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# PROTECTING THE RAILWAY INFRASTRUCTURE FROM THE HAZARDS OF FREIGHT TRAINS CARRYING DANGEROUS GOODS

**Attila HORVÁTH*, Zsolt LÉVAI****

* University of Public Service, Budapest, Hungary, ** Hungarian Institute for Transport Sciences and Logistics Non Profit Limited Liability Company/ Doctoral School of Military Engineering, University of Public Services, Budapest, Hungary

***Abstract:*** *Transport infrastructure and the vehicles that run on it can be ideal targets for terrorists. This is true both for rail transport and for the trains themselves, especially those carrying dangerous goods. Hazardous materials released as a result of a possible terrorist attack can cause far greater damage in terms of human life, material and natural assets than the damage caused by simply blowing up a train. This article describes the rail environment in which dangerous goods are transported, then the relationship between terrorism and rail transport, and finally suggests possible protection methods and procedures of the infrastructure and the trains.*

***Keywords****: transport of dangerous goods; rail transport; RID; terrorism; critical infrastructure protection*

## 1. INTRODUCTION

After the decades of the Cold War, the Western world grew faced with a new way of warfare and a risk factor: hybrid warfare, which mostly meant (military) activities below the level of war. Terrorism is typically one of such phenomena. Terrorism is present in many countries of the world; its aim is to destabilise countries and governments with various methods of asymmetric warfare. Defence against such methods is difficult, because the perpetrators often remain in the background, moreover, even become victims themselves in some cases.

Today, technological development has reached the point where everyday life is linked to a multitude of supply chains that use various elements of infrastructure. One of the most common forms of this connection is the use of transport infrastructure, i.e. the process of goods transport. Consequently, the disruption of supply chains can even endanger human lives. The previously mentioned objective of terrorism can therefore also be the disruption of supply chains. As a result, the vulnerability of individual infrastructure elements has also increased (Horváth & Lévai, 2021). A frequent target of terrorist activities is the infrastructure network, because by destroying some of its elements the material, economic, and social damage, and the loss of human lives can be achieved most easily, which can even undermine the power of governments. In the United States, where the fight against terrorism has always been of prime importance, the focus began shifting on the protection of infrastructures as early as the 1990s. The first document on this topic was Presidential Decision Directive No. 63 by President Bill Clinton, issued in 1998 (NSC-63, 1998). The terrorist attacks in 2001 increased the role of infrastructure protection in the United States, and forced the European Union (EU) to take action too. In 2005, the EU published its Green Paper on the European Program for Critical Infrastructure Protection (COM(2005)576 final, 2005). However, this only established basic principles while the turning point came in 2008, when the EU issued a directive on the issue (Horváth, 2013). According to that directive, elements and subsystems can be classified as critical infrastructures whose failure due to some emergency situation can trigger an extraordinary event that can result in the loss of human lives, economic disadvantages, and material damage, as well as disruptions in the everyday life of society and public administration (2008/114/EC, 2008).

On the basis of what was discussed in the previous paragraph, transport infrastructure elements – as parts of national infrastructure networks – can rightfully be classified as critical infrastructures due to the following factors: they (1) have high value; (2) are located in a large area; (3)

have a significant number of users; and their (4) failure causes significant damage and disruptions.

These statements are especially true for the railway. In this sub-sector, it is not only the destruction of infrastructures that can be expected but attention must also be paid to attacks against vehicles and trains running on tracks, since terrorist acts against them may also achieve the effect desired by the perpetrators. Currently, terrorism is not a very significant phenomenon in Europe, however, the situation in Afghanistan may once again bring the activities of terrorist groups to the fore. At the same time, terrorism is also present in the immediate vicinity of Hungary, as indicated by the attack in Vienna in November 2020. That is why the protection of critical infrastructure must be continuously addressed, and research into the latest protective methods must not stop.

The present article deals with a sub-area of railway transport, the transportation of dangerous goods, and the protection of freight trains carrying such materials. The protection of such trains is extremely important, because terrorist attacks carried out against them have the potential for damaging and destroying not only the infrastructure but also the environment through the transported dangerous substances, which can cause incalculable damage even for the entire continent.

