Possibilities of prevention and reduction of threats affecting the safety and fluidity of land transport

Josef Reitšpís [*1A]; Martin Mašľan [2A]

*__Corresponding author__: [1]Prof. Ing., PhD., MSc, DBA, e-mail: josef.reitspis@vsbm.sk, ORCID: 0000-0003-4248-5758
[2]PhD., MSc., e-mail: martin.maslan@vsbm.sk, ORCID: 0000-0003-1913-655X

[A] University of Security Management in Košice, Košice, Slovakia

Received: September 8, 2023 | Revised: September 22, 2023 | Accepted: September 30, 2023

DOI: 10.5281/zenodo.8397012

Abstract

Ensuring mobility and the necessary volume of transport is one of the basic preconditions for the functioning of the economy. The potential threat to existing transport systems is therefore an area that needs increased attention. The complexity of current transports is due to their growing frequency, extension of transport routes, as well as the growing number of entities that participate in their implementation, which places ever-increasing demands on their mutual coordination. It is necessary to continuously monitor the progress of shipments, identify and evaluate the risks that may affect them. Insufficient attention to this issue can lead to time and material losses, in the worst case, the death of their participants, or to the high financial costs required to rebuild the disrupted system. Transport is an open system in which more and more people are working, whether transported or involved in its organization, which increases the possibility of their failure and facilitates the possibility of attack. Strict application of risk management, assessment and, if necessary, implementation of the necessary measures can lead to the protection of high-value assets. At present, we already commonly encounter concepts such as the intelligent transport route or the autonomous means of transport. All these circumstances, as well as the importance of transport, which we could compare to blood circulation of the state's economy, make it a possible target for various types of attacks. Cyber threats and attacks are becoming increasingly relevant today. Such an attack is characterized by a relatively low level of threat to the attacker himself and possible high damage in its successful implementation.

Key words: land transport, road transport, rail transport, security threats, logistics, cyber-attack, risk management.

Introduction

The development of the global economy is largely dependent on the free movement of people, goods and information. We are witnessing the globalization of the world, but this does not mean global security. World globalization also directly affects transport, the importance and intensity of which is rapidly growing. Both the number of transported persons and the volumes of materials are increasing, the transport routes that can lead through or over risk areas are being extended. A characteristic feature is the fact that transport infrastructure is developing more slowly on a global scale than the requirements it has to meet. The transport system is currently exposed to security threats, both to the known ones, which are constantly taking on modified forms, as well as to many new ones, which are so far only intuitively suspected, or even unknown at all. Individual types of transport have their specifics, their subject may be dangerous substances and materials that endanger both the participants in the transport, as well as the civilian population located along the transport routes, or the overall security of the state. The combination of various factors accumulates the safety risks that affect transport and their possible consequences. Continuous identification of these risks, their analysis using appropriate methods, taking into account the nature of the analyzed system, subsequent assessment and evaluation of identified risks, design of necessary measures, as well as incorporation of acquired knowledge into practical and theoretical training of transport participants is a prerequisite

for safe and smooth transport. losses (time, material, or human). It must be stated that the level of vulnerability of the system is still increasing. An important prerequisite for safe and smooth transport is the implementation of corrective and preventive measures designed on the basis of identification and assessment of risks affecting the transport system. Despite the ever-increasing attention paid to the management of safety risks arising from transport, more than 1.3 million people die in road accidents worldwide each year. Depending on the country, the implementation of the necessary measures may depend on their funding possibilities, but also on conflicts over the provision of passenger security, taking into account the privacy of their guaranteed rights. The flow of transport is largely influenced by the level of protection of the individual assets that are part of the existing transport system.

The present is a period of growing importance of the use of information technology, which leads to efforts to misuse them aimed at economic, military and political weakening of the enemy. It is important for the operation of transports to maintain the ability to operate in the event of unauthorized access to the information system, its infiltration by misinformation, damage to existing databases, which may result in its partial or complete malfunction. The protection of information systems includes elements that increase their resilience, but also the ability to operate transport in the event of their failure. Transports require the interconnection of a large number of information systems, which increases the possibility of endangering them. In order to increase the resistance of the system, it is constantly necessary to upgrade existing ones and add new security features within the hardware and software. The problem is the rapid development of information technology and cyber threats, which is not compatible with the lifetime of vehicles. When procuring means of transport, it is necessary to take into account not only the price, quality, functionality, but also the integration of modern active and passive safety elements.

