is paid in case of transports which include important people, dangerous and sensitive materials. Technical conditions of cargo – especially in case of dangerous materials can be crucial element threatening transport security as well as security of transport mean. In case of transport of explosive, highly flammable and radioactive materials it is necessary to provide perfect technical conditions of tankers as well as transport cases. We can say that transport of persons and transport of dangerous and sensitive products requires 100% technical conditions of transport means. In case of extraordinary event, these vehicles can be destroyed together with its surrounding. (In case of explosion of tanker, which transports gasoline, the fire and explosion can hit object up to the distance of 50 metres.

If we want to apply content of tables n.1 and n.2 to analyse risks of particular transport mean, we have to assess in detail all its sets as well as cargo state. For better imagination, we can assess cistern truck, which is transporting gasoline – look at figure n.3.

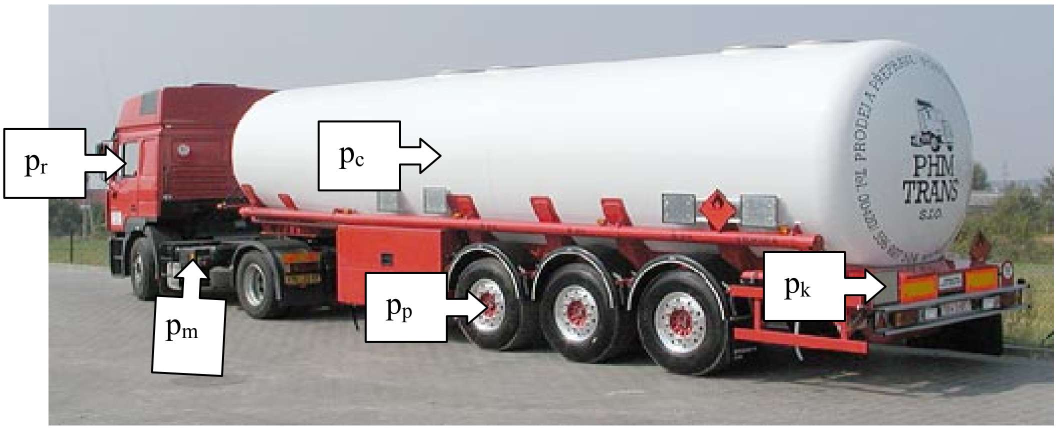

Figure n. 3 Cistern truck with identified threats, Source: Author's photo archive

Total probability of extraordinary event occurrence can be described as sum of probabilities, which can cause extraordinary event. Total calculated value is derived from relation:

$$P = p_m + p_p + p_r + p_k + p_c \quad [1]$$

where p_m is probability of motor failure
p_p is probability of wheel frame failure
p_r is probability of driving failure
p_k is probability of body shell elements failure
p_c is probability of cistern failure

As a possible impact, we can look at financial value of transported gasoline, which can be calculated as transported litres times 1 Euro. Further on, we have to add price of cistern truck and value of driver's life. Total estimated cost is 300 000 Euro.

2.3 Analysis of road traffic management systems

Development and production of road traffic management systems has rich history in central Europe. In past years there is rapid growth in application of technical facilities and technologies, which are known as intelligent transport systems. Basic tool for their application is KAREN methodology. Structure used in Europe is in figure n. 4.

National programme of support for intelligent transport system was signed in 2009 in Slovak republic. One of its parts is proposal to create national transport information system. Structure of proposed national transport information system is presented in figure n. 5.

