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MULTIMODAL TRANSPORT RISK ASSESSMENT WITH RISK MAPPING

Abstract. The article analyzes foundations associated with risk management. The research part is based on a potential risks identification analysis, impact and probability of occurrence and significance assessment for the company performing multimodal transportation services of intermodal transport units (ITU). For this purpose a risk map analysis method was used. Identification of the twenty-four most significant threats led to the identification of the most important elements of the process of ITU carriage, which proper handling allows to minimize possible losses.

Keywords: risk analysis, multimodal transport, intermodal transport unit (ITU), risk map analysis, risk assessment

ZARZĄDZANIE RYZYKIEM W TRANSPORCIE INTERMODALNYM NA PODSTAWIE MAPOWANIA RYZYKA

Streszczenie. W artykule przeanalizowano zagadnienia związane z podstawami zarządzania ryzykiem. Część badawczą oparto na analizie identyfikacji potencjalnego ryzyka, oceny skutków i prawdopodobieństwa wystąpienia oraz oceny istotności dla przedsiębiorstwa realizującego usługi transportu zintegrowanych jednostek ładunkowych (ZJŁ) w przewozach międzygałęziowych. W tym celu posłużono się metodą mapy ryzyka. Wyodrębnienie dwudziestu czterech najbardziej istotnych zagrożeń pozwoliło na identyfikację najważniejszych elementów procesu przewozu ZJŁ, których prawidłowe wykonanie pozwala na minimalizację możliwych strat.

Słowa kluczowe: zarządzanie ryzykiem, transport intermodalny, zintegrowana jednostka ładunkowa (ZJŁ), metoda mapy ryzyka, ocena ryzyka

1. Introduction

Exploring the question of the role that meet the transport services, its scope, frequency range, it becomes necessary to analyze the risk associated with the service process. Risks associated with running any business, especially of companies operating in the transport sector makes management extremely important. Furthermore, in case of multimodal transport, efficient coordination between different modes of transport plays an important role in storage and transport chain.

At the same time quick decision-making has a huge impact on businesses, particularly in the operational area. It is important, therefore, that any maximum limits and safeguards against possible risks are included in the company's strategy. The risk is in fact permanently inscribed in any kind of business, and the role of the multimodal transport operator (MTO) is to minimize the risks by analyzing and causing the necessary changes in processes.

The article presents theoretical foundations associated with risk management containing methodology for risk assessment based on risk map. The research part is based on a potential risks identification analysis, impact and probability of occurrence and significance assessment for the company performing multimodal transportation services of intermodal transport units. For this purpose a risk map analysis is used. Identification of the twenty-four most significant threats in five groups (factors related to: organization of ITU transportation and forwarding, ITU handling and carriage operations, human and technical factors) led to the identification of the most important elements of the process of ITU carriage, which proper handling allows to minimize possible losses.

2. Risk management in the transportation process

There are many definitions of the risk management concept. Risk management is often understood as identifying, measuring and controlling risks in order to minimize and protection against risk¹. Risk management is associated with the planned and deliberate analysis, steering and controlling, the effect of which is to minimize possible losses or maximize the benefits of the analyzed economic process (e.g. logistic, transport). Planning should be systematic, rather than accidental analysis with the desirability derived from business objectives positions and specific order opportunities². During target formulation, risk evaluation allows to avoid the risk and expose of the risks. Risk or uncertainty preference

¹ Dziawgo D.: Credit-rating. Ryzyko i obligacje na międzynarodowym rynku finansowym. PWN, Warszawa 1998.

² Kulińska E.: Metody analizy ryzyka w procesach logistycznych. "Logistyka", nr 2, 2011, s. 385-409.

affects the subsequent processes in the management of the transport company³. Risk management is a logically arranged plan, a system, a process that can be divided into successive steps (phases). An exemplary stepwise procedure methodology of risk management analysis is shown in Figure 1.

