

INTERDISCIPLINARY MODEL OF OPERATIONAL RISK MANAGEMENT FOR THE URBAN TRANSPORTATION SYSTEM - RESEARCH BASIS

SKUPIEŃ Emilia¹, TUBIS Agnieszka²

Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Wroclaw, Poland, EU
emilia.skupien@pwr.edu.pl, agnieszka.tubis@pwr.edu.pl

Abstract

On the study basis the authors found the presence of a gap in the research area of a risk management of urban transportation systems. There is relatively small amount of publications on risk analysis for the urban transportation systems. At the same time, the results already described concern the issues associated with the safety of infrastructure and the accidents. In the published results of researches conducted in Poland and around the world there is a lack of an interdisciplinary approach to risk management in urban transportation systems, in accordance with the holistic approach of ISO 31000. Therefore, it seems important to carry out interdisciplinary research related to the identification of risk factors present in the systems of urban transportation, including technical, economic and social aspects. Special importance has also the assessment of sensitivity of transport processes on the occurrence of defined risk factors and their impact on quality of inhabitants life. The main aim of the article is to present the assumptions currently initiated by the authors for the creation of an interdisciplinary model of operational risk management system for the urban transportation system including buses and trams, which improves the reliability and life quality of inhabitants.

Keywords: Risk assessment, urban transport system, holistic view

1. INTRODUCTION

The quality of public transport services depends on their efficiency of normal operations as well as their performance in case of minor disturbances and major disruptions. The causes of these disturbances can have very different sources: social, economic and technical. Public transport planning and operations are traditionally focused on travel time and costs, while overlooking aspects such as reliability and robustness. However, there is substantial evidence on the impact of unreliable service and service disruptions on passengers' perceptions and costs of these impacts (e.g. [1, 2]). The impact of disruptions may extend beyond direct time losses due to their disproportional effect on travellers' decisions [3].

There is relatively small amount of publications on risk analysis for the urban transportation systems. At the same time, the results already described concern the issues associated with safety of infrastructure and accidents. In the published results of researches conducted in Poland and around the world there is a lack of an interdisciplinary approach to risk management in urban transportation systems, in accordance with the holistic approach of ISO 31000. Therefore, it seems important to carry out interdisciplinary research related to the identification of risk factors present in the systems of urban transportation, including technical, economic and social aspects. Special importance has also the assessment of sensitivity of transport processes on the occurrence of defined risk factors and their impact on quality of inhabitants life. The main aim of the article is to present the assumptions currently initiated by the authors of the research project for the creation of an interdisciplinary model of operational risk management for the urban transportation system including buses and trams, which improves the reliability and life quality of inhabitants. For this reason, in the first place the authors will present an overview of the literature concerning risk management, with particular emphasis on the transportation risk. The next section will discuss the main directions of research conducted in the area of risk management in urban transport. On this basis, authors will define a research gap, which the authors want to

fill with the currently initiated research project. The concept of these studies will be presented in section 4 of the article.

2. RISK MANAGEMENT - REVIEW

In the literature one can find different definitions of risk, depending on the specialty, for which it is specified. A common definition is a statement that risk is the probability of harm or damage occurring from exposure to a hazard, and the likely consequences of that harm or damage [4]. In the social sciences, the risk may be defined as a situation or an event where something of human value (including humans themselves) is at stake and where the outcome is uncertain [5]. Partnerships Victoria [6] claims that risk "is the chance of an event occurring which would cause actual project circumstances to differ from those assumed when forecasting project benefit and costs". The Project Management Institute [7] defines risk as 'an uncertain event that, if it occurs, has an undesirable effect on at least one project objective (e.g., time, cost, scope, quality).

Also, the risk in the area of transport itself is defined in different ways [8]. The first use of the word 'risk' is the probability of an unwanted event; as such, it is a pure number between 0 and 1. A slight variant of this is the probability per time unit, or frequency, of a class of events. The second use of the word is to mean some combination of the probability or frequency of an unwanted event and its outcome. The most common usage is to define risk as the expected or average consequence per time unit of a class of events, such as the mean number of fatalities per year. In that case, the units in which risk is measured implicitly include the units of the outcome, such as fatalities per year.

