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HAZARD IDENTIFICATION METHOD APPLIED TO THE ANALYSES DOMAIN WITH A VIRTUAL FREIGHT FACILITY

The share of rail transport in transportation of goods in Poland has been declining for many years. The chance to reverse this negative trend lies in an intermodal freight transport, which takes advantage of multiple modes of transportation. It is widely used in Western Europe. However, in Poland, there are not enough railroad terminals which would enable handling of containers. There are four times less such terminals in Poland than in Germany. One way to quickly enable access to more terminals is applying the British idea of loading and unloading on running lines. This idea proposes handling of containers directly on tracks between stations, on less used railway lines. Introduction of such service in Poland would require prior evaluation of risks associated with a change in the railway system, in accordance with the EU Regulation 402/2013 (CSM RA). One of key elements of this evaluation is a correct identification of hazards. Especially for the requirements of CSM RA, a method of identification of hazards was developed. It enables searching the analyses domain for hazards generated by the introduced change. This work presents the ideas of this method of identification of hazards and shows some results of using this method for the change in the railway system, which consists in establishing a virtual freight facility at a sample location on the railway line.

Keywords: hazard identification method, analyses domain, railway freight facility, container transportation

1. INTRODUCTION

The share of rail transport in transportation of goods in Poland has been showing a downward trend for many years. In 2015 it was only 12,4% [Główny Urząd Statystyczny 2015]. It is caused both by changes in the structure of economic system

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and by intense development of road transport. This situation is unfavorable for many reasons. Road transport is less environment-friendly and it carries a greater risk of human and material losses than railway transport. One way to work against the marginalisation of railway transport is to promote the intermodal freight transport. However, there are not enough properly adjusted handling terminals. In Poland, for each 10 000 km^2 there is one intermodal terminal. In Germany, this value is over four times greater [Urząd Transportu Kolejowego… 2016].

To trigger the discussion about the situation of rail freight transport in Poland, authors of this work decided to study regulations of other EU countries, concerning the access to the primary rail network. Good sources of information on this subject are websites of national infrastructure managers from countries of Western Europe. Such managers are, among others, Network Rail or DB Netze [Networkrail 2016b, DB Netze 2016]. For example, the British infrastructure manager has an original idea of reloading wood, containers and bulk materials directly on tracks between stations, on less used railway lines. This idea – for the needs of this work – has been called "a virtual freight facility".

According to the EU regulations, especially the Common Safety Method for Risk Evaluation and Assessment [30.04.2013], enabling railway tracks for reloading containers must be preceded by evaluation of risks associated with a change introduced in the railway system. National Safety Authorities and other railway organizations of individual Member States of the EU, among others of the UK, Czech Republic, Germany and Poland, have developed special guidebooks for the entities which propose introduction of such changes [TÜV Rheinland… 2013, Urząd Transportu Kolejowego 2015, Drážní úřad 2015, Office of Rail… 2015]. These guidebooks contain theoretical description of actions necessary for evaluation of risk. However, there are not many examples which would show how to perform this task in the frameworks of specific analyses domains. This also applies to scientific papers published in this topic [Białoń i Pawlik 2014, Chruzik 2014].

The aim of this work is to present the method of identification of hazards associated with introduction of changes in accordance with the Regulation [30.04.2013], on example of the analyses domain where a virtual freight facility has been established.

Chapter 2 discusses the functioning of virtual freight facilities in the UK and contains a proposed model of introducing this idea in Polish conditions. Next, chapter 3 presents the process of identification of hazards associated with functioning of the virtual freight facility. The authors' method of hazard identification was used. This method was developed especially for the purpose of identifying hazards associated with changes introduced to the railway system. Chapter 4 presents a summary and conclusions drawn from the analyses performed for the needs of this work.

2. THE CONCEPT OF VIRTUAL FREIGHT FACILITIES

2.1. The British solution

The national infrastructure manager in the UK, Network Rail, on its webpages [Networkrail 2016a], shares information for entities which would like to get access to the railway network. One of the presented possibilities is to use the existing railway lines for the purposes of handling cargo. This possibility, in this work referred to as "a virtual freight facility", is available only in the case of less operated railway lines, which can be used for this idea without introducing additional limitations in the railway timetable.

