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METHODS FOR DETERMINING THE RISK FACTORS FOR ROAD TRANSIT IN HUNGARY

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Abstract: Road transport is affected by number of hazards in Hungary also. Timely exploration of these risk factors can help to reduce the severity of unexpected consequences. In this article we present and evaluate some of the procedures that can help in this work. The solutions we have now chosen are the mathematical methods, the questionnaire survey and the modeling.

Keywords: Road transit; Risk factor; Hazard source; Traffic system; Mathematical methods; Questionnaire survey; Modeling.

1 INTRODUCTION

The global terrestrial system is very complex because it includes the living and inanimate (natural and built) environment as well as human society (see figure 1). A part of this global environment is the transport/traffic system, which also reacts to changes as a result of events (predictable or unexpected) due to other changes in the global system. The impacts that trigger changes are, in the vast majority of cases, external impacts and how a given system responds to these impacts (affecting the way the system works) is called the sensitivity of a system. The disruptive impacts on transport/traffic systems are basically divided into three major groups, such as:

a) intentional or harmful acts,
b) natural hazards (natural disasters),
c) human-triggered and technological hazards.

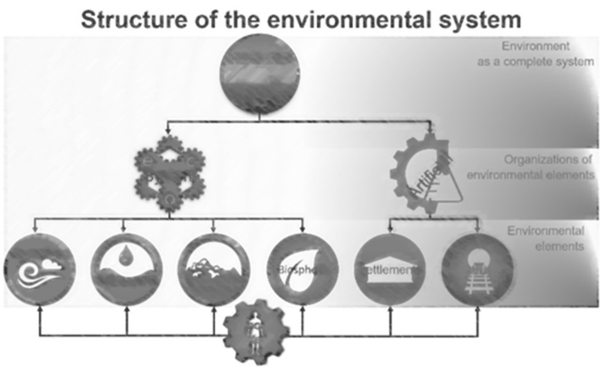

Fig. 1 Major groups of environmental systems
Source: edited by the authors, based on Kerényi. [1]

The factors influencing the sensitivity of transport/traffic (transit of goods) systems can be very diverse.

The territorial segregation of human activities has created a need for relocating and forwarding products, and this need is also the basis for traffic analysis and forecasting. Their analyses and forecasts also include the determination of the sensitivity of transport/traffic systems, the methods of reducing their damage, and the possibilities of increasing their resilience, one version of which is illustrated in this article.

The concept and content of safety/security are constantly changing today due to the development of civilization. Because of this change, we can now distinguish several dimensions of safety/security. [2]

All of the risk factors (such as disruptive or threatening factors) affect the safety of the economy, and thus indirectly the safety of traffic and transportation. In the following we examine, how we can predict the risk factors in order to prevent and reduce the effects of them.

2 CONDITIONS ENDANGERING ROAD TRANSIT (OF GOODS) IN HUNGARY, POSSIBLE METHODS FOR THEIR DETERMINATION

Proper assessment of environmental risks and disruptive impacts and the management of their impacts was performed using three methods, comparing the results obtained. The methods we have chosen and used are as follows:

- determination of the factors influencing the safety of road transit using mathematical methods,
- determination of influencing factors by means of a questionnaire survey,
- modelling.

a) Determination of factors in the road transit (of goods) system influencing its safety using mathematical methods

When examining the determination of the factors by mathematical methods, we started from the fact that we have to perform a risk assessment to prove their determinability. In the calculations, we must therefore accept that a certain risk can be assigned to each hazard, depending on the probability of the event occurring and the severity of the consequences of an

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event. A risk is a combination of the frequency or probability of the occurrence of a particular hazard event (F) and the severity of the consequence (C):

$$R = C \times F \tag{1}$$

In the case of a complex system consisting of independent elements (see transport/traffic system), the total risk can be defined as the sum of the risks associated with each independent hazard:

$$R = \sum ni = 1Ci \times Fi \tag{2}$$

In the calculations, we have to accept that we cannot always fully determine the risk of an emergency. Identified risk is a ratio that indicates whether the risk of our activity is acceptable to us, taking into account the indicators we have defined or set by standards. Of course, determining the degree of risk is not an end in itself, as it allows us to determine the degree of safety of a given activity (resilience, risk-free status - S).

