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Hazards generated by railway traffic and their minimalization by implementation of the research project „Train Driver 5.0”

Abstract: Striving to increase safety is a priority all railway stakeholders. Railway traffic generates many hazards and avoidance them rests first of all on the Train Driver. There are many projects, polish and international, which have important aim: minimalization of the undesirable situations, that can lead to accident on the tracks. In the article have been discussed hazards in the railway traffic and ways to reduce them. Also assumptions and goals one of the projects „Train Driver 5.0” were presented.

Keywords: Railway traffic; Train driver; Hazard

Introduction

Safety of rail transport is a priority for all entities operating on the rail market. The European Union has for many years been making efforts to ensure the interoperability of railways by issuing appropriate legal regulations containing requirements for these entities. They are intended to adapt national provisions so that the level of safety of the European rail system is assured and maintained.

Rail traffic generates many hazards that should be constantly identified, analyzed and monitored to keep the risk of their occurrence as low as possible. The tool used to achieve this goal is, among others required by law to carry out valuation and risk assessment if the railway entity (carrier, infrastructure manager, an entity in charge of railway vehicle maintenance, manufacturer, works contractor, etc.) introduces any changes to the railway system that affect safety.

This article will discuss the types of hazards that occur during train movements and how to mitigate them. A project called 'Train driver 5.0' will be presented, which is a revolution in the field of increasing the level of safety and eliminating risk factors in rail transport.

Types of threats in rail traffic

Under Community law, a hazard is a condition that could lead to an accident, and the risk is the frequency of accidents and incidents leading to the damage caused by the threat, and the severity of the damage [6]. Eliminating the risk is impossible, but it can be minimized, e.g. by shaping people's awareness of the existence of threats, implementing safety management systems, train drivers' training, programs promoting safety.

Threats to rail traffic can be divided into several areas:

1. related to infrastructure (technical),
2. related to the position of the train driver,
3. related to unauthorized persons on the tracks in prohibited places,
4. resulting from atmospheric conditions and random events.

All these hazard groups require the train driver's full concentration and adequate psychophysical ability to drive a railway vehicle.

The first group of threats is related to the railway surface and its condition. The pavement is the part of the railway road that is responsible for the safe and uninterrupted movement of trains. Each of its elements (rails, sleepers, ballast, rail fastening, splints, washers, screws, bolts) has a different purpose, and all together they enable safe driving. The surface loses its properties due to two processes: wear, i.e. the period of compliance with requirements, which causes permanent undesirable changes in operation and damage to components [1]. Both states can lead to hazards in rail traffic. It should also mention the theft of part of the infrastructure (wiring, track screws, rails), which is a real threat to passengers, railway employees and uniformed services.

The second group of hazards refers to the train driver's position. The greatest danger is generated by the driver's fatigue, which can most often be caused by longer working hours due to the lack of monitoring of his work. Train drivers are often employed by different carriers at the same time and work more than required by applicable regulations. As a result, there may be a justified problem with concentration - observation and proper interpretation of the signals regulated in the instructions Ie-1 (E-1), so it applies to every driver. It is both information transmitted by trackside signaling devices and indicators on the railway route that may cause an inappropriate reaction.

In current solutions on the railway network, especially on modernized railway lines, a high concentration and attention are required to maintain proper driving techniques and tactics and adapt it to these indications. An example is a situation when on a very short section of railway track the driver in short intervals of time - a few seconds - must receive and correctly interpret the information transmitted by several crossing warning discs (ToP). These shields inform on the state of efficiency of the warning devices for road users on a crossing within the braking distance behind such a disc. The point is whether the driver can overcome the maximum speed on a given section of the route, or depending on the indications of these shields/shield (as you know, the warning plate is marked with a plate with a number corresponding to the kilometer and hectometer of the passage to which this shield reference) must limit the speed of the train when the target indicated an Osp1 signal for a specific rail-road crossing. At the same time, the driver receives information from the newly built signaling devices after the modernization of the four-position multi-spaced line blocker about the vacancy status of subsequent block distances and indicators. An example is the W-16 passenger stop indicator, which, according to Ie-1 instructions, is set obliquely to the track in front of passenger stops, where there are no semaphores, on the right side of the track to which it relates, at the braking distance of trains in force on a given route, calculated from the W-4 indicator set at this stop.