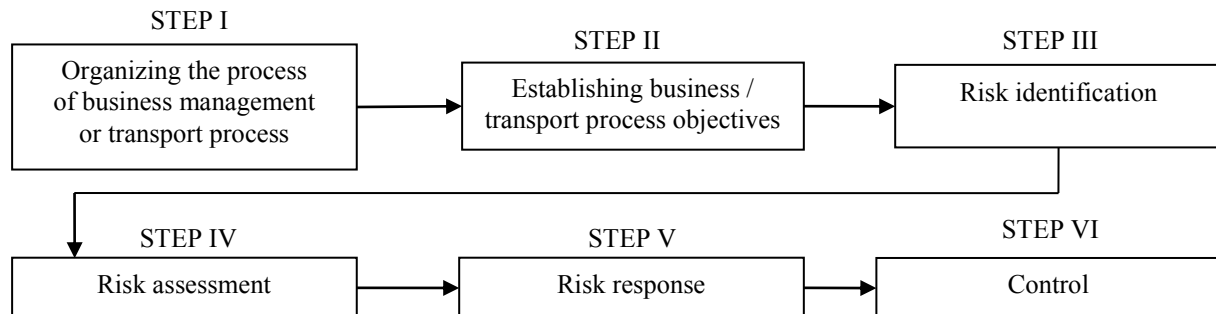


Fig. 1. Multi-step risk management process in a transport company

Source: Own elaboration based on Kumpiałowska A.: *Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym*. CH Beck, Warszawa 2011.

Risk identification is one of the most important and fundamental elements of risk management. Adequate and proper conduction of this process is necessary for the efficient and proper risk management. Stage risk identification is based on collecting the most important information on common threats (internal and external) that may affect directly or indirectly the implementation of the transport tasks assigned⁴. The risks of transport enterprises or processes may involve:

- erroneous decisions caused by inaccurate, unreliable, insufficient and incorrect information,
- ignorance or disregard of rules and set procedures associated with the required documents, the applicable duties of the carrier,
- human factor,
- technical factor,
- random factor.

The risk assessment is possible in many ways⁵ and is the most important, yet difficult and time consuming part of the entire risk management process. Risk assessment process allows to achieve the objective associated with transport task properly done⁶. Uncertainty of potential

³ Kaczmarek T.: *Ryzyko i zarządzanie ryzykiem. Ujęcie interdyscyplinarne*. Difin, Warszawa 2005.

⁴ Rudzińska J., Piekarski W., Dudziak A.: *Zarządzanie ryzykiem a podejmowanie decyzji w przedsiębiorstwach transportowych*. "Autobusy: Technika, Eksploatacja, Systemy Transportowe", nr 10, 2011, s. 362-368.

⁵ Jamroz K.: *Metoda zarządzania ryzykiem w inżynierii drogowej*. Wydawnictwo Politechniki Gdańskiej, Gdańsk 2011.

⁶ Chruzik K., Drzewiecki A., Wachnik R.: The use of FMEA method for risk assessment in MMS. *Scientific Journal of Silesian University of Technology. Series Transport*, Vol. 81, 2013, p. 17-23; Chruzik K., Fellner A.: *Zarządzanie ryzykiem w transporcie*. „Logistyka”, nr 4, 2015 (CD-ROM), s. 7311-7320.

events that may arise during the transport preparation is assessed from two perspectives: the probability and consequences, as shown schematically in Figure 2⁷.

