

## IDENTIFICATION AND SOLUTION OF SAFETY AND OPERATIONAL-ECONOMIC RISKS IN RAILWAY TRANSPORT

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**Abstract:** The paper is concerned with the issue of safety and risks in transport with a detailed focus on rail transport. Nowadays, when it is required to prefer safe and environmentally friendly modes of transport, the knowledge of this issue is important. Part of the paper is an analysis of individual risk factors in railway transport. These include risks in the field of railway safety, natural disasters, economic risks, risks in management systems and technical equipment, and risks related to legislative changes. Attention is paid to comparison and evaluation of individual risk factors in terms of severity and probability of occurrence - frequency. Following the analysis and evaluation of the risk level, are suggest possible or optimal ways to resolve them. The outcome of it is to eliminate or minimize them in the railway transport undertaking. The final part briefly describes the current situation in rail transport, recent developments and the main conditions and assumptions for its further development.

**Keywords:** railway transport, traffic safety, risk factors, risk management, risk rate

### 1. ANALYSIS OF SECURITY AND OTHER RISKS IN RAIL TRANSPORT

There are many risk factors in every human activity, in personal life and in business too. And they require know, manage and solve them. In business and economic activity, the acute need for security risk management was observe in transport for the first time.

The need to cut transport risks was necessary already in the middle of the last century in the start of inland waterway transport. And it continuous especially in the development of rail transport. It was especially for transport safety and the prevention of accidents on a railway route. Technical and organizational measures are found and improved and evolve to perfection. In the course of time, the railway industry was aware of other risk factors with varying degrees of severity. So it was necessary to find ways to manage them. The optimal development of performance and economic results will be according transport requirements.

There are many risk factors in the area of railway transportation. They affect results and efficiency. We divide the aspects into the following main groups:

1. Safety of operation
2. Natural disasters
3. Economy and competition
4. National and international legislation
5. Control systems and technical equipment

The impact of individual factors and their severity, including risk management is different both between factors and within factors. It is appropriate to analyze some extent specific factors. Their content and impact on the performance of railway transport and the risk level of each factor in terms of frequency and severity.

When analyzing the risks, we drew on published articles dealing with the issue for individual risk factors. The second source was long-term experience in railway transport management in the Czech Republic and consultations with experts in individual fields. Brainstorming was used, among others. Where sufficient data were available LCC methods - life cycle costs (Sellner, 2015), RCM and RAM - system of failure-free maintenance or network analysis (Daněk, 2009) and KARS methods - quantitative risk analysis using risk correlation (Pacinda, 2010) were used.

### **1.1 Traffic safety**

The risks are due to technical defects both on the road and its security, as well as on the vehicle fleet. The second serious reason is the failure of the human factor along with the level of control mechanisms. These risks are influenced by the quality of technical equipment, high-quality maintenance and training and control of employees. The defects manifestation is a reduction or local stopping of railway operation, operation hazard and rail accidents with economic consequences in the worst case. Economic impacts also have legislative changes in area of active and passive safety of passengers, transported goods and railway employees. But factors such as exceeding service life or insufficient maintenance may threaten safety too.

For example (Djordjević, 2018) draws attention to the issue of railway level crossing (RLCs) as a critical point characterized by a large number of accidents per year.

### **1.2 Natural disasters**

The goal reasons for the threat to the safety and operability of rail transport lie in the influence of extreme natural and weather conditions. Rail infrastructure is less vulnerable than water and road infrastructure. This is due to the fact that railway lines were built in the past in such a way that the rise in the levels of large watercourses would not endanger them. This has been proven by the major floods in recent decades, when in many cases the good condition of the railway infrastructure has ensured that the railway could take over transport instead of other modes of transport. Yet, the risk of natural disasters remains, and extreme natural phenomena (whether floods or windstorms) can disrupt rail infrastructure. As a result, there are problems with securing substitute transport and economic losses associated with the removal of defects even from unrealized transports. (Otto, 2019) shows, how is it possible make risk reduction in railway transport infrastructure in Austrian railway, focusing in disaster risk reduction. The impacts of abnormal weather and natural disasters on transport and strategies for enhancing ability for disaster prevention and mitigation are presented e.g. (Lu, 2019).