The plan to use the railway line for cargo handling is developed in collaboration with an advisor of the infrastructure manager and must contain the following elements:

- frequency of reloading,
- requirements of other railway companies, eg. maintenance of the railway line's technical efficiency,
- risk assessment and proposed risk reduction measures, in particular the estimation and evaluation of risk of rail track contamination by goods which would be handled,
- any additional procedures for opening and closing the line with an estimation of the cost of their implementation.

Not all goods can be reloaded on virtual freight facilities. Restrictions apply especially to those goods which may have a negative effect on the operation of railway traffic control devices. This method is particularly used for handling bulk materials, wood and containers.

2.2. Proposition of the Polish solution

The information materials of the British infrastructure manager do not contain many information important for the operation of virtual freight facilities and risks associated with it, eg.:

- does virtual freight facility have to be fenced or protected in any other way from actions of unauthorized individuals?
- can a virtual freight facility contain level crossings?

The answers to these and similar questions obviously affect the results of the identification of hazards.

For the needs of further studies in this work, an existing location has been chosen for a virtual freight facility. It will be considered the domain of analyses in the process of identification of hazards. It is a location in the north-eastern Great Poland, in the area of the former railway station in Kiszkowo, on the railway line 377 Gniezno Winiary – Sława Wielkopolska. This line is not used in passenger traffic, and the freight traffic consists mainly of trains to the oil depot in Rejowiec. On the side of a dismantled track No 3, there is a factory of Cargill Polska Sp. z o.o. The view on the chosen location is presented on the Fig. 1.

Fig. 1. The view on the sample location of a virtual freight facility – the area of former railway station in Kiszkowo, near to the railway line 377 (authors' work)

The proposed idea assumed that the fence between the factory area and the railway line is dismantled, and that the available place is used for container handling. Additionally, about two hundred metres from the location shown in the photo (Fig. 1), there is a level crossing, which is also included in the domain of analyses. A more detailed description of the domain of analyses with a virtual freight facility is presented in section 3.2.

In terms of organization of work in the domain of analyses with a virtual freight facility, it was assumed that the loading process is run by the two cooperating entities: the logistics operator and the user of virtual freight facility. The responsibilities of logistics operator are, among others:

− launching a train carrying containers for unloading and containing a sufficient number of empty wagons for loading new containers,

− giving the planned order of wagons in the train to the user of virtual freight facility, to prepare the reloading place,

− conducting shunting within the domain of analyses with virtual freight facility – stopping the train in places that enable free access from the reloading point to the appropriate wagons,

− supervision of the technical condition of wagons during and after reloading.

User of the virtual freight facility is responsible for operations in the reloading point, mainly for moving containers with the use of a container handler.

It should be noted that the intention of this paper is not to analyse all the possible business models within the framework of the – described earlier – analyses domain with a virtual freight facility, and the presented model is only one of several possible. Alternative solution models are, for example:

- focusing all responsibility for handling containers only in the hands of the logistics operator, who provides a container handler to the place of a virtual freight facility on a specially adapted wagon,
- allowing the use of virtual freight facility by several independent users, and so the transition towards a "virtual cargo hold" or a "cargo stop".

3. IDENTIFICATION OF HAZARDS ASSOCIATED WITH RUNNING A VIRTUAL FREIGHT FACILITY IN POLAND

3.1. Introductory notes

It is assumed that – before the introduction of the change within the selected domain of analyses – the risk of hazards generated during the operation of the rail system is managed properly within the framework of Safety Management Systems implemented at the Infrastructure Managers and Railway Undertakings. Based on this premise, it is assumed that there is no need to deal with hazards generated within a specific domain of analyses, because these risks are already being controlled.

Many domains of analyses can be areas of interest within the railway system. The change introduced into the rail system within the selected domain of analyses usually only to a certain extent affects the functioning of the domain and the rest of the rail system.