Results and Discussion

1. Safety aspects affecting the transport system

If we understand transport as an organized system with three interacting basic elements, which are the transport route-means of transport and transport participants (whether active or passive), then we can state that security threats may relate to one of the elements, their possible combinations. The consequences of restricting the flow or failure of shipments can affect both local and global security, and can lead to negative impacts on the health and lives of people involved in shipments, as well as people who are not involved in the system at all. Other consequences are various forms of damage to property, which may be the transport infrastructure, the transported material, the means of transport, or property that has no direct connection with the transport itself.

Transport and its security system are constantly evolving, and the individual elements are characterized by different paces of such development. The development of vehicles, in which new elements of passive and active safety are constantly being applied, is most noticeable. The means of transport and the active participant – the driver act interactively, the applied active safety elements contribute to the reduction or elimination of safety risks on the part of the driver, which can gradually lead to his complete replacement and production of autonomous vehicles. The road-vehicle interaction has been the subject of extensive research in various countries around the world for many years. We are increasingly confronted with the terms ‘smart road’, ‘smart highway’ or ‘intelligent transport system’, which will become part of real life in the future.

These facts could give the impression that the vulnerability of transport systems is constantly increasing due to the technical improvement of their elements. This is just one of the prerequisites for the safe operation of the system. The second is the constant monitoring of the security risks and threats to which this system is exposed. In general, we can divide security threats affecting traffic into 3 groups:

1. Objective (existing without human intervention, thus arising independently of human action). We advise you on these:

a) Technical failures, technological deficiencies and accidents on the road or means of transport.

b) Natural disasters – seismic, volcanic, climatic.

2. Subjective (caused by transport participants, whether active or passive, or by other human actions):

a) Subconscious-unconscious action e.g. under the influence of health problems.

b) Conscious action - intentional or unintentional (eg neglect, arrogance, aggression, influence of alcohol).

3. External attacks on the transport system:

a) Individual and / or organized crime

b) Terrorism - individual and / or organized, for example, attacks using "CBRNE" threats, i.e. "chemical, biological, radioactive, nuclear and explosive". Cyber threats and the use of vehicles as weapons are also increasingly mentioned in this context.

The degree of action of individual threats can lead to extraordinary events, which have different probabilities of occurrence, as well as the severity of consequences. Therefore, it is essential to constantly monitor the security aspects of traffic by analyzing and assessing existing security risks. Every extraordinary event requires a thorough analysis, which examines the causes, course and consequences of its occurrence. Based on the knowledge gained in this way, it is possible to propose the necessary measures. The primary task of corrective measures is to restore the functionality of the transport system. In contrast, preventive measures seek to reduce the existing risk to an acceptable level, which should protect the system from further emergencies.

The safety of transport and its individual components therefore depends to a large extent on the preparation of the system for possible risk situations and the occurrence of extraordinary events. These activities are the subject of Risk Management, i.e. management that prepares the system for dealing with emergencies and crisis situations.

1.1 The importance of logistics for the functioning of sectors of the national economy

The basis of logistics can be derived from the need to address logical procedures (processes) related to the satisfaction of basic human needs, such as satiety or clothing. According to Junemann, "Logistics – the scientific science of planning, managing, and controlling the flow of materials, people, energies, and information in systems." (Junemann, R. 1989). The European Logistics Association defines logistics as the organization, planning, management and performance of flows starting with development and purchasing, ending with production and distribution according to the order of the final customer so that all market requirements are met at minimum cost and minimum capital expenditure.

Since its inception, logistics activities have undergone a gradual development, which is a necessary prerequisite for meeting the ever-changing requirements. They are reoriented from the market of the seller to the market of the buyer, while the delivery time is reduced and the level of provided services increases. The manufactured products are characterized by a higher quality of production, but also by shortening their life cycle and the growing range of the product range while constantly striving to reduce stocks.