### 1.3 Economy and competition

All transport processes, especially in the transport of goods, are dependent on the global and territorial development of the economy and economy. (Peleáz, 2012) focuses on liberalization of the European railway sector in a context of economic crisis. It analyzes the main shortcomings of the liberalization model through a comparison of actual risks, perceived risks and foreseeable risks.

Statistical data published by the Czech Capital Information Agency shows that transport and logistics business is one of the most risky subjects of business and the risk of bankruptcy of companies in the Czech Republic more than twice exceeds the average in all branches of business (Česká kapitálová informační agentura, 2012). In rail transport, due to the size of transport companies, the frequency of bankruptcy is low, but for other types of risks the situation is like that in other modes of transport, but in some cases the impacts are more severe. The level of risk depends on the focus of the economy of each territory, in particular whether it is an open economy with a large share of international trade and the structure, share and orientation of the national economy sector. Clearly, in open economies, global effects are more pronounced. More risky are economies focusing on goods-production than by economies with predominant agricultural production or tourist attractive territories.

The consequences of the economic and economic crises in rail freight are at least proportional to the size and duration of the crisis. Statistical results show that the decline is higher and that, as a rule. So, there is an earlier onset and a certain time shift of the development and the after-effects. The decline in economic and economic results signals the risk of a significant drop in transport. It is deepening also due to austerity measures, and decreases with a delay after the economic recovery.

The risk arising from competition from other carriers is permanent and must be taken into account both when defining the concept of rail transport development and in its operational management. It is topical both for the transport of persons and for the transport of goods. They can be divided into two basic groups, carriers from other domains of transport and other railways carriers.

Risks arise from the economic demands for the final customer. This is the price of transport, both in passenger and freight transport. They consist of changes in transport prices of other transport modes in individual segments and commodities.

The basic risks for the first group consist in the area of reliability and safety of railway transport, in economic difficulty and quality of transportation for the end customer. Technical possibilities and economy of rail transport limit all these above mentioned factors and their optimization.

Competition from other rail carriers is an important factor. It is especially in times of lower interest in the carriage of goods. It concerns, to a lesser extent, domestic transporters, who are usually focused on the transport of bulk materials, to a greater extent large international transporters and freight forwarders too. Development in organization, management and institutional arrangements is very dynamic recently. It consists in the constitution and strengthening of multinational organizations with comprehensive provision of transport, forwarding and commercial activities. This gives prerequisites for reducing overheads, making better use of and optimizing the structure of the means of transports. And, as a result, it leads to helpful and time-bargain offer to customers.

#### 1.4 National and international legislation

Changes in national and international legislation can be a significant risk factor with an impact on operating power and economic results of rail transport. There are two categories of legislation. The first is the national or international legislation affecting the railway transport. The second type of the legislation is in the field of transport especially in railway. It is given by national or international regulations and standards.

The risks from general legislation lead changes in the environmental protection, safety and liability of carriers. Any environmental change affects both investment costs and, as a rule, operating costs. It leads to the necessity of investments related to infrastructure and vehicle modifications in the economic field. This concerns the issue of noise, emission, and also the concept and maintenance of railway equipment. Modifications in the field of railway safety are also in the area of general legislation. They are usually reflected in the modifications of railway regulations and standards. And there they lead to corresponding impacts. The changes in legislation in the area of liability can lead to economic impacts. These focus on higher investment and operating costs. The consequences of tax adjustments may be similar.

The risks arising from the transport and railway legislation are the requirements for modifications to the structure and extra equipment. Sometimes it is necessary a ban on the use of certain units or even whole vehicles in general or for certain types of transported substrates. The second influence is arrangement in standardization and unification of railway equipment.