Determining/defining the domain of conducted analyses is an especially important procedure for the process of identification of hazards. If the domain of analyses is too extensively determined/defined, the process of identification does not involve formulation of hazards associated with the change in the railway system. Instead, it considers hazards connected with functioning of basic structural subsystems of the railway system. These hazards may be generated during operation of the railway infrastructure, management of the railway traffic, using level crossings by road users, etc. In this work, it was assumed that such hazards will not be considered in the assessment of risks resulting from the change introduced in the railway system within the selected domain of analyses.

The domain of analyses should not be determined/defined too narrowly, either. This is so because there is a possibility that the change introduced in the railway system does not generate additional hazards sources and, consequently, does not lead to emergence of new hazards, but it increases the risk of already formulated hazards. For example, losses due to derailment of wagon on a virtual freight facility (and therefore on the track), due to disruptions of railway traffic, are much greater than in the case of derailment of wagon on the real freight facility or station.

One of the possible solutions of the problem described herein, is the method of identification of hazards suggested by the authors of this work. It involves combining two different ways of identifying hazards in order to support the risk assessment process while analysing extensively determined/defined domain of analyses. This approach reduces the possibility of not recognizing new hazards sources in the selected domain of analyses and it enables recognition and rejection of hazard sources not influenced by the change introduced to the railway system.

The method of identification of hazards assumes the existence of two lists of hazard sources identified in the selected domain of analyses and associated with the change introduced to the railway system:

− hazard sources associated with interfaces between all elements of the analysed domain of analyses, eg. a break in communication between the train driver and the shunting supervisor, large pressures in point of contact of wheel and rail, long time of closure of level crossing,

− hazard sources associated with the activities that are substantial to the change. Such activities involve interfering with the elements of the analysed domain of analyses, eg. selecting wrong container, stopping in the wrong place, raising the container too low.

Hazard sources from both lists are identified separately, during the independent search in domain of analyses.

3.2. Identification of hazards associated with interfaces between the elements of domain of analyses with a virtual freight facility

The first stage of the method involves creating a list of selected domain of analyses' elements, which form the domain of analyses in the most complex phase of its functioning after the introduced change. A relatively simple way to develop such list is to provide a scheme which would show the domain of analyses after the change. Each element indicated on the scheme must be included in the list. The schematic diagram of the domain of analyses with a virtual freight facility is shown in Fig. 2. It shows the domain of analyses during the most complex phase of functioning, which is container handling.

Fourteen elements were marked in the domain of analyses with a virtual freight facility (Fig. 2). The train consisting of a diesel locomotive (e2) with wagons-platforms for the transport of containers (e3) moves on the straight section of railway track (e1). At the reloading point (e5), there are containers (e11) and a vehicle used to move them: container handler (e4). On the opposite side of the reloading point there is a station square (e6), which is available for outsiders (e13). Outsiders and car drivers (e14) are also on the road (e7), which leads to the level crossing. The virtual freight facility is operated by: train driver (e8), container handler operator (e9) and a railway company employee with permissions for working as a shunting supervisor and rolling stock examiner (e10). The domain of analyses described here is in contact with the environment (e12) – one of the environmental factors are the weather conditions.

