Critical Infrastructure in the Railway Transport System

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ABSTRACT

The critical infrastructure in the railway transport is very dynamic system. In the last years are created new critical infrastructure elements. The new critical infrastructure element must be protected, like origin, as well. The most critical infrastructure elements are related to the IT development. The new systems haven't sufficient resilience. This article describes the new crisis infrastructure elements in the railway transport. This article suggests ways to improve resilience, too.

Keywords: railways, crisis infrastructure, resilience

1. INTRODUCTION

Rail transport is an integral part of the transport system. Especially, in the developed countries the functioning of the transport system is very important. Thanks to the new IT systems, rail traffic control is changing.

This paper solves the new rail traffic control systems and their impact on the railway transport system resilience.

(2), (10), (12)

2. RAIL TRAFFIC CONTROL SYSTEMS

Historically, the railway transport was controlled locally. It means that every station and junction have own worker (dispatcher or signalman). The worker control train running in the station and in the neighboring track sectors. The disadvantage is a high need for employees. Moreover in the older control systems lot of operations is fully depend on the human (dispatcher). Modern control systems can be controlled remotely. The remote control means that the more than one station is controlled from one point. It means that the stations under control of the dispatcher are not occupied by another dispatcher. The remote control of railway is popular between infrastructure managers, especially in Europe. The system is more effective (in the financial scope of view) and the dispatcher has a better overview of the train movements in the assigned area. The disadvantage is a high investment cost. The higher risk of the transport operation interruption is a disadvantage, too.

The remote control of railways is divided by the line control and central control. Line control means that dispatcher is in the station on the railway line. The dispatcher control train movement on the one railway line. The central control means that dispatcher control traffic in the part of the network (on the various, independent railway lines).

(1), (5) (8)

3. RISK IN THE RAILWAY TRAFFIC CONTROL

The railway traffic control and organization is a sensitive element. In many cases, the railway traffic control meets with critical infrastructure element features, especially in the case of railway traffic remote control. The remote control of railway traffic is certainly very efficient, transparent and smooth way to manage traffic, but the criticality of the railway control is increasing thanks to centralization. In the event of an accident at the railway traffic control center, traffic is interrupted in several sections. If the accident happened in a locally controlled section, the consequences would not be spread to other sections. The ability to railway traffic interruption after terroristic atack on the central railway traffic control center is high, too. Not only these serious threats are a threat to remote traffic control. Even routine maintenance can cause railway traffic interruption on the railway network. In this case, the risk must be assessed.

The risk is evaluated according to several parameters. One of the parameters is the time of function loss. The second parameter is the consequences of interruption on the whole railway system. From these values, it is possible to obtain the level of crisis event seriousness. Table 1 shows the level of seriousness depending on the time of service interruption.

The principle of evaluation is the crisis seriousness. The criticality matrix (Table 1) is dynamic. It means that the seriousness of criticality depends on time. The value of seriousness could be marked e. g. in scale 1 to 10.

Table 1: Level of crisis events seriousness

		Time of function loss [hours]			
		max. 1	1 - 10	10 - 100	min. 100
Level of seriousness	0 – 2	O	O	L	L
	3 – 4	O	L	M	H
	5 – 6	L	M	H	E
	7 – 8	M	H	E	U
	9 – 10	H	E	U	U

Level of Criticality: U – Unacceptable
E – Extreme
H – High
M – Medium
L – Low
O – Minor

Source: (3) with authors' adjustment

The risk assessment is necessary, too. The risk assessment is necessary to determine whether it makes sense to prepare for crisis situations. Figure 1 shows the factors that are used in the risk assessment.

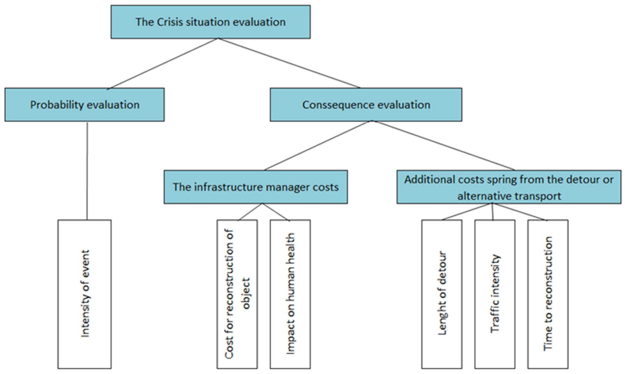

Figure 1: Factors used in the risk assessment
source: (4)

The origin crisis infrastructure object is a railways track, bridges, tunnels and complex building for rail traffic. Usually, in the stations with the local traffic control is not necessary to restore the complete interlocking system. On the other hand, usually in the station which is remotely controlled is not an employee (dispatcher). The dispatcher present in the station could fully replace the interlocking system. This means that the interlocking system must be fully restored for the remote control of railway traffic. The necessary of interlocking fully restore increased the remote control system criticality.

(3), (4), (13)

4. THE RISK CALCULATION

The decision about infrastructure element inclusion in a critical infrastructure set, it is necessary to know its resilience. An element can be included in a critical infrastructure if the frequency of occurrence of an extraordinary event is also high. The decision can be according to the formula:

$$R = p \cdot F_T \cdot F_F$$

- p is the probability of occurrence of an event
- F_T *is a* time of operation interruption in the controlled area
- F_F is increased financial costs on the operation of a substitute system

By this formula, it is possible to determine which traffic control elements are the critical infrastructure elements. The higher the criticality number is, the greater the effort to not create such elements. The criticality of the element is further increased if the individual dispatcher workplaces are centralized. Thanks to centralization, it is possible to save part of the financial costs. Centralization helps in the communication between dispatchers, too. The disadvantage is increasing the value of criticality for these elements.