Commercial conditions in rail transport have certain specifics arising in passenger transport. They come out from the obligation of the state to provide basic transport services. This implies the need for subsidies for all carriers providing this basic transport. The risk is then a change in the rules for financing regional transport by the side of state or regions. There is no such risk in freight train transport which is based only on market principles.

#### 1.5. Control systems and technical equipment

The organizational structure and management systems of the railway enterprise have a major influence on the economic results and position on the transport market. Organizational arrangements are based on the legislative framework. And it has to create conditions for the effective functioning of the company with minimal administrative overhead. The risks are due to the lack of flexibility of the organizational structure and management systems. It is because they do not use modern computer technology and management methods. Structure and qualification of employees are playing an important role in organizational structure.

The technical equipment is very important for the good functioning of the railway. As a rule, the state owns the railway infrastructure. And it is used by the railway carriers on a level playing field. The improvement of its level cannot be influenced by individual carriers. But it is their interest and the interest of the state to have a good quality level of infrastructure. The reason is that the number of passengers and transported goods, especially in international and transit transports, affects the economy and the gross domestic product. The main risk is the lack of funds for the modernization of the railway infrastructure.

The own technical equipment of railway carriers is also important for business economics. Their underestimation is a significant risk factor. It includes railway vehicles. Their good technical conditions, appropriate conceptual and constructional solution

are a prerequisite for success. Energy intensity, quality and efficient maintenance are also important in this area. An important role plays the costs of equipment lifetime (Life-Cycle Costs method) and application of trouble-free maintenance methods. Which have a sophisticated system of preventive inspections and maintenance interventions (Daněk et al., 2009). Other technical devices have a similar meaning too. (Sapori, 2014) proposes the implementation of risk-based methodologies in use by process engineering to achieve a quantitative assessment of security management systems. It also emphasizes the importance of the safety management system (SEMS) for organizations working in transport sector.

## **2. COMPARISON OF RISK LEVELS IN RAIL TRANSPORT**

It is difficult to determine the impact and aim quantification of individual risks and in some cases even impossible due the complexity of rail transport.

### **2.1 Traffic safety**

Security risks have a relatively low frequency and their severity is generally not high and locally limited. The risks related to human factor failure are more serious. According to long-term analysis, the level of safety risks in rail transport is lower than in road and water transport.

### **2.2 Natural disasters**

Risks associated with natural disasters, both frequency and severity, are difficult to predict. So they are hard quantifiable. Natural disasters are few in our geographical zone. But still are a risk factor for all infrastructure constructions, including transport infrastructure and technique. Their frequency is low. But the consequences may be significant in some cases and locations.

### **2.3 Economy and competition**

Risks associated with the development of the economy have a high severity and low frequency. The impacts on freight volumes are generally higher than the economic downturn in the national economy. The time of recovery tend to be longer. This is due to the intensive efforts of carriers to increase the efficiency of businesses. They tend to minimizing transport requirements and reducing raw material demands. The risks of competition from other carriers are very frequent. They involve ongoing analytical, organizational and management activities. Yet, for a well run company with a flexible response to the evolution of the market, the impacts on the carrier's economy are not very serious.

### **2.4 National and international legislation**

Risks are difficult to quantify for legislative and commercial conditions. If they are not in terms of individual transport modes or individual carriers discriminatory, they can be eliminated. It is important continuous monitoring of the preparation and development of these processes. Usually there are less serious but many risks.

### **2.5. Control systems and technical equipment**

Management systems and technical equipment and their good standard are essential for efficient functioning. The frequency of risks in the area of management systems and technical equipment is high. It relates to the development of management and

innovation of technical equipment manufacturers. Severity is not high. Risks are in the concept and strategy of the company, unless it is continually analyzed and updated. Further, they are in the lack of funds for its implementation. In concrete cases, risks can be successfully quantified.

Despite the difficulty and so far little attention paid to the analysis of risks and their consequences in rail transport, it is possible to deduce some general conclusions. Then we can illustrate the dependence of frequency and severity of individual risk factors. This scheme is shown in Fig. 1. Generally, as in other sectors of the national economy, it is necessary to consider risks in transport. We have to know their impact and ways of their elimination or minimization of impacts. The method of expert estimation in combination with statistical data was used to create the diagram.