In the last few years one have seen significant growth and evolution of the concept of risk management. In the 70s of the twentieth century, the obligations of the person responsible for risk management in the enterprise was limited to hazard identification and purchase appropriate insurance [9, 10]. Today it is a complex management process, described as the concept of *Enterprise Risk Management*, whose aim is the holistic management of all risk groups in the enterprise [11]. This concept also has its own ISO standard (*ISO 31000 Risk Management Standard*). Thanks to several years in the study of risk prevailing view about the need for a holistic, interdisciplinary approach to the risk assessment and management [12]. This change has also resulted in the industry - it is particularly important to the idea of Operational Risk Management [13]. The *Operational Risk Management* - ORM helps organization avoid unexpected losses, improve their operational efficiency, promote more efficient use of capital, satisfy stakeholders and to comply with regulations [14]. Therefore the authors in their research will use the definition in line with the ISO 31000 standard [15]. According to it the aim of risk management is usually to assess the risk in terms of the likelihood that particular consequences (negative or positive) will be experienced flowing a defined event, taking into account the possible initiating sources and causes of harm (or benefit). That information provides a qualitative, and often quantitative, basis to develop controls to eliminate, reduce, or modify the risk in a continuous process of review and mitigation.

The risk is a subject of research in all transport systems (e.g. [16, 17, 18, 19]). However it should be noted, that the concepts of risk management methods in transport by rail, air and water are more developed than in road transport [20]. At the same time, analysis of the publications in the EBSCO database from years 2006 to 2016, concerning risk management in transport, allows to distinguish 5 dominant thematic groups, which relate to ongoing research in this area: (1) the risk of accidents in transport (including [21, 22, 23]); (2) the risk of transport of dangerous goods (e.g. [24, 25, 26]); (3) the risk of terrorist threats in transport (number of publications connected with it increased after the year 2001, (e.g. [27, 28])); (4) the risk of road infrastructure (e.g. [29, 30]); (5) the risk of delayed transport (e.g. [31, 32]). These studies were focused on a selected group of threats (typically: technical) occurring in the transport system. Thus it can be concluded that they did not meet guidelines standards of ISO31000. Because, according to the standard, the risk management should be holistic and should take into account not only technical factors, but also human and cultural [15]. The analyzed publications definitely lacked such a holistic approach. It can be concluded that in the current published

research in the area of risk management in transport research vulnerability exists a lack in the form of interdisciplinary risk management models which would be compatible with the concept of Enterprise Risk Management.

3. RISK MANAGEMENT IN URBAN TRANSPORTATION SYSTEM

There is a growing interest in recent years in the analysis of public transport vulnerability and measures to improve its robustness. While network unreliability refers to variations due to inherent uncertainty and recurrent perturbations, network vulnerability refers to exceptional disruptions with severe impacts on system performance [33]. This topic already attracted a lot of attention in road traffic research (e.g. [34, 35]) and in the last decade also entered the public transport research domain [36, 37]. Vulnerability is however limited to the consequences of disruptions on network functionality once they occur. Its antonym, robustness is defined as the capability of a system to absorb shocks and withstand disruptions [35, 38]. Network resilience requires robustness as well as a rapid recovery back to normal operations and performance [39]. Finally, risk integrates the extent to which the system is exposed to various disruptions (i.e. failure probabilities) and their respective impacts.

Among the research conducted in Poland in the area of risk management in transport systems, noteworthy is a project ZEUS, and subsequent projects strictly on urban transportation. The project ZEUS developed general principles of integrated risk management, which has been given the name of the TRANS-RISK [20]. Under the Integrated System of Transport Safety it has not been taken any specific actions related to risk management of hazards in urban transport. However, in the context inference conducted it indicated the need for individual transport modes specific procedures, models and risk measures for use in the context of the general principles of integrated risk management in transport. Continuation of the work initiated by the project ZEUS become a concept TRAM-RISK described, *inter alia* [40]. This method is dedicated to trams risk management. During the work on the development of the method, the authors took on to build a specific model, procedures and risk measures corresponding to the requirements of the tram. The authors in their first publications [40] pointed out that their study will combine the issue of the reliability of tram with the problems of management of its security. However, later publications [41] closely targeted are already on the implementation of this method in the field of security management, and presented the results of studies focused primarily on the risk of an accident. Omitted in these studies issues related to the reliability of transport, which covers three areas [42]: (a) reliability of any connection (terminal reliability) - meaning the probability that all passengers reach their destination; (b) reliability of travel time (travel time reliability) - probability of reaching the destination within a given period of time; (c) reliability of execution of transport network passengers' demand (capacity reliability) - in relation to its capacity.