As train drivers point out, mixed solutions for the location of newly built platforms do not improve safety. Current solutions for the location of platforms on the railway network look like the platforms are opposite, island-like or alternating. In the case of alternating platforms, it is bad practice to arrange them in such a way that when looking in the direction of driving on the right track, arriving at the passenger stop, the platform is first located just when driving on the right track. It is advisable to reverse the order of buildings. It would be better for the train driver if the platform from the opposite direction was first, and then the one seen from the direction of travel (such solutions take place e.g. on the E-20 line - section Warszawa Rembertów - Mińsk Mazowiecki). In bad weather, the driver would have a reference point and would have to travel about 400 meters to stop when approaching a train stop. There would be then a chance that the vehicle would not be stopped from the W-4 indicator, i.e. avoiding the C44 incident. The increase in railway incidents of this type is particularly noted in its safety analysis reports from the Office of Rail Transport.

Threats to the route may also pose a threat. The train driver is not always with the same frequency it travels along a given route. Then he has limited knowledge of the path he travels. It should also be noted that hardly any driver can move in short intervals (it comes to several days) on lines with different configurations as to the arrangement of platforms. According to the regulations, the permissible period of knowledge of the trail is six months. If the train driver does not drive a given route 4-5 months, he forgets its parameters. This creates a certain distraction and increases the risk of C44 rail events. If the driver does not travel regularly on a given railway line with various locations of platforms, after a few months - but not more than 6 - he is obliged to re-recognize the route by going there/back one ride during a day and one at night. However, when the period of absence was more than 12 months, the number of familiarization rides is doubled.

Fig. **1.** Access to the platforms in Ustanówek

Fig. **2**. Stop at the platform edge of track No. 2 in Ustanówek

Dangerous rail traffic-related situations also occur within the station - at the station exit, when the driver has the "clear road" information on the exit semaphore - signal S5 (one

orange light steady), and there is an island platform at the braking distance. This solution, in the absence of solid safety barriers, causes unauthorized shortening of the path for travelers. People jump off the platform directly onto the tracks, often even when the train is moving from the platform. The series of these behaviors cause the driver to be distracted. The issue of the sequence of signaling indications may cause the driver to forget that the S-5 signal was displayed on the semaphore, which means that when leaving the automatic interlock the next semaphore indicates the stop signal. There are known cases of departure from the Warszawa Okęcie station, where the semaphore is behind an arch and the possibility of observing it is very limited due to the people jumping in front of the train. This can lead to colliding with another vehicle that for various reasons had to stop behind the curve.

Another issue is the driver observing the composition of the train starting from the station. In the past, the train manager observed the composition. In new generation and upgraded vehicles, the doors close automatically, so train staff are exempt from this obligation. Currently, this is done in such a way that the door closes automatically, the train manager gives a sign to leave and if someone falls between the platform and the vehicle, no one from the train may notice it.

During the modernization of railway lines, supporting structures of the overhead contact line (haul-offs, slashes, support arms, slant support bars, gate structures of the contact line, baskets of signaling devices placed on the gates) obstruct the driver's clear image of signaling devices.

Fig. **3**. Support structures blocking the train driver's view of the trail

The third group of threats to rail traffic is caused by people staying illegally in the railway area, including those intending to commit suicide. This problem occurs on almost the entire railway line in Poland. Children and teenagers take shortcuts to school. Adults go shopping, jogging or work. Railways divide cities, towns, villages, and eventually communities. New investments (apartments, shopping centers, schools) are often located on both sides of the railway line, which increases the needs of people to cross tracks in prohibited places.

The largest number of those walking on the tracks take shortcuts because the public road is too far. Therefore, they choose the shortest and thus the fastest route, although the designated crossing is only 300 meters away. They usually use already beaten paths, although they are illegal and because of their habits to use these paths. They have been going there for years and do not want to change their habits. Others do it for recreational reasons - to walk a dog, long walks along the tracks are an attraction for them, wandering in the company of colleagues, drinking alcohol, smoking, looking for a place for graffiti [4]. Children can make

a playground on the tracks and jump in front of passing trains, throw stones, climb bridges and traction poles. This requires an increased concentration of the driver. Besides, along the trails, we often see crosses with flowers along the tracks, where inattentive passersby died.

Fig. **4**. A wild crossing

Fig. **5**. A cross by the railway route

Suicides are a separate group that poses a threat to railway traffic. Death under the wheels of a train is treated as an effective way to take your own life, which is why it is such a preferred form.

The last group of threats is associated with bad weather conditions when the visibility on the trail is very limited. Fog or snowstorms may prevent the correct reading of traffic lights and other road markings. Similarly, random events resulting from natural forces may pose a threat to safe driving. We include breaks in the contact line or obstacles in the form of overturned trees due to strong winds.

