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Risk management methods in railway transport critical infrastructure

Transport, critical infrastructure, risk, threat emergency, regulation, protection

Abstract

Risk assessment and management is actual topic in all fields of life. Railway transport as an important sub-sector of critical infrastructure has very evident particularities. This paper is dealing with application of various methods adopted from other fields (especially chemical industry) and using these methods in railway transport. The aim of the risk assessment methods implementation is increasing safety and security level in technical as well as in organizational sphere. The correct use of selected methods brings specific contributions in the field of property, natural environment and especially human life and health protection. The authors are also concentrating on actually the most important sphere of applying the Common Safety Method in real operation conditions of the railway companies in Slovakia.

METÓDY RIADENIA RIZÍK V ŽELEZNIČNEJ KRITICKEJ INFRAŠTRUKTÚRE

Abstrakt

Posudzovanie a riadenie rizík sa stalo aktuálnou témou vo všetkých oblastiach. Železničná doprava ako významná súčasť kritickej infraštruktúry má veľmi zreteľné špecifiká. Autori v článku popisujú svoje skúsenosti s aplikáciou rôznych metód prevzatých z iných oblastí (najmä chemického priemyslu) a použitie týchto metód v železničnej doprave. Cieľom implementácie metód na posudzovanie rizika je zvýšenie úrovne bezpečnosti ako v technickej tak aj organizačnej oblasti. Správne použitie vybraných metód prinesie konkrétne prínosy v oblasti ochrany majetku, ochrany životného prostredia a hlavne v oblasti ochrany života a zdravia ľudí. Autori v článku zameriavajú pozornosť na aktuálne najdôležitejšiu oblasť aplikácie Spoločnej bezpečnostnej metódy v reálnych prevádzkových pomeroch v železničných spoločnostiach Slovenskej republiky

1. INTRODUCTION

Risk assessment in technical systems is getting in the forefront of interest of scientists and experts. In the past attention was paid especially to technical safety, today also the processes of organizational and personal security are optimized. Risk assessment in railway transport is closely connected with solution of tasks of critical infrastructure in sector transportation. Knowledge base is continuously changing, e.g. in year 2008 some trains, selected railway stations, selected bridges and tunnels were considered to be the elements of the critical infrastructure. Today, within the process of defining sector and cross- sector criterions with quantification of financial demands on state budget, these opinions are changing. The scientific- professional standpoint, that has to be decisive, must also consider selection of suitable methods in the whole process of risk assessment in subsector railway critical infrastructure. [1,2,3,5]

2. RISK MANAGEMENT METHODS IN RAILWAY CRITICAL INFRASTRUCTURE

The whole risk management process in railway transport consists of several partial activities. The first step, identification of hazard sources, is followed by risk analysis. Realization of these two basic activities requires selecting the most suitable methods. Identification of hazard sources can be done either by detailed statistical data for given system or expert evaluation. Risk analysis is a basic step in the risk assessment process. The basic classification of usable methods is given by the expression of values used in risk analysis as follows:

- qualitative,
- quantitative,
- semi-quantitative.

At the beginning risk analysis and assessment were connected with use of qualitative methods that generally assessed the subsystem with conclusion that some measures are needed to be accepted or no. At present high degree of using information – communication technologies and expert systems development bring the need to use semi-quantitative and quantitative methods. These methods use broad knowledge basis, present expert systems enable so called data mining from other information systems and internet sources. So very detailed structured information sources are necessary

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for semi-quantitative assessment. Applying quantitative methods is often connected with problems of needed data absence. In that case the expert estimation is usually applied to assign required values. [2,3]

2.1 Risk Management and methods applicable for railway risk assessment

There are many methods and techniques dealing with risk that are used almost in all spheres of human activity with effect. The attention is oriented especially on effort to affect existing risks and their impacts in economy, industry or other field. Risk management is a systematic and logical method of determining the connections, identification, analysis, evaluation, treatment, monitoring and reporting risks connecting with any activity, function or process in such a way that organizations are able to minimize their losses and maximize opportunities.