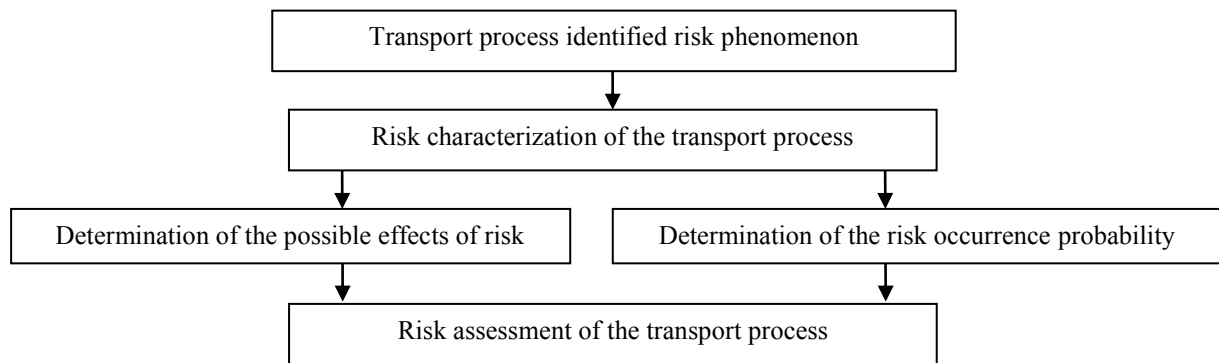


Fig. 2. Elements of the transport process risk assessment

Source: Own elaboration based on Kumpiałowska A.: *Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym*. CH Beck, Warszawa 2011.

Qualitative risk assessment should find a definition for different types of probabilities and consequences of occurrence⁸. The impact assessment of circumstances identified is based on an estimate of the likely outcomes that will affect the organization of the company, and existence of a risk carried with them. Impact assessment of the risks in the transport can be based on a five-point scale, described in table 1.

Table 1

The effects of the transport process risks

Risk effect	Detailed description of the effect	Effect point value
slight	negligible impact on the tasks and goals of the business; minimal financial implications; no legal effect; no impact on the company's image; no impact on the safety of workers	1
small	little impact on the tasks and goals of the business; small financial impact; no legal effect; little impact on the company's image; no impact on the safety of workers	2
average	average impact on the tasks and goals of the business; the average financial implications; moderate legal effects; average impact on the image of the company; no impact on the safety of workers	3
serious	serious impact on the implementation of tasks, serious threat to the date of execution of the order, the possibility of not achieving the target; serious financial losses; serious legal consequences; a serious impact on the image of the company; the possibility of danger to life and health of workers	4
disastrous	the lack of realization of the tasks and goals, not the task within the prescribed period; very high financial losses; very serious and extensive legal consequences; the loss of a good image of the company in the transport environment; violation of workers' safety, health and loss of life	5

Source: Kumpiałowska A.: *Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym*. CH Beck, Warszawa 2011.

⁷ Kumpiałowska A.: *Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym*. CH Beck, Warszawa 2011.

⁸ Kulińska E.: op.cit.

To assess probability of a risk occurrence, the five-step evaluation of the probability that determines how often an event may occur. The detailed description and point value are shown in table 2.

Table 2

Probability assessment of the risk occurrence of transport process

Probability of risk occurrence	Detailed description	Probability point value
very rare or impossible	Possibility of occurrence in exceptional circumstances (from 1 to 20%).	1
small probability	There is a low probability of occurrence of the activity, may occur in exceptional circumstances (from 21 to 40%).	2
average probability	The probability of occurrence is on average possible (from 41 to 60% that will occur more than once a year).	3
big probability	Occurrence of the event is very likely (from 61 to 80% that will occur regularly at least once a year).	4
almost certain	The occurrence is almost certain, occurs regularly every month or more (probability 81-100%).	5

Source: Kumpiałowska A.: Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym. CH Beck, Warszawa 2011.

The risk significance is a measurable effect of materialize adverse events considered as the ration of probability of risk occurrence and risk effect according to the following formula:

$$RS = P \times E \quad (1)$$

where:

RS – risk significance coefficient,

P – probability of risk occurrence,

E – risk effect.

Once the degree of significance has been determined, it is possible to assign each hazard to the appropriate field according to the risk mapping method, as shown in table 3.

Table 3

Risk map

Effects	Probability				
	very rare	small probability	average probability	big probability	almost certain
disastrous	5	10	15	20	25
serious	4	8	12	16	20
average	3	6	9	12	15
small	2	4	6	8	10
slight	1	2	3	4	5

Source: Kumpiałowska A.: Skuteczne zarządzanie ryzykiem a kontrola zarządzania w sektorze publicznym. CH Beck, Warszawa 2011.