According to the authors of this article it is therefore necessary to initiate further research devoted to the concept of risk management in urban transport, which will be focused on both security issues and the problems of service reliability. It is reasonable to also extend these research and in addition to the tram, the bus system should be examined. Especially since this is the mode of transport most frequently used in public transport systems in Poland.

4. CONCEPTION OF RISK MANAGEMENT DEDICATED FOR URBAN TRANSPORT COMPANIES

Based on the analysis of literature and current achievements of Polish researchers, the authors of this articles found that it is essential to carry out interdisciplinary research related to the identification of risk factors present in the urban transport systems. These studies should take into account not only the technical aspects of the analyzed system, but also elements of economic and social conditions. The main objective of this study should be a widening of the current state of knowledge regarding risks associated with the organization of public passenger transport in large urban areas and the development of theoretical, interdisciplinary model of

operational risk management for the public transport including bus and tram, improving reliability and safety of transport, and quality of life.

The starting point of the analyzes should be process approach for the studied phenomena. This is due to the fact that, according to The Risk Management Association process, as risk category, has the largest share of operational risk (65%). Process approach also takes into account the fact that the transport services are carried out in a complex system which is characterized by behavioral, social, economic and technical factors. Perspective process will therefore identify the source of the risks associated with any resource of transport service process on the input. The scope of the proposed resources to be considered in the analysis is shown in **Figure 1**.

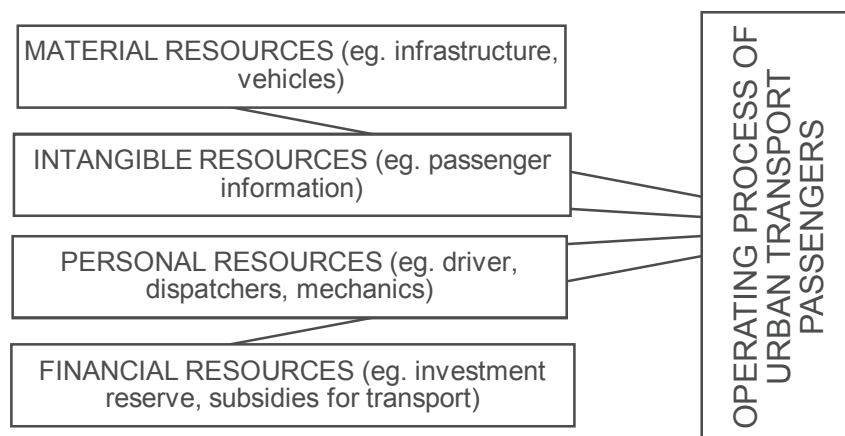


Figure 1 The input resources in the service process of urban transport which are sources of potential risk

Process approach at the urban transport system will also reduce the phenomenon, which has been formulated in the form of one of its hypotheses. On the basis of observations and interviews, the authors found that often the risk management systems of urban transport is individually performed by different groups of stakeholders, in a limited way and does not take into account the existing relationship, which should be included in an integrated strategy to reduce the risk in urban transportation. The organization and implementation of transport involved several entities (organizations) - the organizer of public transport, infrastructure manager and the carrier. The lack of a coherent risk management strategy, common to all of these entities, limits the effectiveness of prevention activities. To verify this hypothesis, the authors provide as part of research to analyze the current risk management procedures applicable to the organizer of public transport, the owner of infrastructure and enterprises of urban passenger transport. It will be evaluated by the degree of formalization, mutual consistency and the scope of monitored groups of threats. These procedures should also be checked for their compliance with the standards defined by ISO 31000.

To the research, it was selected 5 largest agglomeration in Poland with communication of bus and tram: Warszawa, Wrocław, Poznań, Gdańsk, Kraków. This enables diagnosis of multifactorial risk inherent in the system of public transport in large cities. Identification of risk factors belonging to three main groups highlighted in studies (technical, economic and social) will provide a basis for assessing the sensitivity of the test of transport system and impact analysis on the transport processes. It will also examine the impact of the identified risk groups on the quality of life of residents surveyed agglomeration, comfort and communication behavior of people traveling.

The result of the proceedings of the research will be the concept of an integrated, interdisciplinary model of operational risk management systems in urban transport, in line with the standard ISO31000. The model of risk management should take into account the role and the specificity of functioning of public transport in large

cities. It will be focused primarily on the risk factors affecting the reliability and safety of the implementation of passenger transport, but also the source of the danger that determine quality of life will be identified.