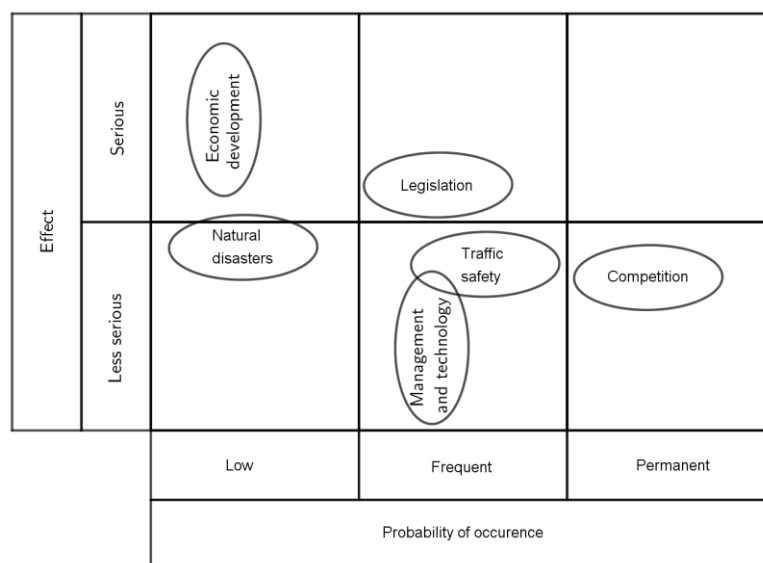


Fig. 1. The diagram probability of risk occurrence

### 3. RISK MANAGEMENT AND MEASURES FOR RISK MINIMIZATION

#### 3.1 Traffic safety

The risks arising from technical defects and the failure of the human being in field of safety have to define. After, it is necessary to take the measures to reduce them. In the case of technical defects, it is timely and consistent maintenance of the equipment as aim inspection of the technical condition. In the case of human factor failure, the basic measure is to establish the necessary professional requirements, perfect initial and periodic training of workers with knowledge and skills verification, and a functional system of control and sanctions. In case of repeated or serious defects, it is necessary to draw conclusions. The changes are in the education and inspection system or in modifications of the construction or maintenance system. The size of the consequences of safety defects can be reduce here also in the case of natural disasters by the best number, equipment and dislocation of technical and accident means.

#### 3.2 Natural disasters

Insurance against the effects of natural disasters is recommend for risks arising from natural disasters (Zuzák, 2009). But this solution is difficult for rail infrastructure. A suitable solution to these risks is preparedness for quick and high-quality removal of

the consequences of natural disasters, for example removal of foreign objects on tracks - trees, stones and landslides. Even more serious is consistent and regular maintenance. It can prevent some potential events disturbing railway traffic. In case of extensive devastation of railway infrastructure - on local lines - it is appropriate to consider the effectiveness of its renewal.

### **3.3 Economy and competition**

With regard to the development of the economy on a global and territorial scale, it is possible to predict to some extent the impacts on the volume of transports. Based on that, we can prepare scenarios for measures to cut losses in case of a decline and pro-growth measures for its revitalization. We check competing companies, demographic and economic developments and a sophisticated progressive strategy. The monitoring and ability to install the strategy leads to a strengthening of the share and influence of rail transport on market.

Defense against competition from other carriers is very difficult. It is based on reducing costs, rationalizing activities and reducing capacity when it is appropriate. A better way is to increase reliability, especially in transport of goods, guarantee of guaranteed transport times and extension of services to the breadth of offer and quality. Another possibility is flexible application of prices of transport and services which are able to compete.

It is necessary to take measures both in the technical area (increasing the permitted speed limit on lines and railway vehicles), in the area of quality staffing, security and traffic management and transport related operations.