Risk prevention in rail traffic

In recent years risk prevention in rail transport has become more important. The source of this state of affairs is primarily EU legislation, which obliges the Member States to carry out valuation and risk assessment to increase the level of safety of the railway system. The railway system is still developing, and the numerous changes introduced to it in all areas are subject to the need to assess them in terms of their importance.

Along with Directive 2004/49/EC on railway safety [2], concepts such as safety management, risk management, and risk analysis appeared in the railway industry. The directive introduced a systematic approach to the discussed issue, necessary among others due to increasingly new, extremely complex technologies, an increase in train speed or an increasing number of railway carriers. Aspects related to traffic management and security systems required carrying out risk analysis, both own and resulting from joint operations, and transferring threats between independent entities of the railway industry - infrastructure managers and carriers [5].

Many different methods are used to prevent the risks associated with rail transport. Educational programs are created informing about the threats and possibilities of avoiding them or minimizing the effects. Infrastructure managers and railway carriers are required to implement and use safety management systems (SMS) in their enterprises and to comply with the principles and conditions of railway traffic safety contained in various national and EU regulations. This applies above all to the employment of employees with appropriate qualifications and competences, knowledge of all current regulations specifying the requirements for railway traffic management and railway infrastructure maintenance as well as the operation of buildings and equipment necessary for railway traffic operation, including possession of certificates for the operation of railway vehicle types.

Employees are required to apply internal regulations, including safety management system procedures appropriate to their workstations, instructions, regulations, etc. Each employee must also be able to respond to irregularities that may lead to an adverse event.

Risk management has become one of the most important issues, with the overall goal being to limit the amount of damage it can cause. In the event of a risk, but also when it is anticipated that a risk may occur, all possible measures shall be taken. All possibilities allowing the transfer of risk in part or whole to the outside - to contractors and/or third parties - are used. All risk areas remaining despite the removal of the causes must be limited. To this end, measures are taken to limit their size.

In the case of risk management in the area of rail transport, it is about improving the safety of both passenger and freight transport. In rail transport, the risk management process scheme is carried out according to the phases contained in Regulation No. 402/2013. The application of this process in this form is obligatory for all entities carrying out activities affecting the safety of rail transport. Risk management involves searching for areas where a problem may occur, then identifying its sources and causes, and then minimizing the probability and effects of its occurrence. In the last stage, prevention and monitoring plans are developed. This is done through risk analysis, which consists of two issues:

1. Risk assessment, based on its estimation, i.e. identification of threats, the vulnerability of the analyzed system to these threats, and the likelihood of the effects of previously identified threats. This raises the issue of risk acceptability, which should be properly identified. The risk should be reduced to the lowest possible level, and at the same time rationally justified, e.g. by social, technical or economic factors [1].
2. Hazard tolerance assessment manifested in the comparison of possible losses with costs incurred for the prevention of threats; this tolerance varies depending on the threat, as some solutions are easier to implement than others.

To minimize the risk of threats, various research programs and projects are being implemented to improve rail traffic safety. They characterize the occurring irregularities and formulate preventive actions in the organizational, personnel, technical and control areas.

One of such projects aimed at increasing the level of security in the rail transport, the "Train driver 5.0" research project is currently being implemented by INFRACERT TSI. The next chapter of the article is devoted to this project.

Train driver 5.0

Train driver 5.0 is an innovative system created for the diagnosis and training of employees employed in positions related to safety and railway traffic management. Scientists, researchers, and railwaymen implementing the project have selected features on which railway traffic safety depends to a large extent. These are:

- the eye-hand coordination,
- reaction speed,
- spatial orientation,
- resistance to frustration and fatigue,
- memory and visual attention,
- assessment of speed and space.

The system is a breakthrough in the principles of assessing and improving the physical and mental abilities of railway workers. It is based on modern technologies, including, among others: VR (Virtual Reality), computer batteries of cognitive tests and RED (Remote Eyetracking Device). It allows recognition of cognitive skills that are key to railway traffic safety, and is also a tool enabling comprehensive training and training in the field of employee professional development.

The system enables the training of cognitive skills adequately to the diagnosed level. Thanks to the use of modern VR technologies, the training environment reflects the real working conditions of the driver and related employees with rail traffic safety.

The essence and purpose of research

The train driver 5.0 project is a model based on knowledge of the driver's cognitive processes and personality components that are key to railway safety, which has been combined innovatively with the latest discoveries in the field of eye-catching technologies. The combination of these elements gives a new quality that allows you to capture the previously inaccessible dimension of information processing while driving a locomotive. The key element distinguishing the project from previous studies is controlling the cognitive and personality variables of the driver's functioning in contact with real incentives. This allows the driver's diagnosis to be transferred to the area of real reactions to situations related to safe driving of railway vehicles.

e purpose of the research is to identify protective factors and risk factors in the driver's behavior in the context of railway traffic safety. It will be implemented through an in-depth and multidimensional diagnosis of the driver's professional functioning. An innovative method of tracking eye movement in the context of changing conditions will be used to determine the professional potential of employees.

