

Increasing the Safety of Railway Crossings

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Abstract: This article is focused on improving safety at railway crossings and points of active and passive safety features. Following these general safety rules we can reduce or eliminate the risks that increasingly affect the right of railway crossings. The article describes redundant lock crossing time which unfavorably affects the rail crossing accidents and the solution which eliminates this factor. The paper is supported by the VEGA Agency by the Project 1/0188/13 "Quality factors of integrated transport system in the effective provision of public transport services in the context of globalisation" that is solved at the Faculty of Operation and Economics of Transport and Communications, University of Žilina.

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1. Introduction

Level crossing of two communications (rail-road crossing, motorway crossing) represents, in general, enhanced risk for users of both roads. The communications conditions have to eliminate, minimize or warn of the enhanced risk, or harmful factors impacting on people situated on communications crossings, or nearby them. It is necessary therefore, to implement into the transport operations a system that is accepted by all users of communications crossings, which ensures increasing, or maintaining the safety level which fulfils a defined purpose. This purpose is the safety and continuousness of transport. The requirements on transport are increasingly challenging and it is therefore necessary to optimize and ensure also safety and continuousness of transport on level crossings and to make them more effective.

The resolution of railway crossings safety technology in the Slovak Republic is published by the Railway Transport Regulation Agency after consultation and agreement with affected authorities (e.g. Higher Territory Entities, Transport Police, etc.). The method of railway crossing safety assessment depends on the railway track type, motorway class, intensity of railway and road transportation, local conditions on both roads and, in some cases, also on the frequency of accidents on railway crossing.

The aim of this safety assessment process is to define generally valid principles of prevention and basic conditions for assurance the safety, protection and continuousness of transport and elimination of risks and factors that underlie accident inceptions, accidents and other damages to health of transportation participants on railway crossings. The priority

of railway organizations is to ensure the safety and continuousness of transportation on railway crossings. The elements used for this assurance can be divided into active and passive safety elements:

- **Active safety elements** – those elements which can by their active influence reduce the probability of the accident,
- **Passive safety elements** – those elements which can by their influence reduce the after-effects on participants of the accident. [1]

2. General Principles of Safety Assurance on Railway Crossings

It is a genuine obligation of every participant on transportation process to follow safety transport rules on railway crossing. These rules result from general principles of safety assurance:

- to eliminate danger and threats and risks resulting from them,
- to accomplish precautions with the respect for all circumstances relative to transport, in accordance with legal acts and other directives to ensure safety and continuousness of transportation,
 - to detect the risk,
 - to evaluate the risk,
 - to evaluate risks which cannot be eliminated, especially when choosing and using transport means,
 - to take actions on liquidation of danger in the place of their inception,
 - to liquidate danger and threats, and if it is, according to achieved science and technical skills, not possible, to

take actions for their eliminations and to prepare actions for their liquidation,

- to prefer collective protect actions against individual protect actions,
- to adapt transport to driver skills and technical progress,
- to respect personal skills, features and abilities, especially when operating transport, when choosing transport means, procedures in transport, with the aim to eliminate or alleviate effects of dangerous factors,
- to plan and to carry out policy of prevention by implementing safe transport means, technologies and methods of transport organization and by increasing quality of transport roads respecting the factors of the environment,
- to plan and to carry out policy of prevention by implementing social actions,
- to publish directives and instructions to assure safety and continuousness of transport. [2]

3. Factors Influencing the Safety on Railway Crossings

Several factors influence safety and continuousness of transportation on railway crossings. The main of these factors are:

- speed,
- human factor,
- transportation character,
- transport infrastructure,
- transport means,
- valid legal acts. [3]

Human factors influencing the safety and continuousness of transportation on railway crossings are also incorrect reactions of participants of transport situations. Incorrect reactions of participants of transportation on railway crossings are influenced by several impacts which have to be analyzed and researched in detail.

Partial impact on incorrect reaction of participant of transport situation on railway crossing is also long time, or frequent waiting of road transportation participants in front of closed railway crossing or in front of light signalling device of railway crossing safety device. Unpredictable reactions of road transportation participants, leading often to deadly injuries, damages to health, or to property damages of considerable values can be the consequence of long time waiting.

It is necessary to analyze in detail the conditions of each railway crossing individually for the purpose of investigation of long time waiting reasons. This is necessary because the factors influencing the time of waiting are very specific. However, the basic layout of a level railway crossing shown in Fig. 1 is valid for every railway crossing in general.