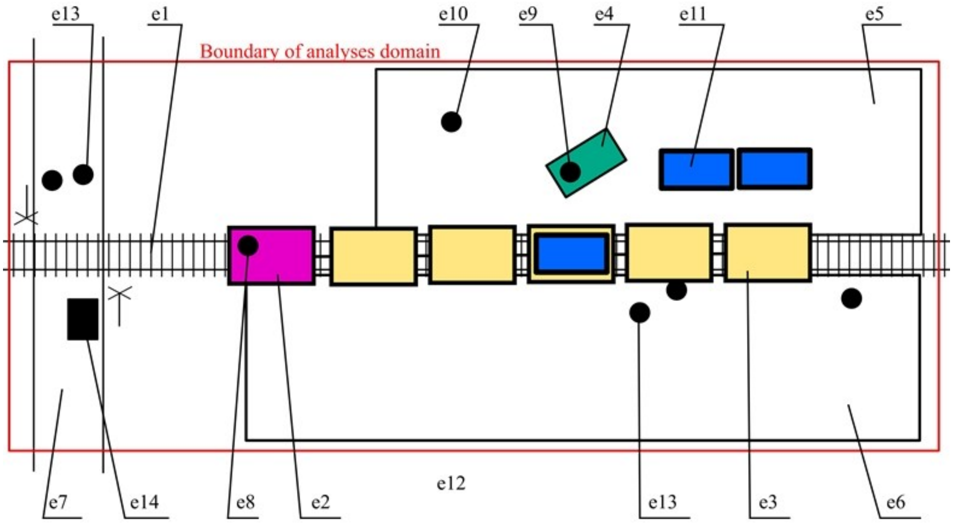

Fig. 2. The schematic diagram of the analyses domain with a virtual freight facility (authors' work)

The next step of applying the method involves creation of the matrix with number of columns and rows equal to the number of identified elements of domain of analyses with a virtual freight facility. Each field in the matrix indicates an interface between two elements, and the whole array includes all the potential, existing interfaces. Of course, many fields of the matrix do not represent all interfaces that may occur at any phase of functioning of the domain of analyses with a virtual freight facility. Examples of such interfaces are: reloading point (e5) – road (e7) or train driver (e8) – container (e3). These fields of the matrix are skipped in the further analysis. After conducting an analysis of the possibilities of occurrence of potential interfaces, the results have been presented in the Table 1.

The existing interfaces (Table 1) show hazard sources as creations (physical, psycho-physical, organisational and personal) appearing by their occurrence, status and properties. In the course of the analyses, researchers should check whether the identified hazard sources are associated with changes to the domain of analyses. According to the authors of this work, in the framework of multiple interfaces existing in the discussed domain of analyses, this domain is in no way modified by the introduction of changes to the railway system. Examples of such interfaces in this domain of analyses are, among others:

- railway track (e1) – reloading point (e5),
- locomotive (e4) – road vehicle (e14),
- station square (e2) – environment (e12),
- container (e11) – container (e11),
- environment (e12) – road vehicle (e14).

Hazard sources, which as a result of changes occur more frequently or generate higher exposure, should all undergo the procedure of grouping, and on the basis of its findings, hazards should be formulated.

Table 1. Illustration of results of analysing the interfaces in any phase of functioning of the domain of analyses with a virtual freight facility (+ sign means creating an interface by a corresponding pair of elements of domain of analyses) (authors' work)

Element	e1	e2	e3	e4	e5	e6	e7	e8	e9	e10	e11	e12	e13	e14
e1		+	+		+	+	+	+		+		+	+	+
e2			+				+	+						+
e3			+	+					+	+	+	+	+	
e4					+				+		+	+		
e5									+	+	+	+		
e6												+	+	
e7								+				+	+	+
e8									+	+		+	+	+
e9										+	+	+	+	
e10											+	+	+	
e11											+			
e12													+	+
e13														
e14														

3.3. Identification of hazards associated with the reloading process

The second stage of the method is based on the HAZOP (Hazard and Operability Study) method, described in the [IEC 61882] norm. This method uses guide words to stimulate the debate on possible deviations from the nominal parameters of the analysed processes or elements. The list of guide words is presented in Table 2.

For each activity in the framework of the process that is essential for the change introduced into the railway system, a discussion is carried out, based on the subsequent guide words summarized in Table 2. For this purpose, authors developed a list of activities needed to be performed in order to load the container onto the wagon:

1. Stop the train in an appropriate place, so that an empty wagon is near to the reloading point.
2. Choose a container you want to load.
3. Drive the container handler to the chosen container.
4. Grab the container.
5. Lift the container.
6. Drive the container handler to the wagon placed on the railway track.
7. Set the container position over the wagon.
8. Lower the container.
9. Confirm that the wagon is ready to be moved after loading of the container.
10. Give a permission for the train to ride.

Activities performed during the unloading of containers are very similar, and thus they do not need a separate description in this work.