The basic determinant of the development of these activities was the transition from manual administration and data processing to their electronic form and implementation of systems enabling comprehensive monitoring of logistics processes in real time. Logistics activities are currently an integrating element, both of the individual internal components of the system and the connection of this system with the environment. The basic premise of this integration is a functional information system that in real time:

- provides information on material flows and current conditions in individual warehouses;
- updates the production status;
- indicates the need to purchase inventory, allows distribution planning;
- provides information on existing and potential customers and suppliers;
- informs about the status of materials at suppliers;

- monitors the ordering process;
- monitors the volume, composition and price level of ordered and delivered products;
- shows the financial flows and payment discipline of the participants;
- monitors the quality of ordered and delivered materials.

A properly selected and implemented information system thus allows to a large extent the mutual substitution of information and material flows, as well as the reduction of logistics performance and costs.

The reason for the functioning of the logistics system defined in this way is the ever-increasing requirements for the volume of transport of people and materials. Such shipments can serve as inputs to production processes, transfers within existing productions and intermediate warehouses, a means of meeting the needs of end customers through the delivery of required products and services. In the period of globalization, these transports are characterized by the growth of risk factors, such as internationalization, the growing length of transport routes and volumes transported, the increasing number of people needed to organize them. For the safe operation of logistics and transport systems, it is therefore necessary to pay constant attention to existing and emerging risks.

1.2 Land transport and its operation in the Slovak Republic

In the conditions of the Slovak Republic, road transport is the most used for these purposes. The basic advantages of this type of transport include its speed, reliability, flexibility, the possibility of direct realization of transported goods and its independence from other types of transport, the diversity of the offered vehicle fleet. Road transport is mostly used for shorter and medium distances. An important factor favoring this mode of transport is the high number of roads, which is linked to the availability of the final destination, without the need for combination with other modes of transport, and lower infrastructure repair costs in case of damage.

The second most used type of transport is rail transport, which is limited by transport routes, the need for sidings, lower speed and higher price. Its advantage is low ecological impacts on the surrounding environment and minimal weather impact. Although this mode of transport allows smooth transfers of materials and people, but in the presence of the above restrictions. This transport works most efficiently in direct transport from train to train. In other cases, it must be combined with road transport for efficient delivery. The speed of transport is greatly influenced by the number of consignors and consignees of consignments within one train. The fastest transport is performed by a direct integrated train, i.e. by a train which transports consignments from one transmitting station from one consignor to one receiving station (siding) for one consignee. The disadvantage is the very problematic transport of oversized materials and the time that this method of transport requires when delivering materials from multiple senders, from multiple stations to multiple recipients.

In the conditions of the Slovak Republic, domestic water transport is of only marginal importance due to the insufficient length of navigable watercourses. In general, it is the most economically advantageous mode of transport suitable for transporting large amounts of materials over longer distances. The disadvantage is the speed of transport, fluctuations in the state of watercourses and weather conditions. A limiting factor is also the technical equipment of existing ports. It is also necessary to combine this transport with other transport types during transport and distribution - ie rail and road transport. As the Slovak Republic does not have access to the sea, maritime transport in the conditions of the Slovak Republic is used only to a minimal extent. However, in a global sense, this type of transport is a means of strategic mobility.

According to existing estimates, the importance of road transport will continue to grow, to the detriment of rail and water transport. The estimates of the European Commission concerning the performance of individual types of transport for the years 2018-2030 in the conditions of the Slovak Republic are shown in the Fig.