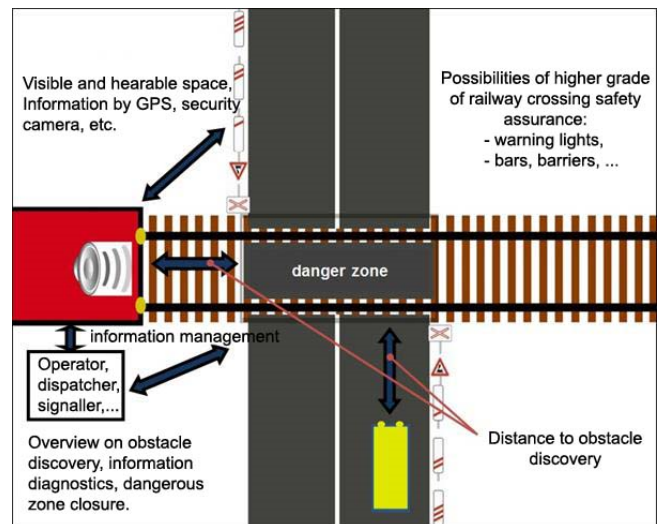


Figure 1. Basic layout of level railway crossing.

4. Basic Influences on Excessive Time of Railway Crossings Closure

From a detailed observation we found out that there are several types of influences on excessive time of railway crossing closure:

- marking and type of assurance of railway crossing
 - category of assurance,
 - marking,
- location of railway crossing considering railway transportation character
 - in railway station,
 - on track,
- speed of railway vehicle
 - railway crossings depending on speed of railway vehicle,
 - railway crossings independent of railway vehicle speed,
- technology of work,
 - possibilities of informing,
 - ways to confirm railway crossing closure,
- way of railway vehicles operation through railway crossing
 - consecutive runs,
 - contrary runs,
- trains intended for specific type of transportation
 - passenger trains only,
 - freight trains only,
 - passenger and freight trains,
- number of tracks on railway crossing
 - single track crossings,
 - double and more track crossings,
- shut-out actions of railway infrastructure manager
 - permanent,
 - short-period,
 - emergency situations,
- space possibilities of infrastructures
 - opacity,
 - geometrical layout of railway crossing,

- incorrect operation of railway crossing devices.

5. The Impact of Railway Vehicle Speed on Railway Crossing Closure Time

According to our statistical research and observations of single track railway crossings and according to generally valid formula for time calculation, we calculated necessary time for single track railway crossing closure for each approaching distance used on the network of Slovak Railways (ŽSR), which are 400 meters, 700 meters and 1 000 meters. We also calculated real time of railway crossing closure and, subsequently, we derived the formula for calculating excessive time of railway crossing closure with the respect to speed of railway vehicle:

$$T_{nut} = L_p / V_{max,dov} \text{ [min] } , \tag{1}$$

where:

- T_{nut} – necessary time for railway crossing closure,
- L_p – railway crossing approaching section length for railway vehicle,
- $V_{max,dov}$ – maximum allowed speed of railway vehicle,

$$T_{sku} = L_p / V_i \text{ [min] } , \tag{2}$$

where:

- T_{sku} – real time of railway crossing closure,
- L_p – railway crossing approaching section length for railway vehicle,
- V_i – actual speed of railway vehicle,

$$T_{nadb} = T_{sku} - T_{nut} \text{ [min] } , \tag{3}$$

where:

- T_{nadb} – excessive time of railway crossing closure,
- T_{sku} – real time of railway crossing closure,
- T_{nut} – necessary time for railway crossing closure.

Graphic description of necessary and excessive time of railway crossing closure for determined speed of railway vehicle is shown in Figs. 2, 3 and 4.

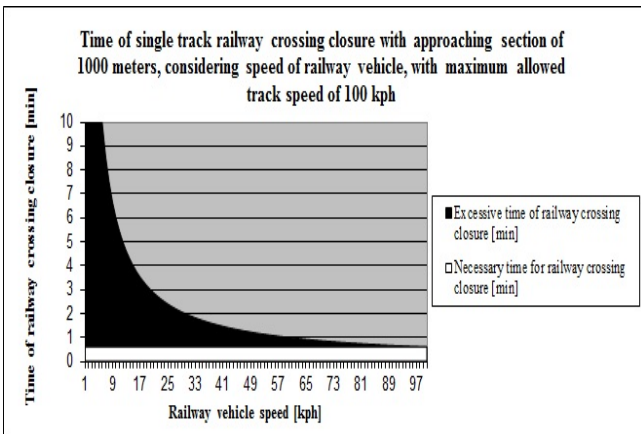


Figure 2. Time of railway crossing closure with approaching section of 1 000 meters.