In the Slovak Republic risk management is introduced and defined by standard STN ISO 31000 "*Risk Management. Principles and Guidelines*". In accordance with this standard, figure 1 presents the key steps of the risk management. [3]

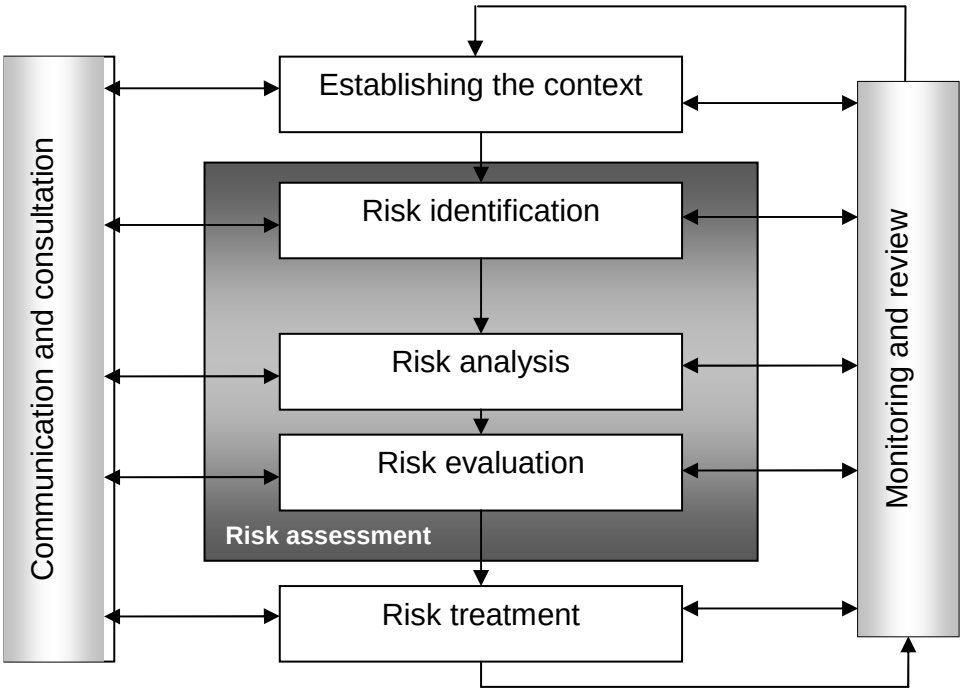

Fig. 1 Risk management key steps [3]

1. The single parts of standard STN ISO 31000 are necessary to be approximated into railway transport system. In introduction the context should be established, that means defining those parts of the railway transport system that will be the subject of investigation. Strategic and organization context and risk evaluation criterions should be defined, too.

2. Within the second step – risk identification – complex assessment of the railway transport threats is necessary to be done. Answers to questions what, how and why can happen are needed to be found.

3. Possible results with criterions defined in advance are compared within risk evaluation. Further the risk importance sequence is defined. Then assessing the risk acceptability is realized.

4. Within the risk treatment possible corrective measures are defined. It is necessary to evaluate their economic justness and possibilities of real implementation. Then to select and plan specific measures to be realized in proper sequence. [2,3]

Communication and consultation as well as monitoring and review are feedback aimed at continuous enhancing risk management process. The whole risk analysis process depends especially on used methods. Appropriate methods should be used in all steps. Because the risk management is not strictly bound to certain system or activity, it can be used also for railway transport and dangerous goods transportation in combination with other needed and appropriate methodologies.

2.2 Selected methods of railway risks assessment

There are many methods dealing with risk assessment and the most widely known and used methods survey is published in „Review of 62 risk analysis methodologies of industrial plants“[4]. Majority of methods given in Table 1 are derived from the most widely known and used methods. Single methods have different use, they provide different kinds of results and have different time and working demands.