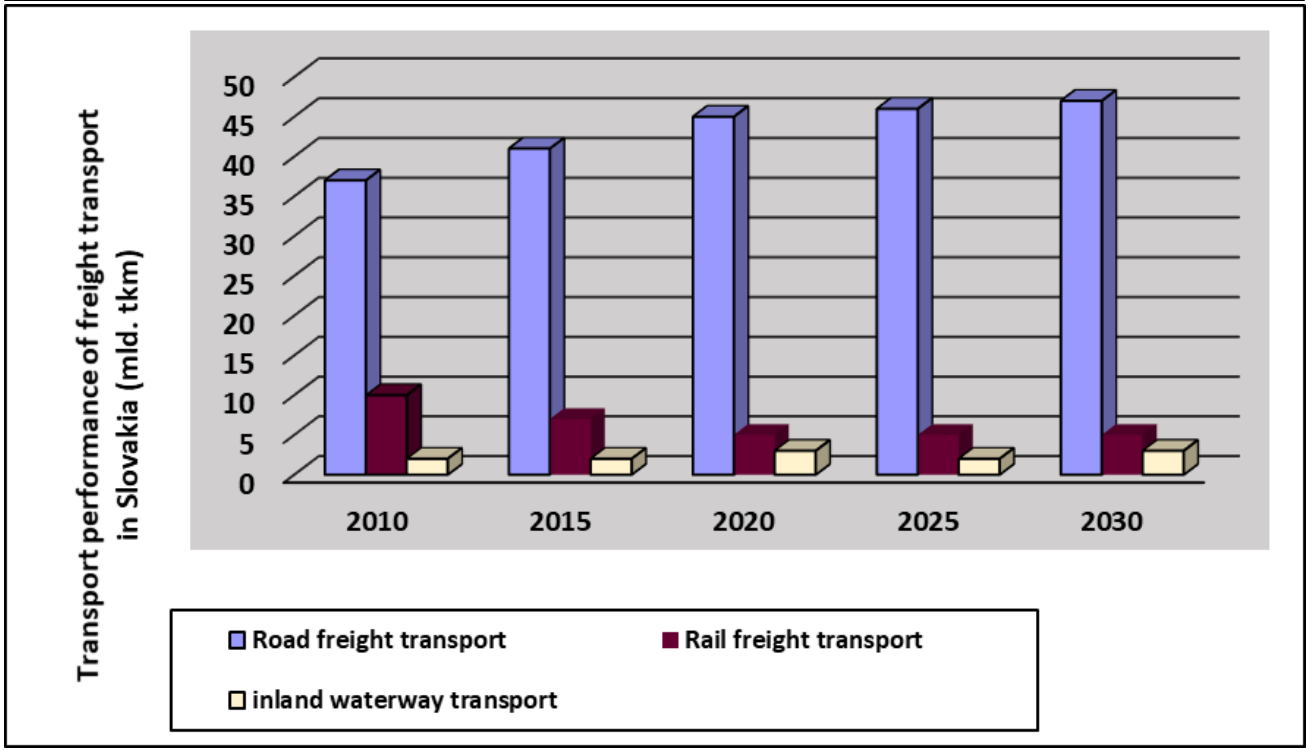

Figure: Prediction of the development of transport performance in freight transport in Slovakia until 2030
Source: European Energy and Transport, Trends to 2030, European Commission

Combined transport (CT) is a transport and handling system ensuring the transport of goods in one and the same cost unit from the sender to the recipient as an unbroken chain. In essence, it is not a separate mode of transport, but an efficient use of interconnected modes of transport (rail, road, air and waterborne), which, due to their comparative and systemic advantages, can reliably meet transport requirements. Intermodality is a transport system in which two or more types of transport are used for the continuous transport of the same load unit within the supply chain.

In the conditions of the Slovak Republic, the combination of road and rail transport is used, or the cooperation of these transports with water and sea transport, to a lesser extent, air transport is also involved in such transports. The basic precondition for high-quality provision of transport logistics tasks is mobility, ie the ability to quickly transfer the required volume of materials or people, either through our own transport capacities or by leasing externally offered transport services. When ensuring the necessary level of mobility, we always take into account the factors that can negatively affect it.

2. Characteristics of safety risks affecting fluidity of land transport

The aim of identifying risk factors is to create a list of events (risk catalog) that could cause undesirable disruption to ongoing processes. At this stage, it is necessary to define as many risks as possible, which will be subsequently analyzed and evaluated. Both external and internal environmental influences need to be taken into account when identifying risk factors. Although individual land transports have their own specifics (weather, transport routes), they also show common elements within which individual risk factors act. The basic prerequisite for effective risk management is its knowledge which enable us to provide following activities:

***Risk analysis*:** it is the process of assessing the causes and sources of risks, their positive and negative impacts, the severity of possible impacts and then determining the likelihood that these impacts may occur. The choice of risk analysis method depends on the nature of the system under investigation itself, on the availability and complexity of the input information - this must be reliable, relevant and must carry the required data, from the stage of development of the research. Identifying

of risk factors create a list of events that could cause undesirable disruption to ongoing processes. At this stage, we define all the risks that will be subsequently analyzed and evaluated. When identifying risk factors, we can use analytical methods as Check list (CA), Preliminary Hazard Analysis (PHA).