$$S = 1/R \tag{3}$$

However, in order to identify the risks associated with road traffic, such as road transit, for a given event or process, we also need to distinguish between two basic concepts, such as risk and uncertainty. [3] According to Homolya, "*A precarious situation is a broader category. We speak of uncertainty when the outcome of future developments is unknown and we cannot say with certainty what the outcome will happen.*" [3;10] The uncertainty factor can be determined by the following formula:

$$(\%) = \frac{100 \cdot \mu_{\alpha} \cdot STDVE}{\overline{X}} \tag{4}$$

$\overline{X}$ is the expected value of a given parameter; STDEV is the standard deviation of a given parameter (standard error). [4] It can be seen that uncertainty can also be determined by a certain degree of standard deviation, which is calculated by the relation

$$P(-\mu_{1-\alpha} < X < \mu_{1-\alpha}) = \boldsymbol{\alpha}. \tag{5}$$

Since we have only been able to identify the uncertainties (and their standard deviations) in the calculations outlined so far, we have found that a simpler and thus faster procedure is needed to determine the risks in the road transit system. We started this work using the *"total probability theorem"*: *"In probability calculation total event system (TES) is the name of a maximally countable system of events (Ɓ1, Ɓ2, ...) for which the following are satisfied:*

$$P\Sigma B_{ii}) = 1 \tag{6}$$

$$P(B_i B_j) = 0\ (\forall_i\ to\ j\ i\int i \neq j \tag{7}$$

$$P(B_i) > 0\ (\forall\ to\ i) \tag{8}$$

That is, if Bi-positive-probability events essentially (i.e., apart from a zero-probability event) cover the entire event space, then any two events are substantially disjoint.

If A and B are two events and P(B)> 0, then we define the conditional probability of A for B by the formula P(A | B) = P(AB)P(B), which means that if we already know that event B has occurred, what the probability of event A is.

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If now A is an arbitrary event, Ɓ1, Ɓ2, ... is a TES, then the probability of A can be calculated in the following form:

$$P(A) = \Sigma P(A \setminus iBi)\ P(Bi)\text{."}\ [4;11] \tag{9}$$

In our study, we found that the total probability theorem is not suitable for determining the extent of road traffic risks because it is a concept that can be defined within zero-order logic, i.e., a logic formula describing a logical operation where the probability of an event is calculated based on another event. Therefore, in areas where risk management methods are used, the continuous form of the Bayes theorem, which can be described by the following formula, is preferred: [3;11]

$$f(y|x) = \frac{f(x|y) \cdot f_Y(y)}{\int_{-\infty}^{\infty} f(x|y) \cdot f_Y(y)\, dy} \tag{9}$$

In the study of the Bayes theorem[3;13-21], we found that it is not suitable for identifying the risks affecting the safety of road transit, as the possible scope of this method is to identify the infrastructural factors influencing an accident, mainly by road infrastructural methods and can be influenced by means, i.e., it gives a static technical approach.

József Gyarmati [5] examined the general and specially used concepts of risk and risk management. The aim of his study was to select procedures that may be suitable for determining the risk of critical infrastructure in a Hungarian environment. In his article, he states that *"The study analyzes in terms of critical infrastructure protection, which is fundamentally technical in nature. However, an examination of the other approaches reveals the possible limitations of the fundamentally technical approaches listed so far. The article therefore summarizes the other principles as well as the criticisms of the technical approach."* [5;79]

The above has shown that the risks affecting the safety of road transit and their responses, due to the complexity of their numbers and impacts, cannot be determined by mathematical methods alone. These calculations can only be used to measure the probability of occurrence of the risks posed by each hazard, regardless of their occurrence in real time. Therefore, we have to search a more objective, easier-to-use method should be developed for app the basis of this method is the adaptation of the convolution of the frequency distribution and the severity distribution, as well as the application of the operational risk management, such as "decision tree". [3;11-13]

b) Processing the relevant parts of a questionnaire survey1, drawing conclusions in order to identify the factors influencing the safety of domestic road transport

The aim of the questionnaire survey was to assess the willingness of the target group (mainly carriers, those working in the transport sector) to respond, in addition to learning about some issues related to road safety. The questionnaire survey provided the following results.[2]

The vast majority of respondents (42 %) consider Hungarian public roads to be moderately safe, while the proportion of those who consider road safety to be poor or very poor is close to the same (40 %). 17 % of the respondents consider the situation to be good, while only 1 % of the respondents gave a very good rating.

It was positive in the survey that the respondents placed the safety of Hungarian road transport in the middle compared to European (not only EU) countries. The result is very significant, as the average rating is 44 %, while the remaining 56 % is divided almost equally between worse and better reviews.

The vast majority of respondents consider the condition of Hungarian roads to be unacceptable (very bad 28 %, bad 39 %, medium 28 %), so, it is clear (without any further survey) that our roads need to be reconstructed (not pitted), repaired and our road network (including European corridors) need to be developed.

Regarding the driving safety of Hungarian drivers[3], it can be stated that ¾ (77 %) of the respondents do not consider Hungarian drivers to be more dangerous than foreigners and only 23 % feel that we Hungarians drive dangerously.