Assigning each hazard to the appropriate field as shown in the risk mapping method allows to classify them into small, average and serious risk groups.

3. Case study of risk analysis for the multimodal transportation process of intermodal transport units

The research was based on the multimodal transport organization of intermodal transport units (ITU), which are usually containers or transport swap bodies. Risk identification and assessment was divided into the following elements (according to the elements of the transport process and other significant factors):

- factors related to the organization of ITU transportation (ITU forwarding),
- factors related to the ITU handling operations (loading and unloading)
- factors related to the ITU carriage,
- human factors,
- technical factors.

The identified factors were carried out during the one-day workshop for twenty six experts, familiar with the subject and experienced in intermodal cargo transport units. Using heuristic methods of brainstorming in a group of experts, the risks in each of the individual group were identified. Although for all groups of causal factors the risks identified differed considerably from one another, the effects of the resulting risk often repeated. For this reason, table 4 presents summary of causes and effects that generate risks related to ITU transport.

Table 4

Causes and effects of identified risk groups in ITU multimodal transport

Risk factors group	Risk causes	Risk effects
Organization of ITU transportation (O)	<ul style="list-style-type: none"> - defects or errors in the container packing certificate, - incompatibility or lack of information in other documents, - illegible or incorrect labelling of the container, - lost documentation. 	<ul style="list-style-type: none"> - breaking contractual terms and losses, - contractual penalties, mandates, - lack of possibility of proper carriage.
ITU handling (H)	<ul style="list-style-type: none"> - worn or damaged elements of reloading machines, - inadequate or hazardous handling of reloading equipment, - defective coefficient of friction of the maneuvering yard, - inadequate location of the loading point, - incorrectly designed transshipment terminal, - overfill of the loading point. 	<ul style="list-style-type: none"> - prolonged handling time, - delays in performance and losses due to downtime, - wear or damage handling equipment, - ITU damage, - threat to the lives or health of operators.
ITU transportation (T)	<ul style="list-style-type: none"> - incorrect marking of the ITU transporting mean, - poor technical condition or insufficient amount of fixing means, fixing the ITU incorrectly, - unfavourable external conditions (weather, climate, etc.). 	<ul style="list-style-type: none"> - mandate or ban on further driving, - not performing the task indefinitely, - the need for ITU reloading.
Human factors (U)	<ul style="list-style-type: none"> - abnormal behaviour or illness of the employee, - haste or slow operator work, - low qualifications of human resources, - carelessness and ignorance of safety rules, - random events (e.g. strike). 	<ul style="list-style-type: none"> - accident or damage of ITU, - suspension of duties, - inability to perform the task properly, - inefficiency.

cont. tab. 4

Technical factors (E)	<ul style="list-style-type: none"> - bad technical condition of reloading equipment, means of transport, ITU or infrastructure, - restrictions on transport accessibility, - low labour intensity of the technical means used, - random factor (e.g., break in energy supply). 	<ul style="list-style-type: none"> - failure of the task, financial losses and contractual penalties, - necessity of the equipment repairs.
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Source: Own elaboration.

Table 5 presents a detailed description of twenty four risks identified in five groups which may occur during ITU handling operations and transportation. Risks are divided into its symbol, name and agreed in the expert group assessment of consequence, probability and significance of the risks.