This analysis serves as a basis for further analyzes such as Ishikawa diagram, ETA or FTA as a risk modelling method or FMEA as a method for basic analysis of the system. Methods for risk modelling enable to create teh scenarios in the course of risk event, based on cause-and-effect diagrams displayed the analyzed problem in a simple form based on its causes.

The most commonly used method for basic system analysis is FMEA (Failure Mode and Effect Analysis). Analysis of the causes of failures and their consequences, the task of which is to select significant risks affecting the system under investigation. The result of the analysis is a clear tabular and graphical representation of both acceptable and unacceptable risks. When designing measures for individual risks, it is always necessary to take into account how the individual components contributed to the total amount of the risk number. If there is a possibility of a high severity of consequences but a very low probability of an event, it may not be necessary to take precautionary measures.

***Risk evaluation*:** a complex process in which we determine the amount of risk in terms of the extent of damage and loss that a given crisis phenomenon can cause and the probability that such a phenomenon will occur, we compare the degree of risk with existing standards, acceptable limits or other predetermined criteria. Based on the degree of risk, we determine the order of risks in terms of their significance, while also taking into account the influence of the probability of occurrence and possible consequences. We then compare the individual risks with the level of acceptability and decide which risks we will address further.

Risk treatment and reduction: is a diverse process, which depends on the nature of the risk itself, the degree of probability of a crisis phenomenon that may cause the risk and the expected negative consequences. Thus, risk reduction can be achieved, for example, through crisis policy, risk diversification (insurance), but also by creating reserves or optimizing processes.

Familiarization of the persons concerned with the residual risks: instruction of competent staff about the risk factors that exist in the individual processes and activities

Ongoing monitoring of the level of risks and the implementation and effectiveness of the measures in place. In this process, the existence of feedback and the continuous incorporation of control findings into the system is essential

Among the security threats which affect land transport and currently need to be given increased attention, we can include:

- Ensuring the operability of the system even in the event of a cyber threat. Focus future research on an integrated approach to ensuring cyber resilience in land transport. The need to ensure a degree of flexibility of IT systems against possible cyber-attacks. Ensuring the operation of transport systems even in the event of an IT failure.

Adaptation of existing IT systems to emerging cyber risks – analysis of threats and deficiencies, measures to eliminate emerging security gaps.

- Timely and effective threat detection. An integrated approach to the timely and effective detection of threats in land transport.
- Safety problems of railways as open systems. Focusing research on an integrated approach to railway safety and public transport – detection, crisis management and human resources training.
- Balancing security requirements and passenger privacy. Privacy and security are often threatened, but also in competing areas. Focus on tools that take privacy and fundamental human rights into account when implementing security measures.
- Security awareness of staff and customers. Focused on training and educational programs for security personnel and measures for seamless communication with passengers.
- Security as part of the system design. The aim is to provide solutions in which safety elements will be designed in the ground transport hardware. This eliminates the additional costs

associated with purchasing additional security features. Security should be part of the ICT (Information and Communication Technologies) projection. An integrated approach to the design of transport ICT security. The increase in security risks requires the design of ICT systems with directly built-in security elements.

- Secure communication links for traffic management systems. Risk assessment and safety protocols for traffic management systems. The number of interconnected control systems as well as systems enabling self-monitoring is constantly growing (see also autonomous vehicles).
- Protection of autonomous vehicles against cyber-attacks. Protection of autonomous vehicles through the joint development and harmonization of cyber vehicle architecture, reliable communication systems and more efficient knowledge exchange.

The overall safety of the transports is always the mutual interaction of its individual components, which are the transport route-means of transport and the human factor. Insufficient attention to the security risks posed by these components can mean an overall threat to the mobility needed for society to function, as well as to the undesirable synergies that can be achieved through low costs and offender anonymity with a low level of system security. A characteristic feature of today's world is its globalization and the growth of international tensions, which are factors that also result in an increase in the number of security risks and related threats affecting transport systems.