The proposed model complies with the requirements set out in Directive 2007/59/EC of the European Parliament and of the Council [3] and the results of research on safety in rail transport, especially with British research conducted by, among others Rail Safety and Standards Board (2015), McLeod, Walker, Moray, Mills (2005), Mackenzie, Harris (2017).

Test procedure

As part of the project, a set of tests has been prepared for drivers to undergo. The research model will be implemented in three stages. In the first stage, a psychological profile of the driver will be created, taking into account the identification of factors responsible for safe behavior while driving. Then, the risk factors that may accompany adverse events will be assessed in rail traffic.

In the second stage, the driver's cognitive potential will be assessed. The study will consist of collecting data describing the driver in terms of features such as the ability to process information, solving problems and making decisions.

The third stage is ocular studies, performed using eye-tracking technology. It involves tracking the movement of the knobs and the pupil's response to external factors, including observation of e.g. the trail, devices, etc. The images from both of these cameras are then processed and analyzed.

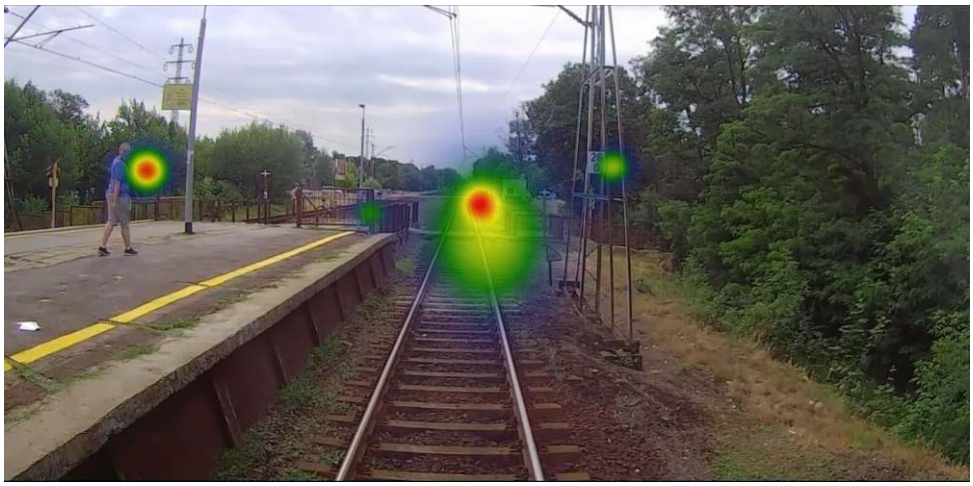

Fig. **6**. A scenery from the test - an eye focus map, so-called "heatmap"

Fig. **7**. Focus on the semaphore

Analyzing what the respondent looks at has countless applications. In the case of a driver, the software can be used, e.g. to check what affects his attention in the cabin and during its construction eliminate driver's distractions.

The second part of the project is a specialist training program focused on improving the value of individual measured parameters. For example, an exercise to control stimulus responses can improve the results of a study on resistance to frustration and stressors. The project intends that in the future an individual set of exercises for employees in the process of employee training and professional preparation will be obligatorily used.