## 2. RAILWAY TARGETS OF TERRORISM

As mentioned above, the railway sub-sector – as part of the transport system as a whole – can be a suitable target for terrorist groups to carry out their actions. Freight trains transporting hazardous materials use the same railway infrastructure as passenger trains, including tracks in urban environment (Kaplan, 2007). This is unavoidable, because the plants that produce dangerous substances, and also those that mostly use them, are located in the vicinity of cities, and no separate railway tracks are built for them. Bypasses exist, but their use reduces the speed of transportation and increases costs, therefore there is hardly any intention to use them. Freight trains carrying dangerous goods on urban railway lines therefore pose a much greater risk, which may also attract the attention of terrorists. Another problem may be that in many cases the city's disaster management units are not even aware of the passage of such trains, so they cannot be prepared for a quick elimination of the consequences of a possible attack. As an example, a theoretical attempt of an attack against a freight train carrying dangerous goods on the railway bridge over the Danube River near Komárom could be mentioned. As a result, the material flowing into and contaminating the river would even threaten the capital's drinking water resources, so human lives could be at risk on a massive scale.

A similarly high figure of casualties may be achieved through a terrorist attack against a major railway junction. In case an explosive attack is committed, the number of victims can be high due to the large number of passengers, and if the target is a freight train carrying a dangerous substance, the additional destructive effect of the released dangerous material must also be taken into consideration. Marshalling yards and trans-shipment stations are facilities which can be regarded the operational elements at risk for the transport of dangerous goods by rail (Horváth, 2014). These facilities must comply with the set of requirements defined in the Council Directive on the management of serious industrial accident hazards related to hazardous substances (so-called Seveso-Directive) (Horváth & Kátai-Urbán, 2013:16-18). The guidelines were issued in three parts (82/501/EEC, 1982; 96/82/EC, 1996; 2012/18/EU, 2012). The conditionality of protection against serious accidents involving dangerous substances are regulated by Directive Seveso III (Cimer *et al.*, 2015:78-91).

Marshalling yards in Hungary are located in the immediate vicinity of passenger railway stations, with the only exception of Szolnok, where they are located at a greater distance from each other. Even Ferencváros, the largest marshalling yard in the country was built in the immediate vicinity of a train station, whose additional problem is that it is situated within the boundaries of Budapest, not far from the city centre. That means that an accident involving a train carrying hazardous materials would have a significant impact on the population of the capital.

It is important to analyse the sources where information can be obtained about the movement of such trains, i.e. to see how to develop appropriate IT protection. Terrorists can get information about the details of train movements not only at the locations (at railway stations or along railway lines), but they may also use the world wide web in order to obtain data. Another field of use of IT is the railway management system. Due to the extreme severity of accidents that occur in the railway sector it is essential that trains always travel only at the permitted speed, which is now regulated by modern railway management systems. At the same time, wrong actions resulting from false directions have the potential of causing serious accidents,

consequently railway management centres may also be targeted by terrorists.

Based on the above, it can be stated that, from the perspective of trains carrying dangerous goods, the top priority targets of terrorists can be urban and suburban railway lines, especially bridges over urban sections of rivers, as well as large railway hubs, railway management centres and electronically available data. Therefore, protection should be focused on these infrastructure elements.

## 3. RAILWAY TRANSPORTATION OF DANGEROUS GOODS

The production technologies around the world require the use of many dangerous substances, but such materials are also manufactured, or generated as by-products. The production, use, and neutralization of hazardous substances do not coincide geographically; consequently, such materials need to be transported between individual sites. Railways comprise one of the means of transport, and in line with the above, it is necessary to ensure the protection of trains transporting environmentally hazardous substances.

**3.1 Carriage rules.** The International Convention on Carriage by Rail created a complex regulatory system for rail transportation. The Convention concerning International Carriage by Rail (Convention Relative aux Transports Internationaux Ferroviaire, COTIF) was signed in Bern on 9th May 1980, and was promulgated in Hungary by Decree 2 of 1986, which has been amended several times since then. The regulation on the international transport of dangerous goods by rail (COTIF Appendix C: Règlement concernant le transport international ferroviaire des marchandises dangereuses, RID) defines the obligations of the actors involved in the transport of goods by rail (or in combined transport) in relation to achieving safety. The rules also cover inspections and official restrictions, as well as the classification of dangerous substances, the listing and packaging of dangerous goods, the production of packaging materials, dispatch procedures, and transportation conditions (loading, unloading, handling of goods). The transportation must otherwise comply with the directive on the land transport of dangerous goods (2008/68/EC, 2008).