The competition risk can be reduced by the co-operation with other modes of transport and carriers, where it is possible to use their advantages. This applies in particular to the development of combined transport. The aim is minimizing transport times while making most use of the advantages and share of transport by railway containers, by contrailers and transport superstructures.

Significant is monitoring of technical progress. It contains implementation of new organizational and technological procedures, appropriate marketing strategy, quality and flexible tariff policy too. It is also advisable to consider cooperation with other domestic and foreign companies.

### **3.4 National and international legislation**

The risk factors arising from national and international legislation are goal and have to be accepted by the railway undertaking. The solution to cut impacts is to check the development and use of transition periods. This allows preparation for strict implementation, but usually leads to extra costs.

The solution in the area of tariff conditions in passenger and freight transport is to improve the offered services and reduce operating costs. There is permanent cooperation with particular important carriers and setting optimal tariffs for freight transport.

### **3.5. Control systems and technical equipment**

The elimination of risks in technical equipment is based on a well-built conception of the company and on enough financial resources for its implementation.

Monitoring of equipment and organizational, technical and business methods and principles of other carriers is also important. The level of management and technical equipment is related to the competitiveness of the company and its market position. Of

course it is influenced by the development of technology and the national and international economy.

Their influence and impacts can be restricted by preventive measures resulting from the evaluation of past events, the creation of crisis plans and the monitoring of the situation with the rapid information transfer system.

#### **4. CONDITIONS AND TENDENCIES OF FURTHER DEVELOPMENT**

From 1995 until the onset of the economic and economic crisis, the performance of Czech Railways increased. In 2008, yet, freight transport showed a slight decline in performance in most European countries, which deepened further in 2009. In 2008, transport performance decreased by up to 15% on a European scale, the situation was worse the following year with a decline of up to 40%. According to UIC data (UIC The worldwide Railway Organization, 2017), the greatest decline was by railways in the Balkan countries. In our country it was about 25%. This was due to the global financial and economic crisis and reduced transport requirements.

Positive phenomenon is that at the end of 2009, compared to the first half of the year in both the Czech Republic and neighboring countries, the decline moderated or stopped and in 2010 and 2011 a slight growth was achieved.

Further decline, especially in the area of industry and construction, in 2012 led to a decrease in transport performance in the transport of goods in the Czech Republic. Dynamics has also decreased in some other countries. Passenger transport also lost dynamics during the economic and financial crisis. The difference was smaller than in freight transport. Since 2014, output has been increasing in passenger and freight transport. The decline in the dynamics of the European economy in the current period began meantime to be felt only in the transport of goods.

The growth of outputs and economic results in rail transport is conditioned by:

- Positive economic developments on a global and European scale;
- Growth of the economy and economic indicators of the national economy;
- Development of international trade;
- Harmonization of transport modes in internalising external costs;
- Effective cooperation between transport systems;
- Continuous improvement of railway infrastructure and technical and technological equipment;
- Optimal segmented organizational structure of railways, use of computer technology and modern management methods;
- Optimal professional composition and number of quality workers ensuring growth of labor productivity.

#### **5. CONCLUSION**

Rail transport occupies an important place in the national economy. Its good and safe function is essential. As in other areas, there are safety and other risks. They reduce the optimal function and lead to losses. It is so necessary to identify these risks and to take preventive measures to prevent or, where appropriate, to cut their effects. The paper outlined ways to meet this goal and the basic conditions for further development of rail transport.

Further development of rail transport is conditioned by a number of factors. The most important is the development of the global and national economy and the internalisa-

tion of external costs. Other basic conditions for effective development are mentioned in the paper. It can be assumed that, despite a certain slowdown, positive developments in rail transport will be maintained. This confirms the volume of global rail investment, which amounted to € 123.5 billion a year before 2008, of which 59% was for new vehicles, 30% for infrastructure and 11% for technology (International Railway Journal, 2008). Currently, investment volumes are even higher. Greater environmental friendliness of rail transport than for road and air transport, as well as tasks arising from the concluded climate protection agreements, contribute to the positive forecast.

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