Table 5

Detailed risk assessment identified in factors related to ITU handling operations

Risk group	Risk symbol	Risk identified	Risk assessment		
			effect	probability	significance
Organizational (O)	O1	incorrectly filled container packing certificate	3	2	6
	O2	improperly ITU labeling	3	1	3
	O3	lack of a permission for the transport and storage of certain goods	3	1	3
	O4	mistakes in filled-in documents	4	2	8
Handling (H)	H1	breaking and falling of the ITU of the gripper	5	2	10
	H2	overturn the ITU stack	5	3	15
	H3	insufficient area on terminal for manipulation	3	2	6
	H4	inappropriate substrate of cargo terminal	4	2	8
	H5	handling equipment failure	4	3	12
Transport (T)	T1	improper ITU or vehicle marking	3	1	3
	T2	ITU theft	5	2	10
	T3	collision or accident involving ITU	5	3	15
	T4	verification of ITU transport process by inspection services	3	3	9
	T5	inadequate ITU securing	5	2	10
Human (U)	U1	accident at work	4	3	12
	U2	failure to comply with working time of drivers	3	4	12
	U3	lack of employee entitlements	3	1	3
	U4	delay or default of an employee	2	2	4
	U5	low qualifications of the driver or operator	3	1	3
	U6	intoxication of the driver or operator	4	3	12
Technical (E)	E1	ITU damage	3	3	9
	E2	mismatch of technical means to a specialized ITU	4	2	8
	E3	technical inadequacy of infrastructure points	3	1	3
	E4	technical failure of the equipment	3	2	6

Source: Own elaboration.

After analyzing the five risk categories, a list of twenty four types of ITU transport risks has been generated for which the significance has been determined. On the basis of the assignment of the impact (effects) and probability of the risk it was possible to determine its position on a risk map (table 6).

Table 6

Risk map of ITU transport

Effects	Probability				
	very rare	small probability	average probability	big probability	almost certain
disastrous		H1, T2, T5	H2, T3		
serious		H4, E2	H5, U1, U6		
average	O2, O3, T1, U3, U5, E3	O1, H3, E4	T4, E1	U2	
small		O4, U4			
slight					

Source: Own elaboration.

Eleven types of risk in all categories have been assigned to the low significance group. These are hazards typically with little or no impact on the performance of ITU transport tasks or with minimal financial impact and little legal impact. Typically, these events do not affect the image of the transport company and the safety of the people working there. At the same time, they can be a threat, which is possible under exceptional circumstances.

Eleven potential threats have been classified as medium significance. The average significance of the risks poses a threat to the objectives pursued and may cause financial losses. The average level of risk requires continuous monitoring, checking and careful action.

The greatest concern is the classification of the two threats to the most important risk categories (parameters H2 and T3), which are classified as: overturn the ITU stack on the terminal yard and collision or accident involving ITU during its shipment process. The effects of these events entail very high financial losses or legal damages, and often the loss of prestige of the transport company. The risk associated with these accidents can also have major consequences for the loss of health or life of workers responsible for containers and swap bodies handling and transportation.

For all identified risks, a detailed description and a remedial action plan have been developed. Introducing them to handling and transport procedures will eliminate or reduce the impact of each risk.

4. Conclusion

Risk management is related to the planned and purposeful analysis, steering and control of the risk, resulting in minimizing possible losses or maximizing the benefits of the process, for example: transport process, being analyzed.

Risk analysis, after assessing the most important parameters or the consequences and the probability of an accident, should be completed with detailed compilation of all the risks that may occur in a company or transport process, taking into account the significance of the danger.

The research part of the paper presents an analysis of potential risks identification, impact and probability of occurrence assessment and evaluation of each risk significance for the company performing the service of ITU multimodal transport and handling. Formulation of the twenty-four most important threats allowed identification of this part of the ITU transport process, which has the greatest diligence in their implementation to minimize possible losses. To evaluate the extent of the hazards, the risk mapping method was used. From the analysis it can be concluded that the two most important threats are: overturn the ITU stack on the terminal yard and collision or accident involving ITU during its shipment process (H2 and T3). Remedial measures to minimize these risks are to train and sensitize drivers and handling machines operators of the threats associated with their work, also according to the compliance of handling equipment operation procedures. Another introduced modification may be periodic employee surveys, hiring well qualified drivers assuring appropriate safety standards as well as providing them convenience of technical adaptations of the machines.

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