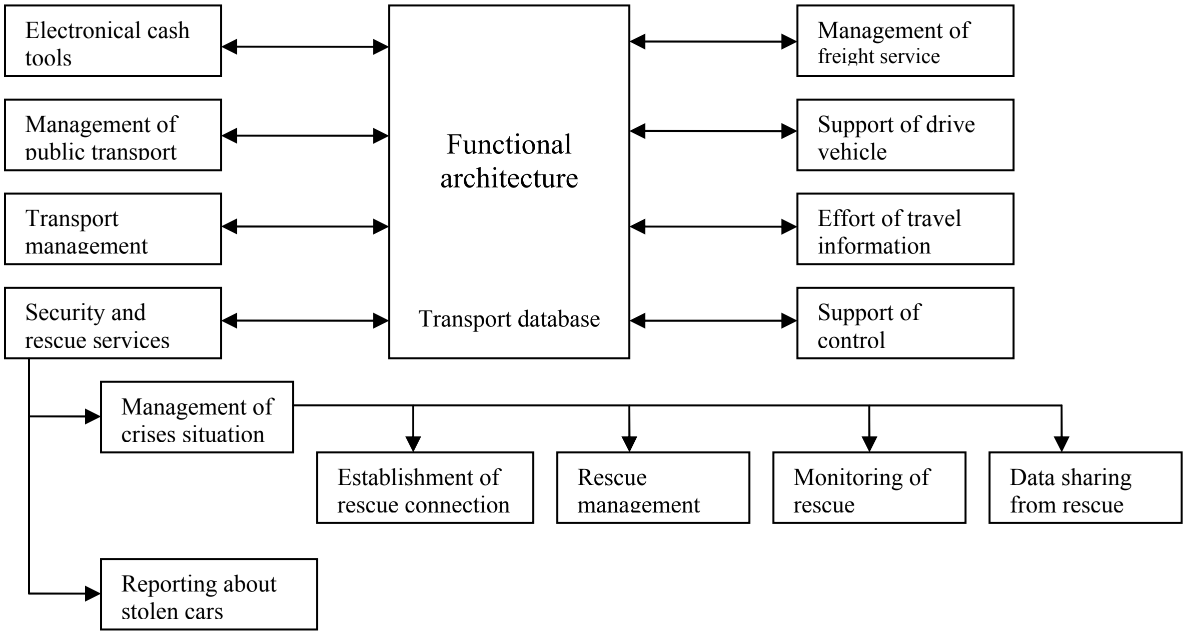

Figure n. 4 KAREN functional architecture Surcce: [2]

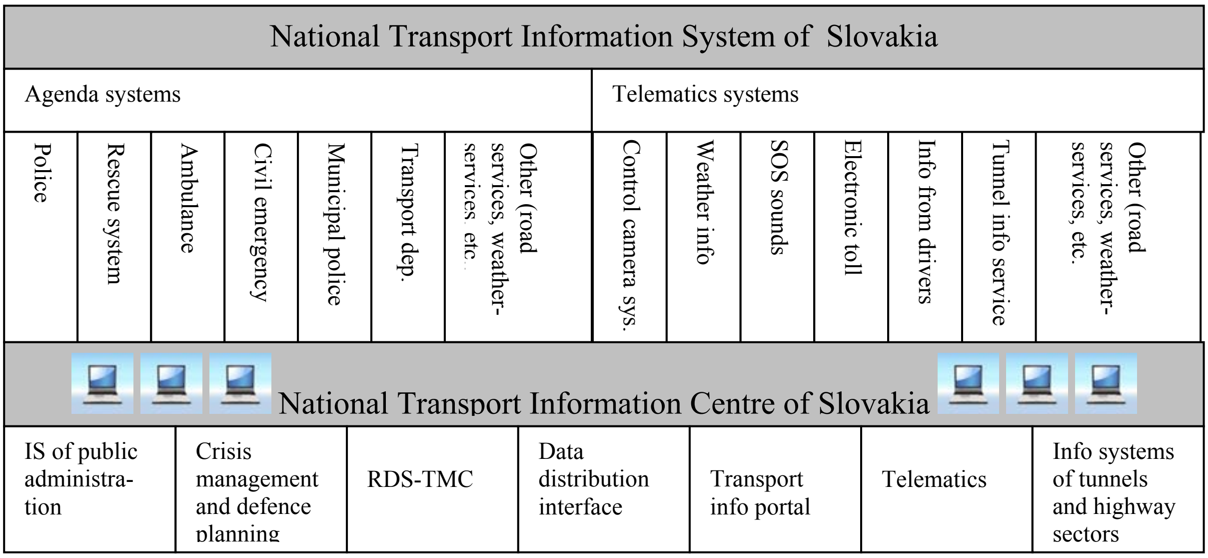

Figure n. 5 National transport information system in Slovakia, Source: [4]

If we want to assess level of road transport management, we should have a look on solutions, which are now used in Germany. In this country they use variable electronic road signs on highways and 1. class roads as a standard. In eastern European countries is building of such modern road signs is the task for next years.

3 Conclusions

In future we will present other project results – influence legal frame on road traffic security and influence of human behaviour. The research itself will be oriented on security enhancing on critical accident locations.

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