5. SUMMARY AND CONCLUSIONS

Research carried out by the authors so far indicate the presence of vulnerabilities research in the area of risk management systems of the urban transport. Research reported in the literature relate primarily to the risks associated with damage of the infrastructure and the occurrence of accidents. There is no publication taking into account a broad analytical look, focused on interdisciplinary risk assessment. For this reason, there was an initiative to launch a study on the risk of urban transport taking into account the standards of ISO 31000.

The article guidelines provide an introduction to the study initiated by the authors. The need for such research arose on the basis of an annual internship realized in the public transport carrier in Wroclaw and detailed analysis of the projects implemented so far by the Polish scientists. It seems that the development of these will be important for management science, sciences of security and transport. The results will increase the current state of knowledge concerning the management of operational risk in the system of public transport in large cities.

REFERENCES

- [1] RIETVELD P., BRUINSMA F.R., VAN VUUREN D.J. Coping with unreliability in public transport chains: a case study for Netherlands. *Transport. Res. Part A* 35, 2001, pp.539-559.
- [2] VAN OORT N. Incorporating service reliability in public transport design and performance requirements: international survey results and recommendations. *Res. Transport. Econ.* 48, 2014, pp.92-100.
- [3] COX A., PRAGER F., ROSE A. Transportation security and the role of resilience: a foundation for operational metrics. *Transport Policy* 18, 2011, pp.307-317
- [4] BATARLIENE N. Risk analysis and assessment for transportation of dangerous freight, *Transport*, Vol. 23, No.2, 2008, pp.98-103
- [5] ROSA E.A. The logical structure of the social amplification of risk framework (SARF): Metatheoretical foundations and policy implications [in:] *The Social Amplification of Risk* N. Pidgeon, R.E. Kasperson, P. Slovic (ed.), Cambridge, 2003
- [6] PARTNERSHIPS VICTORIA Risk Allocation and Contractual Issues. A Guide. Department of Treasury and Finance of the State of Victoria, Melbourne, 2001
- [7] PMI A guide to the project management body of knowledge PMBOK. Third Edition Project Management Institute Inc Newtown Square Pennsylvania, 2004
- [8] EVANS A.W. Risk assessment by transport organizations, *Transport Reviews*, Vol.17, No.2, 1997, pp.145-163
- [9] CLOSE D.B., BIDEK C. T. The development of risk management: four theories; *The Journal of Insurance Issues and Practices*, 1 (3), 1977, pp.37-45
- [10] CLOSE D.B. An Organization Behavior Approach to Risk Management; *The Journal of Risk and Insurance*, 41(3), 1974, pp.435-450
- [11] BHARATHY G.K., MCSHANE M.K. Applying a Systems Model to Enterprise Risk Management, *Engineering Management Journal*, 26 (4), 2014, pp.38-46
- [12] JUST R.E. Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. *Agricultural Systems*, 75, 2003, pp.123-159
- [13] KALLENBERG K. Operational risk management in Swedish industry: Emergence of a new risk paradigm, *Risk Management* 11 (2), 2009, pp.90-110
- [14] KING J.L. *Operational Risk: Measurement and Modelling*. Chichester: John Wiley & Sons Ltd., 2001
- [15] Polska Norma PN-ISO 31000: Zarządzanie ryzykiem . Zasady i wytyczne. Polski Komitet Normalizacyjny, 2012
- [16] KIERZKOWSKI A., KISIEL T. Simulation model of security control system functioning: A case study of the Wroclaw Airport terminal. *Journal of Air Transport Management*, 2016, <http://dx.doi.org/10.1016/j.jairtraman.2016.09.008>
- [17] ZAJAC M., SWIEBODA J. Initial FMEA analysis of the container transport chain. Source of the Document Safety and Reliability: Methodology and Applications - Proceedings of the European Safety and Reliability Conference, ESREL 2014