Tab. 1. Survey of the basic and the most used traditional methods for risk assessment usable in railway transport [2]

Method	**Short**
As Low As Reasonable Practicable/ Achievable	ALARP/ALARA
Hazard Analysis	HAZAN
Check List Analysis	CLA
Cause Consequence Analysis	CCA
Hazard Tree Analysis	HTA
Fault Tree Analysis	FTA
Event Tree Analysis	ETA
Failure Modes And Effects Analysis	FMEA
Safety Audit	SA
What if Analysis	WFA
Globalement Au Moins Aussi Bon	GAMAB
Human Reliability Assessment	HRA
Relative ranking / Hazard Indices	RR / HI
Routine Tests	RT
Rapid Ranking	RR
Hazard and Operability Study	HAZOP
Preliminary Hazard Analysis	PHA

ALARP / ALARA (As Low As Reasonable Practicable / Achievable) – introduces the principle to lower the risk on such a level that is achievable (executable) in practice. The effort is concentrated on achieving the lowest risk value and in situations when the risk reduction on required level is not possible to achieve, this risk value can be accepted (but cannot be too high) if it is proved that this value is not able to be reduced by reasonable way. This principle is used especially in Great Britain. In the Slovak Republic this method is used in connection with radioactive materials

Hazard Analysis - HAZAN is one of the variants of the failure tree analysis. There is required to decide if it is necessary to do some changes to reduce this danger. The basic requirements for decision making are: frequency of failures occurrence and their probable consequences including acceptability criterions.

Check List Analysis – CLA uses check records of items or steps. Complete check list contain data “yes”, “no”, “is not suitable” and “other information are not needed”. Check lists are often used to find out conformity between regulations and standards. This method is important as the way that enables to analyse important problems and compare them with in advance prepared record. It is also suitable for detecting the problems that already have arisen.

Cause Consequence Analysis – CCA is method integrating FTA and ETA analysis. Description of possible accident results is the result.

Hazard Tree Analysis - HTA - principle for assembly of hazard tree is selection of some general type of accident adequate for covering problems we want to solve. These accidents types are in detail categorized and present the opening stage in risk analysis.

Fault Tree Analysis - FTA is so called deductive method. This method is used for searching accidents or system failures and determining the causes of these negative events. Evaluation is made by graphical model of system failures various combinations including human factor failures that can result in so called top event, i.e. principal system failure (accident).

Event Tree Analysis - ETA enables graphical presentation of possible accident results following from the initiatory events. The result is graphical and numerical presentation of possible accident scenario with quantity of failures and errors leading to top events, i.e. accident. The basis of this method is development of certain negative event through other affecting factors to result impact – accident.

Failure Modes and Effects Analysis - FMEA assess possible equipment failures and their impact on technological process at various levels. It is used for identification of failure kinds on single equipment and systems.

Failure Modes, Effects and Criticality Analysis – FMECA extends FMEA method. It includes characteristics of failure existence frequency or their probability.

Safety Audit – SA- this audit is understood in relation to existing operations and includes systematic and critical assessment of selected aspects of transport technology operation or single transport equipments. It presents inspection rounds that can have character from informal visual inspection to formally finding that takes more time. Assessment is made by team of people of various professions.

What if Analysis - WFA – the aim of security assurance by this method is identification of dangerous situations in technological process. With help of typical questions beginning with traditional „What happen if" are detected causes for accidents and measures for increasing security are proposed. There can be expressed any objection concerning security and may not be expressed as question.

Human Reliability Assessment - HRA - the aim of this method is to identify possible human mistakes, their effect and reasons. It presents systematic evaluation of factors affecting the action of operators, technicians, maintenance men and other personnel in transport. It systematically names the mistakes that can occur in the course of standard operation of technologies or in emergencies.

Relative Ranking / Hazard Indices means assessment of process seriousness on the base of physical-chemical properties of substances, technical-security parameters, their quantity, process thermodynamics and other characteristic events. These methods do not allow monitoring causal dependences cause and effect.

Rapid Ranking – RR enables rapid ranking of danger through inflammability, explosiveness and toxicity indexes. Inflammability and explosiveness indexes are determined on the base of material factor and degree of so called general and specific danger (risk sources) of process. Technological process or transport unit are classified in one of three categories according to the resulting value of mentioned indexes.