(3), (6), (9), (12)

5. RISK REDUCTION AND RISK PREVENTION

The elements which are the critical infrastructure elements are difficult to replace. It should be an attempt not to create such elements, due to the difficult replacement of these elements. If it is necessary to create critical infrastructure elements, it is appropriate to reduce their criticality. If it is necessary to create critical infrastructure elements, it is appropriate to reduce their criticality. The criticality of the element could be reduced:

- distributing functions with less importance to other locations
- dividing the main function into other points that are mutually substitutable
- build a replacement traffic control center for crisis situations
- In the event of a crisis event, the regional (smaller) control centers can intervene to the area controlled by the central traffic control center

Risk reduction proposals have different financial demands. The financial demands of the solution are important and must not exceed the cost of possible interruptions. The financial cost of the risk reduction proposals is not deal in this paper.

Distribution of less important function to the other locations

The core activity performed at the central traffic control center will remain same. Other supporting activities related to the train movements will be moved to another workplace in another location. The advantage of this solution is fact that criticality number is no longer increased, moreover, it is reduced. The disadvantage is worst communication between dispatchers thanks to the different location of them.

Divide the main function into other points that are mutually substitutable

This solution reduces criticality in the rail transport control system. The total transport network resilience is higher than that in the system controlled from the central control center. The disadvantage is inconvertibility of operations in the sections controlled by various control centers.

The regional control centers can intervene to the area controlled by the central traffic control center

This option will be used only during the crisis situation occurred on the central traffic control center. This solution keeps the central traffic control center in operation. It takes into account regional (smaller) traffic control centers for secondary railway lines. The regional control centers, in the event of the central control center failure, substitute their function. The advantage of that the train movements will be organized from the central control center. The organization of trains movement will remain same. In the event of the central control center failure, their function is distributed between regional dispatcher control centers. The disadvantage is that regional control centers have limits for traffic management in their own allocation area.

As the appropriate proposal is an option of regional traffic control centers possibility to intervene in the network controlled by the central traffic control system. In this system will remain efficient traffic control management by the central traffic control center with their advantages. Moreover, the regional traffic control centers are backup for the central traffic control center. This system has a high resilience.

(8) ,(12), (13)

6. THE RESILIENCE CALCULATION

Regional traffic control centers like a backup of central traffic control centers have higher resilience. This higher resistance could be expressed by the formula:

$$\binom{n}{k} = \binom{n}{n-k} = \frac{n!}{k! \cdot (n-k)!}$$

In the formula n means the number of regional control centers used for backup during the crisis situation. The k means the number of all regional control centers and central control centers in operation. The combination of all possible backup options is expressed in the formula above. The k control centers are ready to control train movements on the defined railway network. The designated railway network is a part of national railway infrastructure with high importance for the national economy. On the other hand, the regional control centers are not able to control train movement everywhere. Train movements on the railway lines controlled originally from regional control centers will be interrupted during the crisis situation. The railway lines controlled originally from regional control centers will not control due to the busyness of dispatcher on the train movements on the defined railway network. This workflow is a sub-optimal. Trains movement on the secondary railway lines (on the network which is not defined railway network) during the crisis situation is not necessary. Trains movement keeping on the defined railway network is more important for national economy than on another railway line. In comparison, this system has lower cost, especially in the traffic control centers maintenance. Moreover, the time lack of loss control is shorter than in the system without possibility to take control in the defined railway network. Like an example could be used the Czech Republic with one Central Control Center with the 16 regional control centers. Every control center can take over the control of train movements in the defined area and every railway track can be controlled from 8 control centers. One regional control center is not able to replace all area controlled by the central control center. The two control center is able to replace on control center with a reduced timetable on the defined railway lines.

Thanks to this step increases the resistance of the defined rail network. The rail transport control combination from several regional dispatch centres significantly reduces the probability of interruption of traffic. In addition, the possibility of the changeability individual dispatcher canters makes the system even more flexible.

The proposed steps will increase the defined railway network resilience only through traffic control organization change. The step will not lead to a significant increase in the cost on resilience. The measures for the crisis situation of the rail transport control (in normal traffic) will not reduce the comfort for dispatchers and the loss of the necessary control flexibility. In the event of the crisis situation, will be used resources which are not only backup. The original objectives of these backup resources will be scaled down (during the crisis situation). Similarly, flexibility during the crisis situation in traffic management may be missed. The authors research is focus on regional railway lines which will not be managed, due to the transfer of responsibility for a designated railway network. The following author’s article will be focus on this topic, too.
(6) ,(7) ,(11), (12), (13)

7. CONCLUSION

This paper shows the trend that has occurred in recent years in the railway traffic control system. This trend is a centralization of railway traffic control. Control of railways from central traffic control is very efficient. On the other hand, the criticality level of the control system is very high. The compromise that offers this article is an acceptable alternative.
This article is the first in a series of articles evaluating the reduction in the resilience of the rail transport infrastructure with the current implementation new information technologies.

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