Regarding the question on the training and further training of drivers working in goods transport, 81% of the respondents consider the training of professional drivers to be important or very important, and 17 % moderately important, the relevance of which is unquestionable.

The next question examined the overall relationship between transport safety and environmental safety (occupational safety). The answers clearly prove (92 %) that the external influences on drivers affect more or less (rather more) the safety of driving, such as traffic safety and the safety of goods transit. Accepting[4] the survey data requires the following steps[5]:

- identify, through further assessment, which confounding factors in this area (personnel, organizational, infrastructural, their combination) have the most negative impacts on drivers,
- develop an action plan after assessing and prioritizing confounding factors,
- in parallel with the international acceptance of the plan, its implementation in Hungary,
- processing, publishing and fine-tuning the results of the implementation,
- promoting international acceptance by disseminating experience.

The provisions of the EU's mobility package clearly increase the costs for law-abiding carriers, so, that its requirements (without proper control) will give third-country companies a competitive advantage and may adversely affect the operation of intra-EU carriers. The vast majority of respondents (80 %) consider that the unauthorized activity of foreign carriers (belonging to the black or gray zone) is not only an economic problem, but also a road safety problem. [6] Based on the answers to the question, the action to be taken is not in question: more efficient control (technical, organizational), strict sanctions.

By processing the relevant parts of the questionnaire survey and summarizing the findings, we concluded that it ensures data that provide results not suitable for real-time identification of hazards, but this method should be used to refine the results provided by other methods[6].

1 Based on a questionnaire survey carried out by Péter Boda.

2 The detailed evaluation of the questionnaire and the detailed presentation of the conclusions drawn from it are the subject of a future study.

3 During the processing of the questionnaire, we were confronted with the fact that this question was incorrectly worded, as it should have applied to professional drivers working in the transportation of goods. Due to the incorrect wording of the question, no conclusions have been drawn in this regard, the data are only informative.

4 The relevance of the data is ensured by the fact that 60 % of the respondents (14 % are drivers out of 100) work in some position in the field of road goods transport.

5 Without details.

6 In this article not all issues and otcomes are presented that related our topic.

c) *Identification of factors influencing the safety of road transport of goods in Hungary, drawing conclusions by modeling*

In order to make it easier for us to understand the world around us or to get information about its possible changes, in many cases we make a model of things . These models allow us to understand what is happening (has happened or will happen) and why it is happening.

The evaluation of the result of modeling is done by some comparison, which is based on the principle that one model does not exist. A model can always only be interpreted together with an event modeled by it and must satisfy the conditions of similarity between the two. This means that the evaluation is performed in a relation of at least two objects.

Taking into account the previous findings - in one version - we prepared a model for the identification of the factors influencing the safety of road transport in Hungary and for drawing conclusions.

The following options, methods and procedures were considered and selected during the development.

The function of a model is descriptive:

- its structure is analogous,
- its system of criteria is formal,
- its nature is qualitative, including mental,
- it is static based on the examined processes,
- its elaboration is manual,
- its type is: Forrester-Meadows model. [8]

In developing the model, we examine the interaction of six sectors (sub-processes). They are:

- traffic routes,
- traffic technology,
- traffic environment,
- traffic management,
- others (legal environment, resource allocation, emergency response, quality of service, transport IT, sustainability,
- vehicles.

Relationships of each sub-process within the six sectors:

- intentional or harmful acts,
- natural hazards,
- human-triggered and technological hazards.

Since we did not have a computer program to perform the comparison, we performed the modeling manually. Therefore, as opposed to the original Forrester-Meadows model, we did not get run-down curves, but a relationship diagram showing possible responses to an event (confounding factor).

In addition to the theoretical modeling - in another experiment - we also modeled a given (recorded) situation, which was implemented using the *"Graph Model"*. [8] (The presentation of the experiment will be the subject of another study, but the results were used to draw the conclusions of this article.)

During the examination of the identification of the factors influencing the safety of road goods transport in Hungary by modeling, we came to the conclusion that before making transport safety decisions - similarly to the previous two test methods - the possibilities of modeling should be used in order to achieve the most effective results.