- [18] NOWAKOWSKI T., WERBINSKA-WOJCIECHOWSKA S. Data gathering problem in decision support system for means of transport maintenance processes performance development. Safety, reliability and risk analysis: beyond the horizon, Steenberg, RDJM; VanGelder, PHAJM; Miraglia, S; et al. (eds.), Proc. of 22nd Annual Conference on European Safety and Reliability (ESREL), 2013, pp. 899-907.
- [19] RESTEL F.J. Impact of infrastructure type on reliability of railway transportation system. Journal of Konbin 25 (1), 2013, pp. 21-36
- [20] JAMROZ K., KADZIŃSKI A., CHRUZIK K., SZYMANEK A., GUCMA L., SKORUPSKI J. TRANS-RISK - an integrated method for risk management in transport, Journal of KONBiN, Vol. 13. No.1, 2010, pp. 209-220
- [21] JAMROZ K. Highway Engineering Risk Assessment. Archives of Transport, 19 (1-2), 2007, pp.67 - 74
- [22] STEPHAN K. , KELLY M., MCCLURE R. , SEUBSMAN S. , YIENGPRUGSAWAN V., BAIN Ch., SLEIGH A., THE THAI COHORT STUDY TEAM Distribution of transport injury and related risk behaviours in a large national cohort of Thai adults; Accident Analysis and Prevention 43,2011, pp.1062-1067
- [23] SZYMANEK A. Risk acceptance principles in transport; Journal of KONBiN, No 2(5), 2008, pp.271-281
- [24] BUBBICO R., DI CAVE S., MAZZAROTTA B. Preliminary risk analysis for LNG tankers approaching a maritime terminal; Journal of Loss Prevention in the Process Industries 22, 2009, pp.634-638
- [25] GLICKMAN T.S., ERKUT E., ZSCHOCKE M.S. The cost and risk impacts of rerouting railroad shipments of hazardous materials; Accident Analysis and Prevention 39, 2007, pp. 1015-1025
- [26] VAN RAEMDONCK K., MACHARIS C., MAIRESSE O. Risk analysis system for the transport of hazardous materials; Journal of Safety Research 45, 2013, pp. 55-63
- [27] ABKOWITZ M.D. Transportation risk management: a new paradigm; Submitted for consideration for presentation at the Annual Meeting of the Transportation Research Board and for publication in Transportation Research Record, 2002
- [28] MILAZZO M.F., ANCIONE G., LISI R., VIANELLO Ch., MASCHIO G. Risk management of terrorist attacks in the transport of hazardous materials using dynamic geoevents; Journal of Loss Prevention in the Process Industries 22; 2009, pp.625-633
- [29] SALLING K.B. A New Approach to Feasibility Risk Assessment within Transport Infrastructure Appraisal; Procedia - Social and Behavioral Sciences 74, 2013, pp.468 - 477
- [30] SU D., GUO Z., LI Z., ZHOU Y. Operation risk model and monitoring-warning system of expressway tunnels; Transportation Research Procedia 14, 2016, pp.1315 - 1324
- [31] AVINERI E., PRASHKER J. N. The impact of travel time information on travelers' learning under uncertainty. Transportation 33, 2006, pp.393-408
- [32] DE LAPPARENT M. Attitude towards risk of time loss in travel activity and air route choices. Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, 14, 2010, pp.166-178
- [33] CATS O., YAP M., van OORT N. Exposing the role of exposure: Public transport network risk analysis, Transportation Research Part A 88, 2016, pp. 1-14
- [34] JENELIUS E., PETERSEN T., MATSSON L.-G. Importance and exposure in road network vulnerability analysis. Transport. Res. Part A 40 (7), 2006, pp.537-560.
- [35] SNELDER M., VAN ZUYLEN H.J., IMMERS L.H. A framework for robustness analysis of road networks for short term variations in supply. Transport. Res. Part A 46 (5), 2012, pp.828-84
- [36] JENELIUS E., CATS O. The value of new public transport links for network robustness and redundancy. Transportmetrica A 11 (9), 2015, pp.819-835.
- [37] DERRIBLE S., KENNEDY C. The complexity and robustness of metro networks. Physica A 389 (17),2010, pp.3678-3691
- [38] REGGIANI A., NIJKAMP P., LANZI D. Transport resilience and vulnerability: the role of connectivity. Transport. Res. Part A 81, 2015, pp. 4-15
- [39] BARKER K., RAMIREZ-MARQUEZ J.E., ROCCO C.M. Resilience-based network component importance measures. Reliab. Eng. Syst. Saf. 117, 2013, pp.89-97
- [40] KADZIŃSKI A., GILL A. Konceptcja implementacji metody TRANS-RISK do zarządzania ryzykiem w komunikacji tramwajowej. Logistyka 3, 2011, p. 1053-1064
- [41] KADZIŃSKI A., WARGUŁA J., GILL A. Szacowanie i wartościowanie ryzyka zagrożeń związanych z odcinkiem szybkiego tramwaju na poznańskiej sieci tramwajowej. Logistyka 3, 2012, pp. 939-948
- [42] BERDICA K. An introduction to road vulnerability: what has been done, is done and should be done. Transport Policy, Vol. 9, 2012, pp. 117-127