Conclusions

The complexity of current transports is due to their growing frequency, extension of transport routes, as well as the growing number of entities that participate in their implementation, which places ever-increasing demands on their mutual coordination. Increasingly, external services are being rented out, either by transport customers or their providers. Outsourcing-using of external capacities represents advantages related to specialization, speed of deliveries, or their actual implementation in case of insufficient internal capacity, or quality of provided services. However, this always means the entry of an external element into the system, whose staff, IT systems and activities cannot be controlled and managed as efficiently as existing internal resources.

A prerequisite for the functioning of the transport security system is the continuous innovation of existing technical equipment and technologies, which should ensure their functionality and ability to respond to existing and anticipated security risks and threats that may occur in this system. The level of use of established technologies always depends on the knowledge, motivation and working conditions of the staff -internal or external who work with existing technologies. Within transport, we can define the following areas of use of security technologies, systems and related activities:

- Access control.
- Security of transport assets and cargo.
- Cyber protection.
- Safety of employees, visitors, passengers.
- Loss prevention.
- Perimeter protection of space and buildings.
- Place of transaction.

At present, we already commonly encounter concepts such as the intelligent transport route or the autonomous means of transport. All these circumstances, as well as the importance of transport, which we could compare to blood circulation of the state's economy, make it a possible target for various types of attacks. Cyber threats and attacks are becoming increasingly relevant today. Such an attack is characterized by a relatively low level of threat to the attacker himself and possible high damage in its successful implementation. An increasingly important place in management activities, therefore, occupies risk management. It is a continuous process that is a means of effectively identifying and assessing risks, in case there is a need to design and implement the necessary measures. The implementation of these measures is often associated with the need to spend certain funds. The need to secure these funds means an increase in the total cost of running the system, but

overall, they represent only a certain percentage of the total value of the asset to be protected by these measures.

References

Soušek, R. (2010). Doprava a krízový managament.Pardubice: Institut Jana Pernera, 2010. 260 s. ISBN 978-80-86530-64-2.

Mesároš, M., Kiss, I., Majerník, Ľ. Logistika, VŠBM, Košice, 2008. 108 s. ISBN 978-80-89282-17-3

Kortschak, B.H.(1994). Úvod do logistiky: Co je logistika? Praha: Babtext, 1994. 176 s. ISBN 80-85816-06-7

Buzalka, J. (2012). Teória bezpečnostných rizík. Bratislava: Akadémia PZ 2012. 168 s. ISBN 978-80-8054-547-5.

Smejkal, V., Rais, K. (2006). Řízení rizik ve firmách a jiných organizacích. Praha: Grada publishing,a.s. 2006. 300 s. ISBN 80-247-1667-4.

Reitšpís, J., Bartlová, I., Hofreiter, L. (2004). Manažérstvo bezpečnostných rizík. Žilina: Edis – vydavateľstvo Žilinskej univerzity. 2004. 296 s. ISBN 80-8070-328-0.

Přibil, P., Janota, A., Spalek, J. (2008). Analýza a řízení rizik v dopravě. Praha: BEN-technická literatura. 2008. 526 s. ISBN 978-80-7300-2140-0.

Straka. M. Logistika distribúcie, EPOS 2013, 399 s. ISBN: 978-80-56200-15-5

Tichý, M. (2006). Ovládání rizika:analýza a management. Praha: C.H. Beck. 2006. 396 s. ISBN 80-7179-415-5.

Paleček, M. (2006). Prevence rizik. Praha: VŠE 2006. ISBN 80-245-1117-7.

Hofreiter, L. (2004). Bezpečnosť, bezpečnostné riziká a ohrozenia. Žilina : Edis – vydavateľstvo Žilinskej univerzity. 2004. 146 s. ISBN 80-8070-181-4.

Kuracina, R., Ferjenčík, M. (2006). Nástroje pre oceňovanie rizika a vyšetrovanie havárií. Recenzovaný zborník. ISBN 80-8073-649-9

Zborníky z vedeckých konferencií Riešenie krízových situácií v špecifickom prostredí, FŠI ŽU, Žilina 1996-2005

Stn En ISO 31000: 2011: Manažérstvo rizika.