However, the application of rules to protect human life and environment also has economic impacts and sometimes these regulations seem bureaucratic. The European Commission's 2015 report on the implementation of the White Paper on transport policy (COM(2011)144, 2011; A8-0246/2015) stated about this bureaucracy that the transportation of dangerous goods represents an administrative difficulty for carriers, and therefore measures were proposed to promote the simplification and harmonization of regulations, which was approved by the European Parliament. These measures may increase the amount of dangerous substances transported by rail, making the protection of trains an even more important task.

**3.2 Railway cars.** Many types of railway wagons are suitable for the transport of dangerous substances; their usability depends on the type and packaging of the goods. Tank wagons are suitable for the transportation of liquids, and gases in various states of matter. Hazardous materials in specifically suitable packaging can be transported in open wagons, while materials that must be protected from the effects of the weather, even when packaged, must be transported in covered wagons. Flat wagons are used for transporting containers or truck trailers by rail. In such cases, the dangerous substances are in the container unit itself or in the trailer. There are also dangerous goods that must not be transported in the types of wagons listed above; in such cases specially constructed railway wagons are needed.

All of this is important because to determine by visual inspection whether the cargo is classified as a hazardous material is only possible in the case of freight trains with a very special composition (for example, when a train consists of only tank cars).

**3.3 Supervision of rail transport.** Before 2012, it was the responsibility of MÁV Zrt. itself to carry out the inspection of the transport of hazardous materials, i.e. the company conducted the supervision in the framework of self-inspection. Due to changes in legislation, in 2012 this task was taken over by the disaster management authority, and since 2016 there has been a round-the-clock inspection on an experimental basis at Kelebia border station, where all departing and entering trains are inspected. As a result of continuous inspections by disaster management units, the number of irregularities has significantly decreased (Balogh, 2019:21-34).

## 4. OPPORTUNITIES OF PROTECTION OF TRAINS CARRYING DANGEROUS GOODS

**4.1 Physical Protection.** Physical protection can be applied both in the case of infrastructure and trains. In the case of infrastructure, this means

the prevention of direct access to tracks and to the control centre, while in the case of trains, physical contact with the train is prevented.

In the case of open railway tracks between stations, the physical protection cannot be completely ensured. Protective fences may be built along open tracks, however, these need to be interrupted, for example, where the railway line is crossed by a public road. Road crossings offer direct access to the tracks consequently; an explosive device can easily be planted in the appropriate place. On the most critical stretches, i.e. on the track sections where trains stop (for example sections to the entry signals of railway stations), the construction of barbed wire fences or noise protection walls can solve the problem. However, they can be crossed with the help of various cutting tools, therefore complete security will not be provided. To increase security, it is recommended to run a low-voltage electric current through the fences, which do not cause a lethal electric shock, however, it can indicate any break in the system (for example, when the wire fence is cut). In such a case, the system sends a warning signal to the control centre, where appropriate measures can be taken. It may be necessary to rapidly and accurately determine the location of the intrusion, which can be done by using night vision cameras.

The above solutions cannot be applied for tracks at railway stations because access to the railway cars must be ensured there. In this case, traffic management procedures can be applied to ensure that freight trains carrying particularly dangerous substances avoid major passenger traffic junctions. If this is not possible, these trains must be operated at the station on a track that is located farthest away from passenger areas and buildings. In practice this means the outermost tracks of stations, which are not always in perfect condition, but keeping the station tracks in good condition can help provide adequate protection. As a result, it is important that these tracks can be passable at a speed of at least 40 km/h – as most of these tracks only have switches that can be used at a speed below 40 km/h – so that passing through the station does not take significantly longer than using the main tracks passing through.

Another protective element is the monitoring obligation regulated by railway instructions, which may oblige railway employees to either continuously or periodically monitor such freight trains at the station, including both movement coordination and visual inspection of the train (Hungarian State Railways F.2, 2012).

Permanent personal presence may also be a suitable protection method. In the case of trains carrying high-value goods (for example, motor vehicles), the solution is that the train is escorted by guards who stay by the train during its entire stopover at the station, and monitor the movements in the vicinity. Personal surveillance can be important in keeping terrorists at bay as well. Guards can be employed to escort the train throughout its entire journey, or guarding may be ordered only for the duration of stopovers at a station. The latter can only be a solution in the case of a longer scheduled stay, since stopovers resulting from operational movement control are not determined in advance, and in the case of a shorter stay (e.g. 10-15 minutes) it would be too expensive to organize guarding. In the case of trains transporting particularly dangerous materials, it may be necessary to provide an armed escort and even secure their route with armed forces.