Preliminary Hazard Analysis - PHA – this hazard analysis provides very quickly survey of operational hazards that can be start base for detailed analysis. This way can be also applied in early stage of planning when only very general purposes and technological schemes are to disposal.

The first step, selection of appropriate methodology, is the most important step for the complete risk assessment of the railway transport system. Because not every method is usable for risk assessment in relation to transport system, selection of appropriate method is affected and conditioned especially by:

- results we want to achieve considering the reality that each methodology has its limitations,
- availability of needful information about examined system that are necessary for application of selected methodology.

2.3 The most often used methods for railway risk assessment

The most often used methods for railway risk assessment are as follows - IAEA-TECDOC-727, CPR 18E - Purple Book, TRA, ARAMIS and Common Safety Method. [2]

Method IAEA-TECDOC-727 presents so-called screening method that enables classification and determination of social risk sources priorities. This methods allows classification of danger from mobile sources (road, railway, water flows), completion of accidents consequences assessment with probability aspect based on historical data from accidents in the past.

Method according to CPR 18E - Purple Book was elaborated and issued by TNO organization. It allows quantitative risk assessment for transportation of dangerous goods. The specific process of risk assessment for transportation of dangerous goods is second part of document CPR 18E-Purple Book and start from analysis of reports dealing with former accidents.

Method according to Guideline for Chemical Transportation Risk Analysis - TRA elaborated by Center for Chemical Process Safety - American Institute of Chemical Engineers (AIChE). The security study elaborated according this methodology present risk measure in relation to transport operations of dangerous goods by qualitative, semi-quantitative or quantitative approach. In quantitative and semi-quantitative approaches are in principle used the same methods as in methodology Chemical Process Quantitative Risk Analysis – CPQRA.

Methodology Accidental Risk Assessment Methodology for Industries in the framework of the SEVESO II directive - ARAMIS uses two existing methods and principles for risk assessment. I tis based on created reference accidental scenarios according to:

- types of equipment,
- present dangerous substances,
- conditions of running processes.

This methodology was developed within research projects of the European Union. The risk assessment is based on assignment of risk measure through integration of three independent partial indexes:

- assessment of accidental scenarios importance, so called S-INDEX,
- assessment of effectivity of risk management, so called M-INDEX,
- assessment of vulnerability of the risk source environment, so called V-INDEX.

Common Safety Method – CSM – this method for risk evaluation and assessment arose on the basis of the EU decision that in April 2004 approved Directive 2004/49/EC on safety on the Community's railways to support harmonization of railways safety and regulation of railways in Europe. Figure 3 present the process of the risk assessment and management.