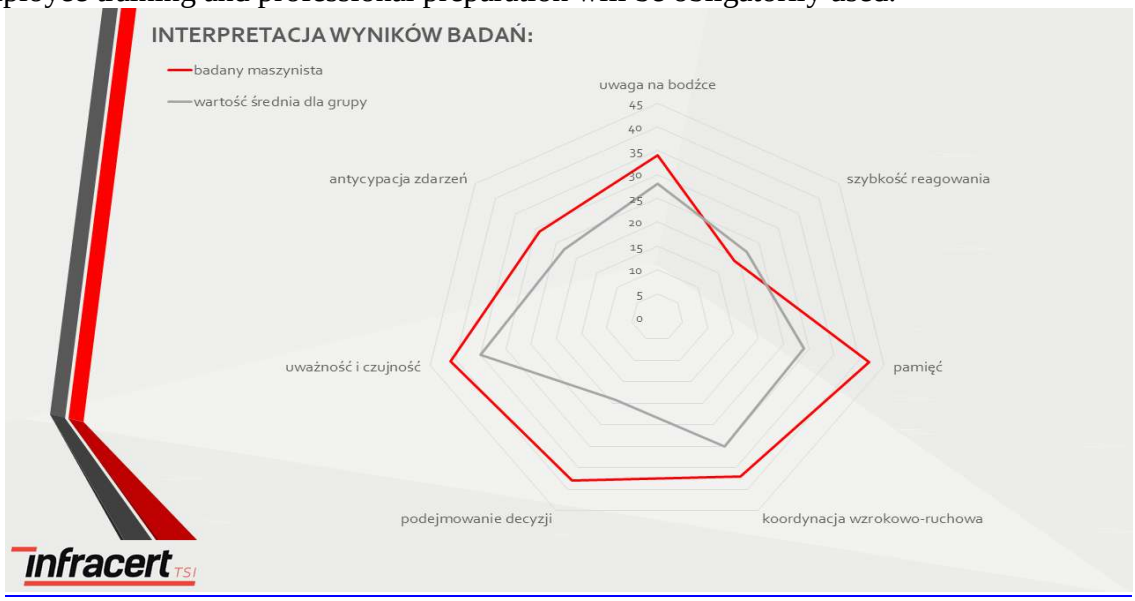

Fig. **8**. Measurement of incentives response control

Research is carried out by a team of professionals in the field of railway safety, transport psychology, and prevention of risky behaviors.

The benefits

The train driver 5.0 system generates benefits that can be considered in four areas: train drivers, carrier, passenger and rail transport system as a whole. Drivers increase their cognitive competence, which is especially important in the case of retired train drivers and can have a positive impact on the labor market in this sector. Carriers gain knowledge about

the level of competence of their employees and can use it in the process of improving the safety management system and adapting the training system to the needs of employees. In the longer term, the benefit will also be a reduction in railway adverse event rates.

Each of the people participating in the project by raising their competence reduces the risk of accidents and reduces their potential effects. This is an advantage for the entire railway system, and above all for passengers who can feel safer.

Among the assumed benefits that the project will bring there are:

- elimination of potentially dangerous situations,
- limiting the number of events and accidents,
- increasing rail traffic safety,
- diagnosis of employee training needs,
- continuous improvement of professional competence
- shaping a safety culture,
- a new dimension in occupational medicine,
- a significant improvement in the quality of training on simulators

Conclusions

Every year, many adverse events occur on the rail network, including accidents and incidents. Among the reasons, the so-called "Human factor". Many mistakes could certainly be avoided or even minimized.

In addition to risk analysis, which allows the identification and minimization of threats in various areas, including those related to the human factor, it is also important to diagnose employees responsible for railway traffic safety. Unfortunately, this issue is not currently being raised as it should be. Train drivers responsible for train safety are particularly vulnerable to adverse events. Their work requires increased concentration and constant observation of the environment. The answer to this problem is the "Train driver 5.0" project, which among many projects and programs for improving safety is an innovation in the field of diagnostics and training of employees related to railway traffic safety. There are more and more entities interested in participating in the project, including Łódź Agglomeration Railways, Koleje Wielkopolskie or the State Commission for Investigating Railway Accidents.

Source materials

[1] Bałuch H., *Zagrożenia w nawierzchni kolejowej,* Instytut Kolejnictwa, Warszawa 2017.

[2] Dyrektywa 2004/49/WE Parlamentu Europejskiego i Rady z dnia 29 kwietnia 2004 roku w sprawie bezpieczeństwa kolei wspólnotowych.

[3] Dyrektywa 2007/59/WE Parlamentu Europejskiego i Rady z dn. 23.10.2007 roku w sprawie przyznawania uprawnień maszynistom prowadzącym lokomotywy i pociągi w obrębie systemu kolejowego Wspólnoty.

[4] Garlikowska M., Gondek P., *Problematyka wypadków kolejowych związanych z samobójstwami i przechodzeniem przez tory w miejscach niedozwolonych*, Problemy Kolejnictwa. Wyd. Instytut Kolejnictwa. Zeszyt 174/2017.

[5] Rozporządzenie Komisji (UE) nr 1078/2012 z dn. 16 listopada 2012 w sprawie wspólnej metody oceny bezpieczeństwa w odniesieniu do monitorowania, która ma być stosowana przez przedsiębiorstwa kolejowe i zarządców infrastruktury po otrzymaniu certyfikatu bezpieczeństwa lub autoryzacji bezpieczeństwa oraz przez podmioty odpowiedzialne za utrzymanie (Dz. Urz. UE nr L320/8 z 17.11.2012).

[6] Rozporządzenie 402/2013 z dnia 30 kwietnia 2013 r. w sprawie wspólnej metody oceny bezpieczeństwa w zakresie wyceny i oceny ryzyka.