Table 2. Basic guide words of the HAZOP method and their general meanings [IEC 61882]

Guide Word	Meaning
NO OR NOT	Complete negation of the design intent
MORE	Quantitative increase
LESS	Quantitative decrease
AS WELL AS	Qualitative modification/increase
PART OF	Qualitative modification/decrease
REVERSE	Logical opposite of the design intent
OTHER THAN / INSTEAD	Complete substitution

In the case where a guide word enables identification of a negative scenario, such scenario is written (mostly in form of table), together with its causes and consequences. In this way, scenarios which are not directly connected with the change introduced in the railway system, are also identified. It is different than in the first stage of the method of identification of hazards presented in this work, where interfaces not changed between elements of the domain of analyses are not considered.

Negative scenarios describe the condition of the domain of analyses after activation of hazards. On basis of these scenarios, hazards can be formulated and added to the hazard register which was created in the first stage of the described method. The number of hazards identified in the two stages of the method and the way they are formulated depends largely on the experience of people carrying out the procedures of identification of hazards. A clue is the aim of identifying hazards – the opportunity to assess risk and reduce it, primarily through the proceedings focused on the hazard sources.

4. SUMMARY AND CONCLUSIONS

The British idea to use railway tracks for reloading cargo can be applied in Poland as well, but – according to the EU law – it requires evaluation of risks associated with a change introduced in the railway system and introducing appropriate amendments to the regulation of general conditions of conducting the railway traffic.

The authors of this work proposed a model of identification of hazards which consists in separate analyses of interfaces between the elements of the domain of analyses and actions performed in framework of the domain, associated with the introduced change (functioning of a virtual freight facility within the domain of analyses). The model helped to identify 20 hazards. These hazards are related to the operation of virtual freight facilities, and their activation leads to the following eight consequences: serious injuries, damage to the train and/or a road vehicle, lack of possibility of reloading, provision of the wrong container, disturbance in the timetable of trains because of the additional closure time of the track, damage to the container handler, damage to the wagon and closure of the railway line due to the derailment of the wagon. Their detailed presentation is beyond the scope of this paper.

Further testing of the proposed model of identification of hazards is necessary in order to develop detailed guidelines for formulating hazards resulting from negative scenarios recognized with the use of guide words of the HAZOP method.

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METODA IDENTYFIKACJI ZAGROŻEŃ W ZASTOSOWANIU DO DOMENY ANALIZ Z WIRTUALNĄ BOCZNICĄ KOLEJOWĄ

Streszczenie

Udział przewozów kolejowych w transporcie towarów w Polsce od wielu lat spada. Sposobem na odwrócenie tego negatywnego trendu są popularne w krajach Europy Zachodniej przewozy intermodalne, pozwalające wykorzystać zalety kilku gałęzi transportu. Zauważalny jest jednak brak terminali pozwalających na przeładunek kontenerów – ich liczba przypadająca na powierzchnię terytorium Polski jest ponad cztery razy mniejsza niż w Niemczech. Jednym ze sposobów na szybkie zwiększenie dostępności terminali jest brytyjski pomysł na „wirtualne bocznice”, a więc możliwość przeładunku kontenerów bezpośrednio na torach szlakowych mniej uczęszczanych linii kolejowych. W celu wprowadzenia takiej usługi w Polsce niezbędne jest przeprowadzenie oceny ryzyka zagrożeń związanych ze zmianą w systemie kolejowym, zgodnie z wymogami rozporządzenia UE nr 402/2013 (tzw. CSM RA). Jednym z kluczowych składowych tej oceny jest poprawna identyfikacja zagrożeń. Specjalnie dla wymogów CSM RA opracowano metodę identyfikacji zagrożeń, pozwalającą na takie przeszukiwanie domeny analiz, aby skupić się na zagrożeniach generowanych przez wprowadzaną zmianę. W pracy przedstawiono założenia tej metody identyfikacji zagrożeń oraz wybrane wyniki jej zastosowania dla zmiany w systemie kolejowym polegającej na uruchomieniu wirtualnej bocznicy w przykładowej lokalizacji na linii kolejowej.

Słowa kluczowe: metoda identyfikacji zagrożeń, domena analiz, bocznica kolejowa, przewozy kontenerowe