3 USE OF RESOURCE AVAILABLE FOR PROTECTION

The resources available for protection are also scarce in relation to the physical extent of the critical infrastructure systems, so, their use needs to be optimized. This is also true for road transit, where increasing the efficiency of the factors assigned to the task of strengthening transport safety also plays a role in increasing it. One way to do this is to apply network theory, which is of great importance in system organization. Among the theses of this interdiscipline is that the stability of networks depends on so-called robustness. The more complex a system is, the more interchangeable elements it contains, that is, the more robust it is, the less vulnerable it is to adapt network theory procedures when sharing security elements. The highlighted nodes that carry the properties of the graphs (see Figure 2) determine the stability of the system. Their failure (to a certain extent) leads to the collapse of the given system (system component). In this way, the level of protection can be enhanced with increased resources by increasing the security/safety of said central components. That is, when applying risk management techniques, protection resources should be focused primarily on the segments that are most at risk. Based on the above, it can be stated that the criticality of a particular infrastructure, and thus the magnitude of the damage caused by hazards, can be reduced by organizing it into a complex network or raising its dependence on resources from a local, regional level to a global level.

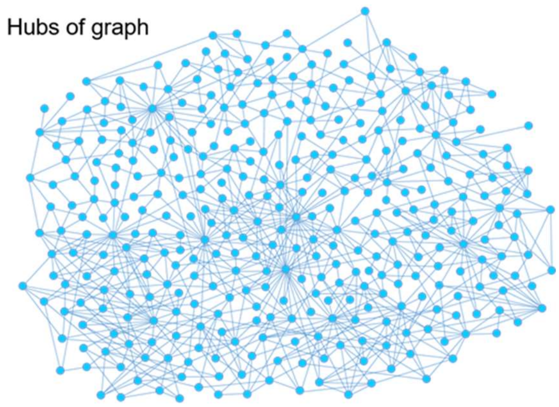

Fig. 2 Large graph with hubs
Source: https://images2.pianshen.com [9].

We can conclude that higher dimensional factors, such as global systems, represent a qualitatively higher level due to their own internal resources and thus allow access to more resources than those available to users of local capacities.

Based on the above, we can record as the most important tasks of the protection of critical infrastructure, including road transit:

- assessing according to the central requirements and principles (identification of hazards and disturbances) and continuous maintenance of its results,
- planning and monitoring based on uniform criteria,
- preparing the relevant bodies and freight carriers for contingencies, incident management and participation,
- maintaining on-call and monitoring systems, provision of mutual information,
- organizing and maintaining on-call units that can be deployed immediately, providing them with equipment,
- increasing system security/safety (duplication of connection, possibly duplication, etc.).

4 CONCLUSION

The three methods examined in this article are not comparable according to the axioms of the research methodology, as the questionnaire surveys belong to the category of qualitative research, the mathematical methods belong to quantitative research (while modeling, depending on its type) and are used for different purposes to provide results. Nevertheless, in our opinion, the methods are comparable, and the point of connection (apart from the research methodology) is usability.

In terms of usability, the following conclusions can be drawn for the methods studied:

- none of the three examined methods is suitable for real-time forecasting of intentional or harmful acts (hereinafter A), natural hazards (hereinafter B) and human-triggered, technological hazards (hereinafter C),
- the mathematical methods for the three groups (A, B, C) can only be partially used for vehicles (e.g., applicability) and for the so-called forecasts for "others" (legal environment, resource allocation, quality of service, transport IT, etc.),
- questionnaire surveys cannot be used for vehicle forecasts either (for either group), as they require special knowledge and expertise;
- none of the methods can be used to identify all hazard sources (A to C, or even a group of hazards, e.g., 'A') in real time,
- although the questionnaire survey is basically suitable for a combined examination of the emerging hazard sources, it only works for the long-term forecasts and the decision-making process.

In overall, based on our research in our present study, we concluded that a distinction should be made between the definition of hazards and risks in order to adequately define the influencing factors. During the study of the calculation (forecast) of hazards and risks, we have demonstrated that each hazard can be assigned a certain risk, which depends on the probability of the occurrence of the event and the severity of its consequences.

By examining the mathematical method of determining the risk factors influencing the safety of road transit (goods transport), we proved that the risks affecting the safety of road transit and the answers to them cannot be determined only by mathematical methods.

By conducting a questionnaire survey, we proved that the Hungarian society is interested in the issues concerning traffic safety and forms an opinion on them. Based on this, we have established that questionnaire surveys are important in assessing the possibilities of improving and enhancing the situation of traffic safety, but they are not suitable for determining specific, real-time hazard sources.

During the examination of the identification of the factors influencing the safety of road transport in Hungary by modeling, we concluded that modeling is of paramount importance in assessing the situation and improving the possibilities of traffic safety. We also proved that the advantage over mathematical and questionnaire methods is that, if applied correctly, it also shows the possible answers to an occurring event (confounding factor).

In overall, we have concluded that the examined methods should be used together (in combination) before making a given decision on traffic safety. We also found that the investigated methods only have a limited ability to identify the hazard sources (not at all in real time), so, it is expedient to use them in order to determine the possible responses (especially prevention).

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