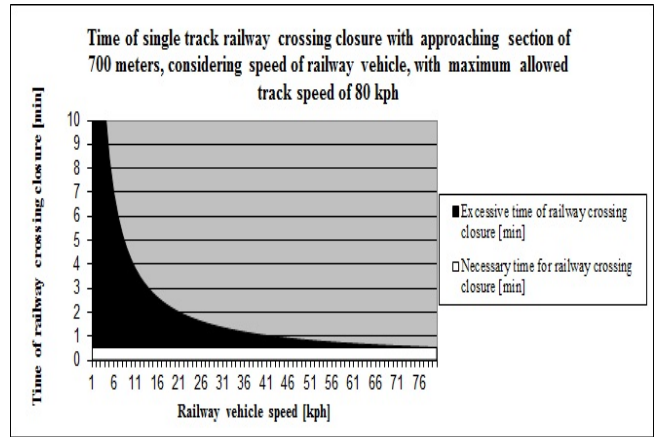


Figure 3. Time of railway crossing closure with approaching section of 700 meters.

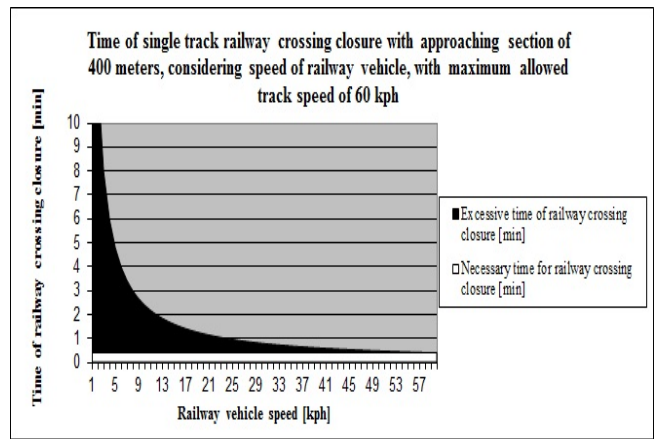


Figure 4. Time of railway crossing closure with approaching section of 400 meters.



Figure 5. Passenger train No 3509 on single track railway crossing with light- equipped interlocking device with bars in Railway station Žilina district.

Table 1. Numbers of secured railway crossings in Slovakia in the past years

Number of secured railway crossings in Slovakia / years	2007	2008	2009	2010	2011
warning cross	2307	2265	2220	2219	2205
railway crossing interlocking device	1085	1102	1076	1081	1079
mechanical bars (including 20 permanently locked)	123	103	100	98	94
light-equipped railway crossing interlocking device	962	999	976	983	985

6. Accident Occurrence on Railway Crossings

Railways of the Slovak Republic (ŽSR) has marked every railway crossing with the system of unique identification number of railway crossing for the purpose of signaling possible risk, or for eliminating the consequences of accident. This mark is black number on white ground in reflex foil (for better visibility in conditions of reduced visibility). In case of emergency it is necessary to report this number on emergency telephone number 112. Samples of identification numbers of railway crossings are shown in Fig. 6.



Figure 6. Unique identification numbers of chosen railway crossings.

A leading employee of ŽSR organizational unit in whose district the accident happened is responsible for organizational assurance of liquidation works and a possible substitution for passenger transportation. He cooperates with a control dispatcher, train dispatcher from organizational unit management and leading employees of participating organizational units. He is responsible for a detailed observation and analysis of on-line recordings at electro-dispatcher. Authorities of ŽSR (infrastructure manager) and railway transport operator authorities do act together and coordinate when accident occurs on railway crossing.

Table 2. Accidents on railway crossings and their consequences

Slovak Republic / years	2011	2012
Number of accidents	140	136
Departed	15	11
Seriously injured	41	68
Slightly injured	19	20

7. Conclusions

It is possible to prevent the accidents on railway crossings which occur in everyday life taking preventative measures together with implementing new technologies into operations. Present technologies used in practice do not use the kinetic component of train movement which expressly influences the time necessary for railway crossing closure. However, this component is just one of the factors which impacts on excessive time of railway crossing closure. The excessive time of railway crossing closure influences the reactions of road transportation participants on the railway crossing and it negatively affects their behaviour. Elimination of this excessive waiting time can, therefore, cause the increase of safety and decrease of potential risks on railway crossings. Safety maintenance has to be and is the top priority in the chart of obligations of transportation process participants, on railway crossings. The investments to increase safety of railway crossings cannot be limited as they are negligible when compared to the price of a human life. This is the reason why grade-separated railway crossing is becoming the best solution which completely eliminates the excessive time of railway crossing closure.

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Figure 7. Grade – separated railway crossing.

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