The physical protection of control centres is aimed at preventing unauthorized access. Entry into the building can best be physically prevented with armed guards, and it is also necessary to install windows with bars to prevent entry. The appropriate entry authorization can also be controlled with IT devices.

People may come into physical contact with the trains during loading and unloading, as well as during the trains' stay at the station. The loading and unloading operations can take place on the premises of the transport companies as well, therefore in this case physical contact is controlled and prevented in accordance with the protocol of the given company. Trains are always assembled and structured at a railway station. During shunting (wagon coupling), it must be ensured that no unauthorized persons can get close to the wagons. This can mostly be achieved by monitoring the tracks and trainsets. As it has already been mentioned in the previous point it is not easy to determine the load of (covered) freight cars from the outside, but at the same time, the labels affixed to the car or the load (see RID) indicating the dangerousness of the goods can be revealing. Entry into the wagons must be prevented by the simultaneous use of car locks and lead seals that provide adequate security.

**4.2 IT protection.** Nowadays, the key role of information technology is unquestionable. In the field of railway transportation, it is present in the data management relating to trains and wagons, in the management of transport, and in various access control solutions.

During rail transport, information about the loaded goods accompanies the entire process. As a result of IT development, paper-based documentation has been replaced by electronic documents, so the data of trains, wagons, and consignments are recorded in digital form. From a security point of view, this means that the data of trains carrying dangerous substances must be recorded, stored, and transmitted in a way that no unauthorized persons can obtain them.

The weakest link in the transmission chain is the human. Influenced by threat, they are able to release information that should otherwise be managed as confidential. This means that any information managed by humans can be obtained; therefore, efforts must be made to ensure the confidentiality of information transmission and electronic data transmission. Of course, in order to operate trains, the signallers still need information, and they even need to know if a particular train carries dangerous goods so that in such cases the transportation rules appropriate for this type of trains can be applied. Based on the above, the involvement of only the absolutely necessary number of people is recommended in the case of trains transporting dangerous goods.

In the case of IT information transmission, blockchain-based data transmission is recommended, which significantly complicates both the acquisition of data (Lévai & Üveges, 2020:103-139) and any unauthorized access to information. The technology itself is not unbreakable, but the time required for hacking exceeds the time of detection of the action, so the necessary measures can be taken in time.

However, there are trains transporting hazardous materials on the rail network, whose protection does not allow IT-based data transmission. The procedure recommended in such cases in connection with the protection of transport will be discussed in more detail below.

**4.3 Transport protection.** The protection of train service covers the conduct of train meets and movement on open tracks. For risk reduction purposes it may be necessary to create a transportation plan that allows a train carrying dangerous goods to avoid train meets. It is the properties of the carried hazardous material, which should be the basis of decision whether a given train can meet other trains on the open track, and what safety distance must be established between two trains at a station. The required safety distance may prevent a planned train meet at certain railway stations due to the scarcity of available tracks, which may result in an upset timetable. (Here it is worth recalling the usability of the outermost tracks of stations.) However, tolerating a resulting delay is still a minor inconvenience only. There may also be situations where there is a facility or equipment (for example, a gas tank) near which a train transporting hazardous materials cannot pass, so the number of appropriate tracks of the station is reduced and the number of trains staying at the station may also be limited. This can have a negative impact on timetables as well, so in such cases those who prepare the transport plan have a significant responsibility, at the same time however, the primary aspect of their task is of course to ensure the safe running of trains.

The vast majority of trains are operated on the basis of a timetable, so all service points on the train's route as well as the company providing the locomotive must be aware of the timetable. This in itself is a significant number of employees, and the specialists working in control centres are also added to this. Timetables are prepared with the use of IT and are sent to the involved parties. The timetable appears in the IT systems of the capacity distribution organization that prepares it, of the railway company that ensures the movement of the trains, and of the railway company that manages the transport. There is no closed network among the individual companies in Hungary, therefore data is transmitted via the Internet.

As mentioned in the IT protection part, the data of certain trains carrying particularly dangerous substances must not be forwarded via IT, and it is not recommended to store them on a computer for a long time either. Due to the above, the schedule of such trains is prepared only shortly before their operation and is communicated to those concerned. The schedule must be prepared in compliance with tight security measures. In such cases, electronic mailing is not allowed, the involved parties only receive a printed-out schedule, which must be destroyed in a controlled manner immediately after the train has passed. In such cases, the human factor cannot be eliminated, which is why sometimes traffic security has to be ensured with the involvement of law enforcement agencies.