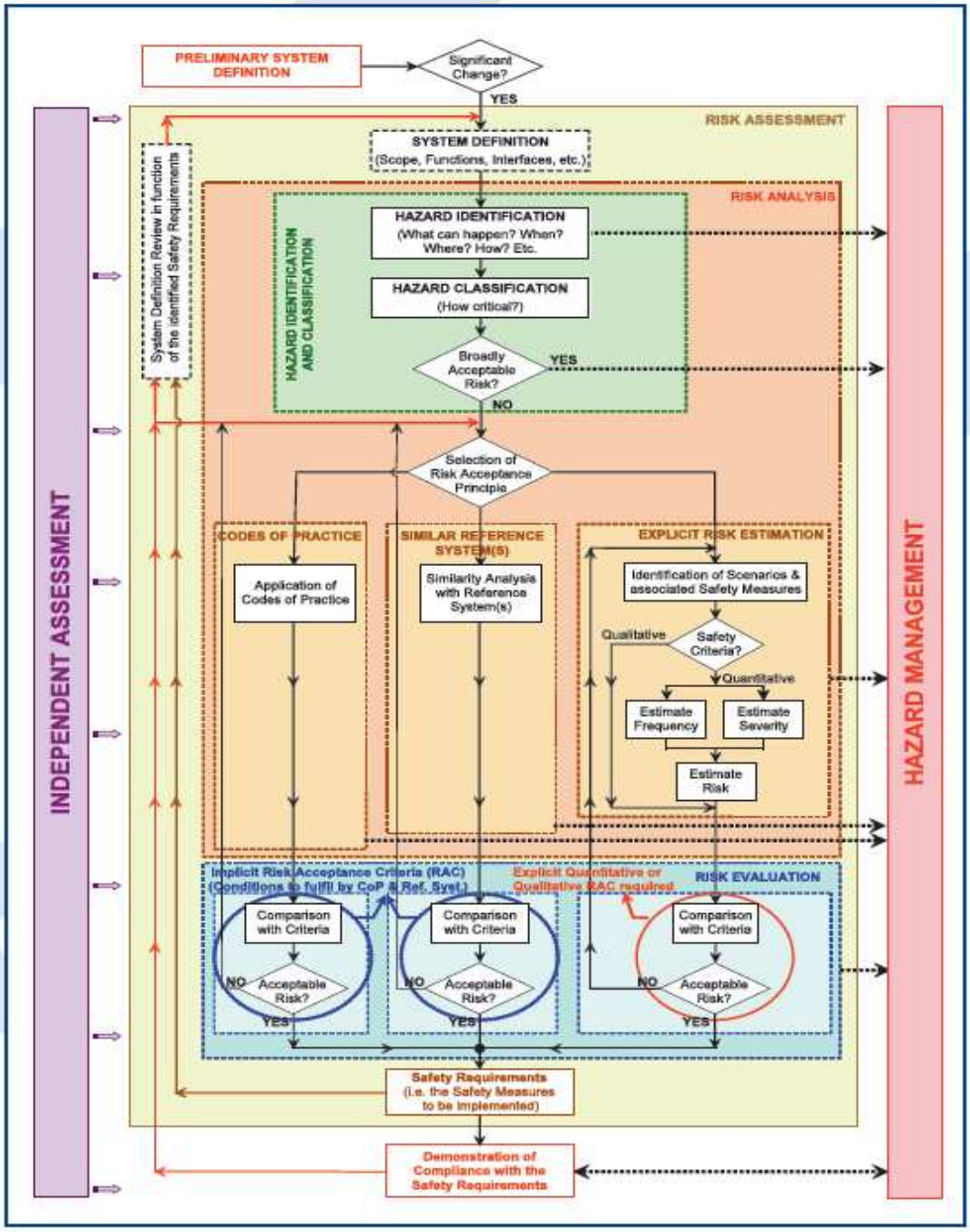

Fig. 3 Risk management framework in CSM Directive [5]

3. CONCLUSION - RECOMMENDATIONS FOR USE OF RAILWAY RISK ASSESSMENT METHODS

The actual trend in railway transport risk assessment is oriented especially on transport of dangerous goods with focus on transport security in tunnels. Solving security in tunnels was initiated by the situation in road transportation of dangerous goods. Concerning the railway transport the member states of the European Community must apply Regulation concerning the International Carriage of Dangerous Goods by Rail (RID) to the carriage of dangerous goods by rail in national traffic and to carriage between the Member States. The General Guideline for the Calculation of Risks in the Transport of Dangerous Goods by Rail elaborated by the Intergovernmental Organisation for International Carriage by Rail (OTIF) introduces basic principles for risk assessment in situations where the risk connected with the transport of dangerous goods is relevant.

From comparison CSM with Guideline issued by OTIF follows that they are compatible even though their scope and purpose are not exactly identical. The CSM is more general; OTIF guideline is oriented specifically on the field of dangerous goods by rail. CSM includes more activities within the risk management.

At present in the Slovak Republic conditions any method that would serve as appropriate apparatus for risk assessment in railway transport and transport of dangerous goods are not defined in general. Elaborated and specified solutions that are transferred to legal environment of the SR are defined especially for enterprises and operations (industry) where the sources of threats in respect to dangerous goods presence are placed. The legal environment of the SR deals with transport of dangerous goods and consequential assessments of hazards only in relation to ensuring protection of inhabitants.

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This paper was supported by project APVV 0471-10 Critical Infrastructure Protection in Sector Transportation.