The shunt rules of freight trains carrying dangerous goods are also aimed at risk reduction. The so called protective wagon positioned after the locomotive is used for reducing the risk of explosive impact of a collision or of the smoke and ash coming out of diesel engines. The integration of such a railway car into the trainset may be necessary in several places even within or at the end of a train. The railway instructions clearly

regulate the kind of wagons that can be used in a protective role (it is not always necessary to have an empty wagon). The use of a protective car reduces the effects of a collision or derailment, thus providing greater safety during transport.

**4.4 Protection of Budapest.** Hungary's railway infrastructure is structured in a fashion that neither east-west nor north-south railway transportation can avoid the country's capital city. The most important railway crossing across the Danube River is located in Budapest, and the north-south railway line (Germany – Czech Republic – Slovakia – Hungary – Balkans) also passes through Budapest. The map showing the railway elements of the Trans-European Network in Hungary clearly shows that the Danube River can only be crossed by rail in Budapest, which fact puts a significant burden on the capital's railway network (Fig. 1.).

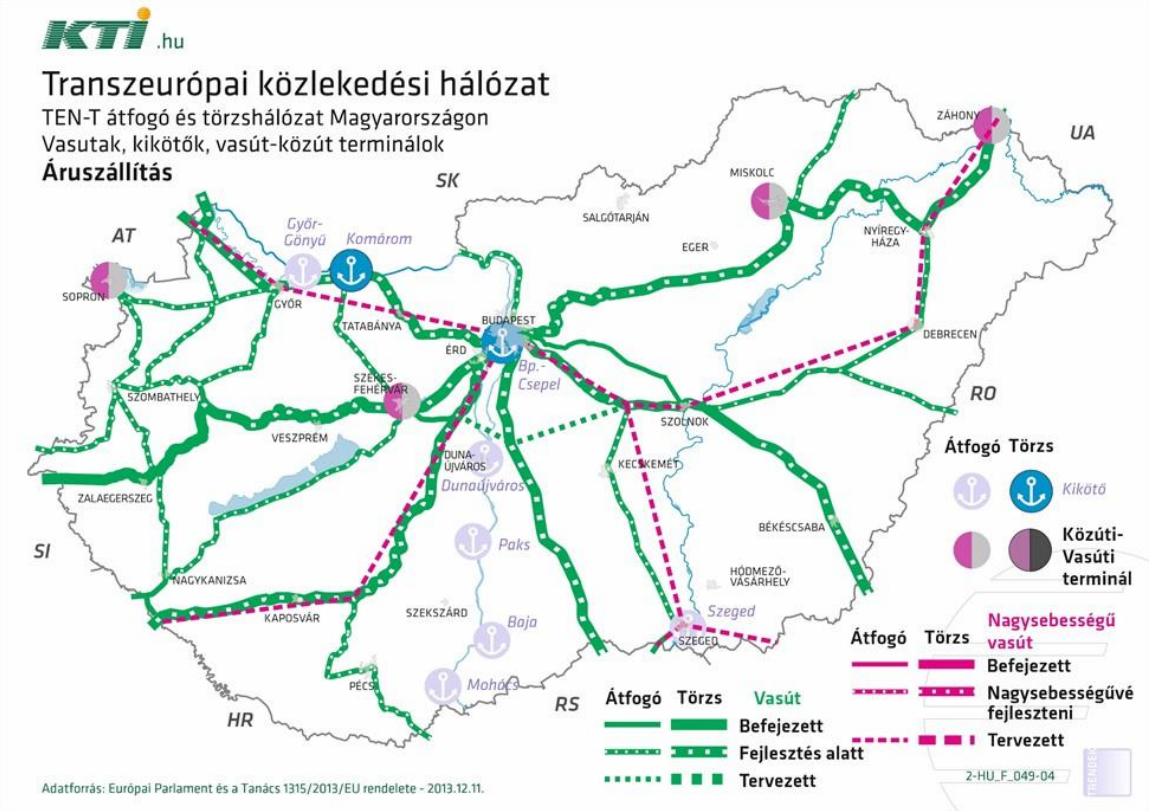


Fig.1 Trans-European railway network in Hungary (source: KTI)

If the objective is to transport dangerous goods by rail in an east-west direction, the Budapest network has to be used. This generates risks due to several reasons:

- an accident that occurs can cause significant damage to the country's largest railway junction, so that the entire east-west railway traffic can be paralyzed;
- an environmental disaster would occur in the country's largest city, so a significant number of injuries and victims is conceivable;
- the restrictions necessitated by the accident may affect units of public administration, which may cause problems on a national scale.

It is therefore obvious that the railway transport of hazardous materials in large residential areas (large cities) entails great risks, therefore the designation of a bypass route is definitely recommended. Since currently the Türr István Bridge in Baja is the only other option for crossing the Danube in Hungary, located outside the boundaries of Budapest, the route of the bypass is clearly defined. However, that bridge crosses the Danube also within a town whose population is around 35,000, so the risk is not eliminated, it is only decreased. The bypass route consists of many single-track, diesel-hauled and low-capacity stretches, consequently disproportionately increased travel time and transport costs may be expected.

This is precisely why the authors of this paper consider it necessary to build a railway bridge over the Danube River in Hungary, which is not located in the central territory of settlements. The line should pass through a rural area instead. This way,

the new line can be established primarily for the purpose of transporting goods, and would not have a passenger transport function. The plans are ready for the construction of the so-called "V0" railway line (named after the "M0" highway that runs around Budapest). The V0 railway line would bypass Budapest in the south, be dedicated to freight traffic, provide a speed of 160 km/h, and would be an electrified, two-track stretch. Its primary task would be to provide adequate transit capacity for rail freight transport through the country. The construction of the line can basically be realized as a completely new, green-field investment or may be based on existing or abandoned railway lines as brown-field investment (Tóth, 2021).

It is obvious that the V0 railway line would be also perfectly suitable for transporting hazardous materials by rail because it would not pass through inhabited settlements, and the trains would not encounter passenger trains either.

Due to its importance, the line will most likely be part of the Hungarian critical railway infrastructure network, so its protection will be a priority task in the preparation of the country for defence purposes. At the same time, the protection of the railway line will provide protection to the trains travelling along it, including, of course, trains carrying dangerous goods. The construction of the railway line will also ensure the protection of the Hungarian capital while providing better protection for freight trains transporting dangerous goods.

## 5. CONCLUSIONS

Previous defence research proves that transport infrastructures are among the "soft" targets of terrorists (Horváth, 2014). This is especially true for the elements of urban transport networks. The significant number of potential victims and high-level media coverage put traffic in the crosshairs of terrorists. The rail transport sub-sector – as part of transport – ensures the day-to-day functioning of a country through the transport of people and goods. Terrorist actions planned against the system attempt to block this functioning.

The present article examines a special case of rail transport, the operation of freight trains carrying dangerous goods, from a security point of view. The effect of the destruction described above can be increased if it targets a freight train transporting dangerous goods. The release of hazardous substances may increase the already significant level of damage, adding to the harm done to nature as well.

Due to terrorism, which is still present in the 21st century, critical infrastructure protection continues to play an important role in the defence preparation of a country, therefore the development of adequate protection is essential. This article deals with the issue of protecting railway infrastructures, and illustrates the issue with the example of freight trains transporting hazardous materials. First, the railway environment for the transport of dangerous materials is presented, followed by clarifying the relationship between terrorism and rail transport. Presenting the necessity of protection, possible protection methods and procedures are proposed.

The main findings of this article can be summarized as follows:

- physical protection measures for freight trains carrying dangerous goods must cover infrastructure elements, control centres, and trains alike;
- railway wagons must be protected with physical locks and, if necessary, with armed guards;
- when organizing the protection of train transport, the most important issues to decide are whether a train carrying dangerous goods can meet other trains, since its schedule and route must be planned accordingly;
- risks stemming from the level of danger are reduced if the wagons are positioned in the trainset in line with the appropriate aspects of protection;
- in order to protect Budapest and preserve the operation of the country, the construction of the V0 freight railway line bypassing Budapest is recommended.

The presented proposals can be used not only as a means of defensive measures against terrorist acts because a railway accident involving a train carrying dangerous goods can occur not only due to sabotage, but also because of carelessness, human error, or adverse environmental conditions. Some of the recommendations can be used for managing the consequences of accidents, and their application can reduce the risks of accidents. In this way, human lives and the living world of natural environment can be saved. It is worth mentioning which Kaplan highlights in his already cited article (Kaplan, 2007): experts recommend that the industrial use of hazardous materials should be reduced, thereby reducing the number of freight trains transporting such substances, which will also reduce the level of danger and risk.

In the opinion of the authors, the research cannot stop at this point. As a possible direction for further research, a broader examination of the

topics of the above findings is recommended, within the framework of a comprehensive (military and disaster management) transport protection research and development project.

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